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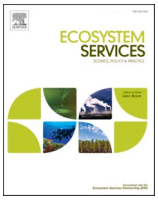

Societal benefits of river restoration – Implications from social media analysis

Nina N. Kaiser [a,b,*], Andrea Ghermandi [c], Christian K. Feld [a,d], Yaron Hershkovitz [a], Martin Palt [a], Stefan Stoll [a,b]

[a] University of Duisburg-Essen, Faculty of Biology, Department of Aquatic Ecology, Universitätsstraße 5, 45141 Essen, Germany
[b] University of Applied Science Trier, Environmental Campus Birkenfeld, Post Box 1380, 55761 Birkenfeld, Germany
[c] University of Haifa, Department of Natural Resources and Environmental Management, 199 Aba Khushy, Haifa 3498838, Israel
[d] University of Duisburg-Essen, Centre for Water and Environmental Research, Universitätsstraße 5, 45141 Essen, Germany

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ABSTRACT

The success of river restoration projects regarding its effects on cultural ecosystem services (CES) and contributions to human well-being is not frequently evaluated. Here, we recorded CES and associated values of a restored river site based on social media posts of visitors. We analysed 605 photographs from three social networking sites (Flickr, VKontakte and Instagram) taken at a prominent river restoration site in Israel, at the estuary of the Kishon River. An automated image labelling approach identified seven photo clusters, of which six could be directly related to the restoration site. Of those, three CES clusters were linked to biophysical properties of the environment (instrumental values); two others were linked to human perception of the environment (relational values); one cluster addressed both characteristics, thus showing the mutual relationships of CES-based values. The method was able to reveal previously unrecognised values of river restoration, but also overlooked CES that are known to take place at the site. Our approach can be useful in informing future river restoration projects and freshwater resource management programs, by providing a cost-effective framework for the assessment of their success in supporting or promoting CES and thus helping to render such programs more beneficial for human well-being.

1. Introduction

River systems provide many ecosystem services and contribute to human well-being (Díaz et al., 2018; Hanna et al., 2018). Many rivers worldwide, however, are severely degraded by multiple land and water uses imposing, amongst other pressures, severe hydrological and morphological alterations of the rivers and their floodplains (Vörösmarty et al., 2010). River restoration (including similar concepts like river rehabilitation (Dufour and Piégay, 2009)) aims at reversing these negative consequences by establishing flow and habitat conditions that are more similar to the natural (reference) conditions, which in most cases is also used to evaluate the success of the measures.

Cultural ecosystem services (CES) are increasingly in the focus of environmental researchers and managers as the dependence of human well-being on them is better understood (Calcagni et al., 2019; Daniel et al., 2012; Guo et al., 2010). CES are also the most instantly recognisable and cognitively easily accessible type of benefit to the wider public (Calcagni et al., 2019), especially when compared to other ecosystem services (ES) of river restorations (e.g. nutrient retention). Due to the non-material nature of CES and the consequent difficulties in assessing them (Hale et al., 2019; La Notte et al., 2017), this ES category is typically assessed through surveys, economic valuations (including willingness-to-pay-studies), to estimate benefits and values (Hernández-Morcillo et al., 2013; Ho Huu et al., 2018; La Rosa et al., 2016), as well as a range of other approaches (Cheng et al., 2019). The assessment of the most intangible ESs (e.g. sense of place, social relations, spiritual values) is particularly challenging (Andersson et al., 2014; Chan et al., 2012b, 2012a).

The way in which restored rivers are perceived by visitors and which CES are connected with restoration is rarely observed. Most studies on restoration monitoring focus on biodiversity and regulating services (Jähnig et al., 2011; Kaiser et al., 2020; Weber et al., 2019). With the

* Corresponding author at: University of Duisburg-Essen, Faculty of Biology, Department of Aquatic Ecology, Universitätsstraße 5, 45141 Essen, Germany.
E-mail addresses: nina.kaiser.aqua@uni-due.de (N.N. Kaiser), aghermand@univ.haifa.ac.il (A. Ghermandi), christian.feld@uni-due.de (C.K. Feld), yaronhe@tauex.tau.ac.il (Y. Hershkovitz), martin.palt@uni-due.de (M. Palt), s.stoll@umwelt-campus.de (S. Stoll).

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exception of a limited number of qualitative research studies (Brandenburg and Carroll, 1995; Verbrugge et al., 2019), how the population perceives restored rivers is usually not systematically monitored or recorded. In some cases, there are organized visits for local residents to the restoration projects that are announced in the regional press, but these are generally not accompanied by a scientific or systematic analysis and rather mostly serve to showcase the completed measures to the public.

Recently, interest has been growing around social media data for their potential to usher in an efficient and less resource-intensive way to assess CES in environmental studies (Ghermandi and Sinclair, 2019). The metadata of social media items like photographs, tweets or videos (e.g., geotags, timestamp) are particularly useful in describing the interactions between people and nature at specific locations and points in time. Analysis of geotagged photos counts were found to correlate well with official visitor counts in a range of applications, and are generally considered a suitable proxy for visitation intensity (Zhang et al., 2020). The method has been used to quantify nature-based tourism and recreation (Tenkanen et al., 2017; Wood et al., 2013; Sinclair et al, 2018) or user preferences for improved water quality (Keeler et al., 2012). But also intangible values like landscape aesthetics were mapped (Langemeyer et al., 2018; van Zanten et al., 2016). Manual content analysis of geotagged photos revealed diverse recreation activities, including fauna, flora and scene experiencing and viewing, hiking, biking, public green space use recreation with dogs and boating (Angradi et al., 2018; Oteros-Rozas et al., 2018). To accelerate image classification and to make it reproducible even for large datasets, automated image recognition has been applied recently (Gosal et al., 2019; Lee et al., 2019; Richards and Tunçer, 2018). Freshwater systems have been in the focus of researchers, however none of these studies included restoration projects (Angradi et al., 2018; Ghermandi et al., 2020a; Hale et al., 2019; Keeler et al., 2012; Sinclair et al., 2019).

Social media data can provide insights into different categories of ES values, including both instrumental and relational values, as previous research has highlighted (Calcagni et al., 2019). Instrumental values refer to properties of the natural environment that are regarded as valuable ("useful" in a utilitarian sense) to human beings (Justus et al., 2009). They are often, though not exclusively (Loomis et al., 2000), reflected in direct physical interactions with nature and its biophysical properties (e.g., angling to water or picnics to green space). CES also encompass a range of non-use values (e.g. in the sense of bequest or existence values), which however are not the subject of this study. Relatively recently, the concept of relational values was introduced to overcome the former dichotomy existing between intrinsic (i.e., valuable independently of humans) and instrumental values of nature, in an attempt to cover the entire range of values perceived by people (Chan et al., 2016; Pascual et al., 2017; Stenseke, 2018). Although the practical usefulness of the distinction has been questioned (See et al., 2020), relational values, understood here as relationships between people that involve nature (Chan et al., 2016; Pascual et al., 2017), are considered better suited to capture intangible values associated with human perception (e.g. cultural identity) (Capineri, 2016; Chan et al., 2016; Pascual et al., 2017; Vejre et al., 2010). For example, nature as a place where humans can meet other humans while providing cultural identity or social cohesion is an important source of relational values (Chan et al., 2016; Pascual et al., 2017). Verbrugge et al (2019) have investigated the role of restoration in the formation of sense of place, distinguishing between place identity and place dependence. Place identity is described there as the process of place becoming part of self-identity, whereas place dependence emphasises the functional importance of place for engaging in activities. In this work, we consider relational values as the umbrella term for place identity related values and instrumental values as the umbrella term for place dependence related values.

In this context, one of the peculiarities of social media data is that they can capture the users' views on nature, in a way that is unbiased by the interviewers' interaction with the interviewee, while at the same time being informed by the cultural background of the user and the social norms that inform his or her broader social network (Chen et al., 2018; Langemeyer et al., 2018, Calcagni et al., 2019). It is also a geospatial source of user-generated content, which is unbiased and independent of spatial planning policy interests or objectives. As such, the data can reveal knowledge gaps in user perception and behaviour in restored river areas (Angradi et al., 2018). In particular this method does not quantify the potential CES supply of an area, but the actual flow of CES, since it requires a person who is the recipient of the CES, namely the social media users (Burkhard et al., 2014; Hale et al., 2019; Yoshimura and Hiura, 2017). Moreover, it can be applied to identify and distinguish among different types of CES associated with the area under investigation.

This study is, to our knowledge, the first study that investigates the usefulness of social media data, here geotagged photographs, to explore CES and the associated values in a restored river section. Our case study is a prominent river restoration project at the Kishon River in Haifa, Israel. Building on the notion that social media photos that were taken on-site allow detecting visitors' perception of river restoration and the benefits they obtain from the restored area, we show how this type of data can be used as an effective tool for the identification and characterization of the different types of CES ensuing from river restoration, thus potentially providing new insights for the planning and management of such interventions.

2. Methodology

2.1. Study area

The relationship of people and the river Kishon goes back to biblical times (The Bible, n.d.). It is one of the largest coastal waterways in Northern Israel, draining approximately 1000 km^2. By the end of the 20th century the last kilometres of the river, which drains to the Mediterranean Sea, were heavily impacted by urban and industrial wastewaters and sediment contaminants (Tal and Katz, 2012). The severe pollution of the river and consequent contamination of the Mediterranean Sea shifted public concern, increased environmental awareness and political will, and led to legislative measures to improve water quality (Barcelona Convention, adopted in 1976, amended 1995, entered into force 2004, UNEP/MAP, 2001), however, mainly focussing on waste water treatment improvements. In 1994, the Kishon River Authority was founded, having the responsibility to administer and maintain the river restoration and rehabilitation efforts. In 2001 the Kishon Master Plan was launched by the Israeli Ministry of Environmental Protection and the Kishon River Authority defining a set of rehabilitation measures such as suitable criteria for water quality, reallocation of suitable water and the removal of pollution sources and contaminated sediment (Tal and Katz, 2012). As a result, water quality improved dramatically and the ecological condition gradually recovered (Becker et al., 2019; Gasith and Kleinhaus, 1996; Hershkovitz, 2017). In addition, the development of public parks was planned for the lower section of the river. The HaKishon Park (32°48′11.9″ N, 35°01′49.1″ E) was constructed in 2001, covering an area of 2.1 ha (Fig. 1). The Kishon River Authority plans to expand the publicly accessible area upstream, however as plans also exist to expand the port area, there are competing interests for land.

2.2. Social media photo collection and data processing

We collected data related to the HaKishon Park (Fig. 1) from three different social media networks, Flickr, VKontakte and Instagram, which we used as a tool for investigating the park visitors' preferences and perceptions (Guerrero et al., 2016; Hale et al., 2019). The photo collection was performed on 15 June 2019 and covers all publicly available photo posts from the study area published between 2015 and

Fig. 1. Aerial photo of east Haifa with the location of HaKishon Park (red oval) and the river course (ESRI ArcGIS Map Service, 2017). A view of the park as seen from boat (small photo, credit: Kaiser et al., 2020). The right side shows the geographical location of Israel and its border states (GADM - Database of Global Administrative Areas, 2018) and the position of Haifa in the north of the country.

2019. Photo posts were accessed through the respective Application Programming Interfaces (API) (for Flickr and VKontakte) or manual retrieval (Instagram) and searching for location tags within the study area *('Kishon river')*. Location tags of Instagram are pulled automatically from Facebook locations, the user can decide to give the post a location tag or not. Photos were spot-checked to ensure they were actually taken in the park.

We are aware that users of social networks are not necessarily representative of the entire society or population. We rather see the information from social networks as a complementary and supplementary source of data to existing data and methods. Previous research has shown that despite different user groups on the various platforms, the preference heterogeneity for sites with aesthetic and outdoor recreational values does not change substantially (van Zanten et al., 2016). By using three different social networks, we tried to minimize the bias that could arise from using only one network (Ghermandi et al., 2020b).

We used an automated image analysis through an online cloud-computing platform to assign text labels to the content of each photo (Google Cloud Vision, 2019). Google Cloud Vision is a machine-learning tool which can run with pre-trained models for image recognition and labelling. Up to 20 different labels can be attributed to a single photo and each label is delivered with a measure of reliability (the algorithm's attributed likelihood of occurrence). Only labels with a reliability of 0.5 or higher are returned. Several previous studies have assessed the accuracy of computer vision cloud-based services in detecting visual elements in photographs (Al-Omair and Huang, 2018; Dodge and Karam, 2016; Nilsson and Jönsson, 2019; Temel et al., 2019), including their accuracy in identifying biophysical environment elements in photographs of nature-based recreation (Richards and Tunçer, 2018; Runge et al., 2020), generally finding that they perform well, especially for high-level concepts. For our dataset, we proceeded with up to 20 labels per photo and the labels were arranged in descending order according to reliability. We accessed the API of the computer vision service with the R package RoogleVisions (RStudio Team, 2015; Teschner, 2019) to process the whole dataset. The resulting dataset was a table with 605 rows (photos) and 1020 columns (unique labels), with each cell containing the reliability score (range: 0.5–1, or NA for 'not available').

Proceeding from the expectation that similar photos share similar labels (Lee et al., 2019; Richards and Tunçer, 2018) we performed a similarity analysis, in a manual loop based on pairwise Jaccard Indexes of photo labels' reliability values (presence/absence), to find clusters within the dataset (Song et al., 2020). The similarity matrix was then converted into a distance matrix and finally into an R-'dist' object to perform hierarchical clustering. Hierarchical clustering was done with the R package 'fastcluster' using Ward's distance (Müllner, 2013; RStudio Team, 2015). The appropriate number of clusters was determined by the maximum average silhouette width (Fig. S1, Supplementary material). The list of labels per cluster served as a basis for individual cluster headings (Table 1). A degree of subjectivity in the overall naming of the clusters is part of the process of linking the labels to CES, in assigning parent labels to the clusters, we adopted existing literature (Lee et al., 2019; Richards and Tunçer, 2018). We intentionally did not search for possible matching CES categories or examples of classification of our photos beforehand (before clustering the photos), as previous work has shown that the prior use of schemes can influence the results (Angradi et al., 2018).

Regarding the image recognition algorithm, we noted that several labels were very similar (e.g. "nature", "natural environment", "natural landscape") and were often jointly attributed to the same photo. We, therefore, introduced parent labels, to combine similar labels and avoid semantic redundancies. A cluster analysis, however, revealed similar results for both originally and alternatively labelled data, so that all further analysis was deployed using the original dataset.

We then looked at every tenth photo of the clusters and checked whether the classification of the photos to the respective clusters was correct.

2.3. Interviews

Interviews (for questionnaire see supplementary material) were carried out in the HaKishon Park on four weekend days with good weather conditions in March 2019 (n = 32). We asked park visitors about their frequency of visits, hometown, leisure activities in the park, their favourite features of the park and collected basic demographic data. The interviews were intended to complement the visitors' statements about the park as a place of recreation with the photos actually

Table 1
Top ten labels of each cluster and their frequencies of occurrence. Numbers in parentheses represent the total number of labels per group. Almost all clusters are distinctly defined by relatively few labels (180–286), which means that fewer labels are needed to cluster the described properties of the photos. In contrast, the cluster "picnic & miscellaneous" consists of almost twice as many labels (546) each of which occurs at a much lower frequency.

Relaxation and joy (197)	n	Green nature (193)	n	Landscape aesthetics (245)	n	Social relation (286)	n
Smile	90	Tree	41	Sky	70	Grass	48
Photography	87	Plant	37	Tree	65	Fun	46
Fun	80	Vacation	24	Water	60	Leisure	42
Vacation	75	Woody plant	23	Cloud	50	Recreation	42
Selfie	71	Arecales	21	River	49	Summer	39
Happy	70	Palm tree	21	Grass	42	Plant	38
Cool	67	Grass	16	Lake	38	Vacation	37
Summer	65	Sky	12	Morning	35	Child	30
Friendship	53	Date palm	11	Plant	34	Tree	29
Leisure	45	Tourism	11	Sunlight	31	Smile	28
Marina (180)	n	Picnic, dogs and miscellaneous (546)	n	Self-portrayals and posing (240)	n		
Vehicle	77	Carnivore	16	Photography	71		
Boat	74	Food	16	Leg	55		
Watercraft	65	Vehicle	15	Summer	53		
Sky	55	Cuisine	14	Beauty	51		
Marina	52	Photography	13	Vacation	48		
Water	52	Canidae	12	Fashion	47		
Harbor	50	Dog	12	Long hair	46		
Port	47	Dish	11	Cool	42		
Sea	46	Dog breed	11	Smile	42		
Vacation	45	Plant	11	Clothing	34		

posted and collected on social media. Interviews were tested for age-group effects using Kruskal-Wallis H-Test and subsequent U-Tests for pairwise comparisons (non-parametric data). Since the number of interviews is relatively low, we did not apply more advanced statistical techniques to avoid over-interpretation of the data.

3. Results

3.1. Labelling and clustering

The numbers of unique photo labels per cluster (Table 1) indicate that almost all clusters are distinctly defined by a comparable magnitude of labels ranging from 180 to 286. Only one cluster ('picnic & miscellaneous') consists of almost twice as many labels (546), each of which occur at a much lower frequency. This cluster contains photos with labels such as 'dog' and 'food' and generally rare labels with low occurrences.

Overall, we identified seven different clusters of photographic content, with an uneven distribution of content amount among the clusters (Figs. 2 and 3). Six out of seven clusters are associated with the restoration site, whereas one cluster is distinct in its content (Fig. 2). The distinct cluster comprises photographs of the marina, which is located in closed proximity to the park ('Haifa's fishermen's wharf'). Two clusters have a dominant nature-related content, which we named 'green nature' and 'landscape aesthetics' because they predominantly show vegetation ('green nature') and river scenery ('landscape aesthetics'). Both these clusters together represent 23.9% of all photos related to the restoration site (excluding cluster 'marina'). The other four clusters mainly contain

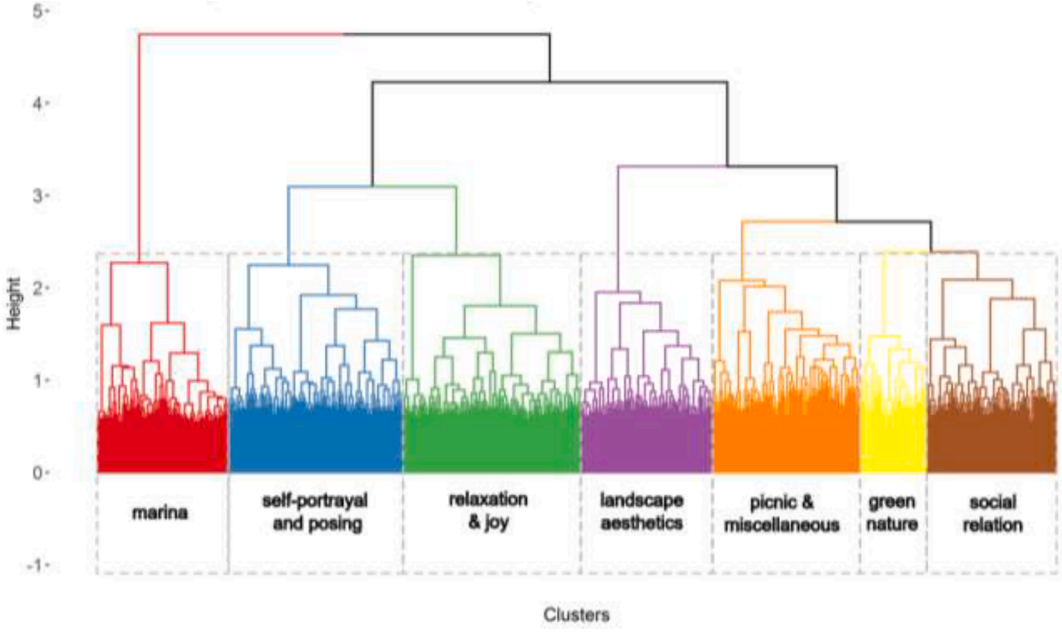

Fig. 2. Cluster dendrogram for the matrix of 605 photos and 1020 labels, based upon the presence/absence of labels. The seven clusters were identified by maximal average silhouette width and assigned a caption to name the respective CES cluster. The cluster on the left side is distinct from the other clusters and represents photos of the marina area. The x-axis represents the different clusters, the y-axis shows the dissimilarity of the clusters to each other by the dimensionless height h.

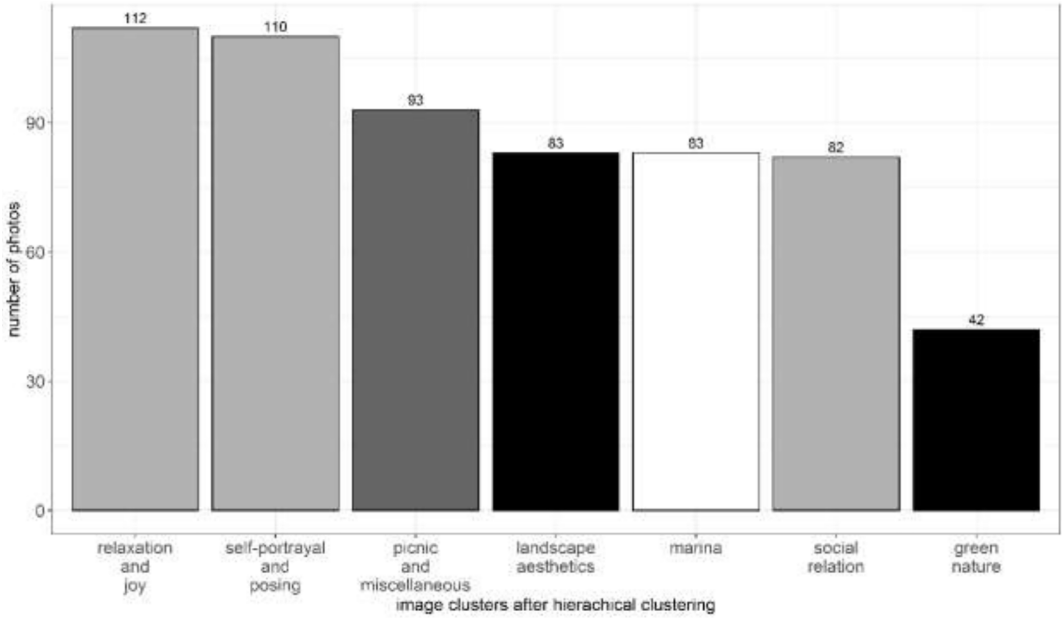

Fig. 3. Number of photos by cluster. The three light grey clusters were attributed to relational values (relaxation and joy, self-portrayal and posing, social relation). The two black clusters were attributed to instrumental values (landscape aesthetics, green nature) while the white cluster "marina" is not directly associated with the restoration site. The dark grey cluster "picnic and miscellaneous" has elements of instrumental and relational values why we organised it as instrumental values with a relational component.

photos of people in nature. Here, the range covers everything from portraits and selfies to group photos.

Time pattern of postings reveal that visitation mainly occurs on weekends and holidays with visitation peaks in spring and autumn (Fig. 4). We suspect that the peak in photo posts in 2017 was related to the increasing popularity of Instagram in Israel at the time, which appears to have stabilized since (NapoleonCat, 2021).

The most important difference between the field survey (interviews) and the photo labelling approach concerns the lack of two individual CES. Angling and rowing are classical forms of river-related recreation; however, these two activities are missing in the clusters identified through the photo labelling approach. Angling was identified through the interviews (but not rowing), while both, angling and rowing were discovered in very small numbers by looking at the photos (n = 5) during the manual control of every tenth photo of the clusters respectively.

Due to the wide-angle lenses used in most smartphones, distant activities on the water are difficult to document. We were able to discover rowers in the distance on some pictures as we looked at the pictures in large parts ourselves. Photos purposely depicting rowing ended up in the cluster "marina" since the largest label overlap existed for "vehicles" and "watercraft" and the photos of rowing were not specifically enough related to other labels to warrant an own cluster. The few angling photos ended up in the picnic and miscellaneous group.

Quantifying the number of photos gives a stronger indication for relational values in the context of "place identity" (N = 304 photos) than for instrumental values of "place dependence" (N = 125 and 218 photos respectively, including "picnic & miscellaneous") (Fig. 3).

3.2. Interviews

Gender distribution of interviewees comprised 56% female and 44% male respondents. Most respondents belong to the age classes between 20 and 50 years (75%). The majority of respondents live within a distance equivalent to a 15–30 min car drive away from the park (78.1%), with only a small minority coming from a distance of more than one-

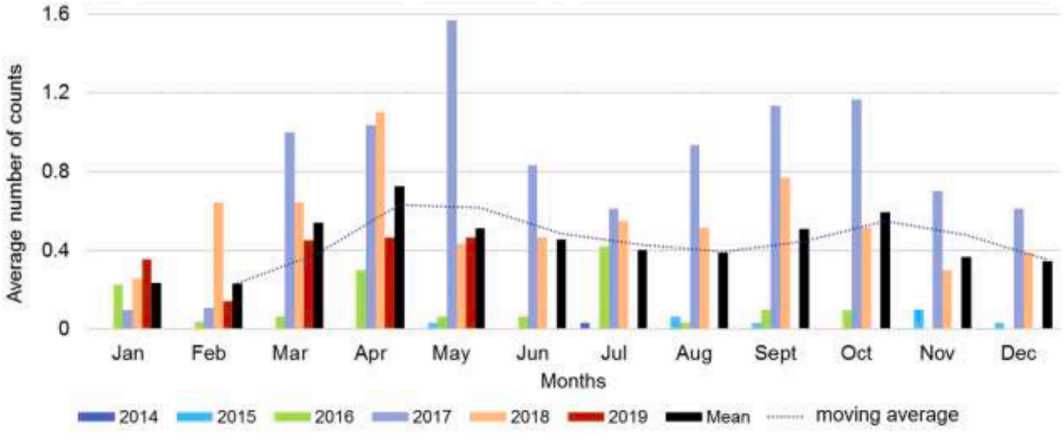

Fig. 4. Average number of photo postings per month from July 2014 to May 2019. Time pattern of postings reveal that visitation mainly occurs on weekends and holidays with visitation peaks in spring and autumn.

hour car drive away from the park. Long-distance travellers were attracted by word-of-mouth communication (Fig. S2, Supplementary material).

Most people visit the HaKishon Park relatively frequently, between once or twice per month (69% of the respondents), followed by occasional visitors (3–4 times/year, 25%). With 3% each, weekly and first-time visitors were rare.

Notably, only 56.3% of the respondents were aware that the HaKishon Park is part of the Kishon River restoration project, even though the project is well-known across Israel and especially so in the Haifa metropolitan region where it is located. Notably, 69% of visitors come in larger groups of six or more people.

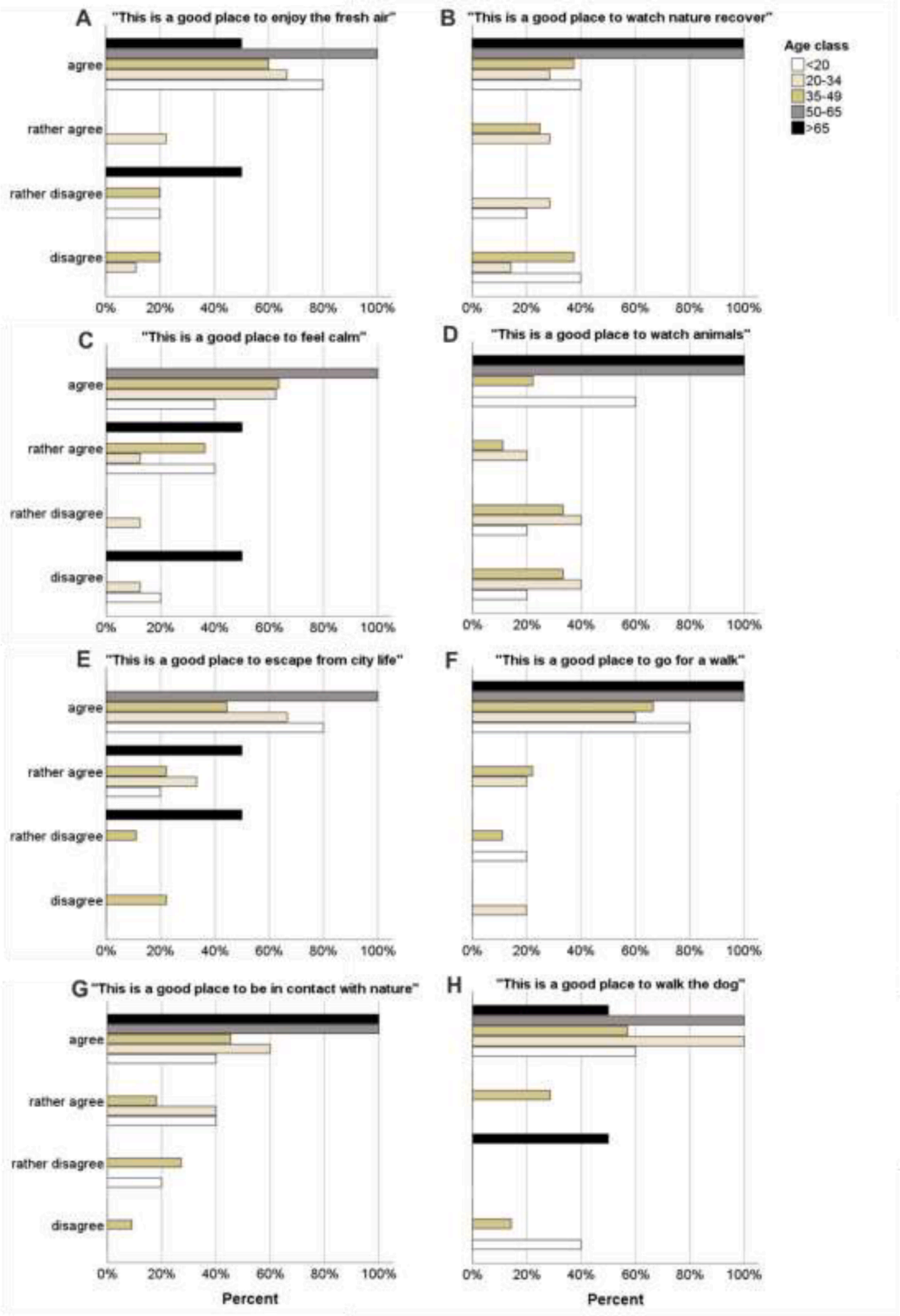

Fig. 5. Level of agreement to selected statements during interviews (A–H). No significant differences were observed between the groups (Kruskal-Wallis-Test). There is broad agreement across all age groups about the multifunctionality of the area.

No significant differences were observed between age groups and level of agreement with selected statements (Kruskal-Wallis-Test). There is broad agreement across all age groups about the multifunctionality and acceptance of the area by users (Fig. 5).

Fig. 6 shows the respondents' statements regarding their favourite features in the park. The favourite attribute is the open landscape with the green grass, followed by the opportunity to be outside in nature that the park offers, both instrumental values of nature. These are followed by the quietness and the possibility to have a barbecue. In total, five of the favourite attributes of the park can be assigned to instrumental values (open space/grass, be in nature, be next to the water, fresh air, fishing) and four to relational values (silence/quietness, barbecue, relaxing, place to be with family/friends). We would not assign the two attributes "accessibility/free" and "dog-friendly" to any determined categories, as they are too unspecific and it would require clarification which values are associated here. For instance, "accessibility/free" could be interpreted as the possibility of being in nature "for free", in which case it would be an instrumental value; however if, on the other hand, it meant having an accessible natural place where you could meet up with friends, it would be assigned to relational values. The insight from the data is that people attach attributes from both value categories and consider them important in the park.

4. Discussion

4.1. General points

With six out of seven determined clusters related to the Kishon Park, and the remaining cluster representing the nearby marina, our approach was able to separate photos related to the study site from those unrelated to it. It is important to emphasise that since December 2018, when changes in the services took place in response to privacy concerns, Instagram photos are no longer associated with precise locations, but are geo-tagged by the users themselves. Therefore, the ability to separate photographs by means of the depicted content rather than precise location bodes well for the approach in future studies with data later than 2018.

We would have expected many more overlaps between labels within the clusters, instead, they seem quite distinct with only some tags (like "plant" and "summer") appearing in multiple clusters. The reason why the two activities "rowing" and "angling" do not form a cluster of its own, may be in particular due to the specific nature of the activities. Rowing is not suitable for self-photographing in action and may, therefore, be less frequent in appearance. Since angling is officially not recommended at this site, one might argue that anglers do not want to take and upload photos of themselves while operating in the legal grey area.

In order to be able to explicitly demonstrate restoration effects quantitatively, a meaningful comparative (before/after) system would be required, which was not available in the context of Kishon Park, as access to the river was not possible before the implementation of the measures and thus no posts were available.

4.2. CES related to the biophysical environment

We describe the two clusters that relate most strongly to the surrounding nature as "green nature" and "landscape aesthetics". These clusters, although we discuss them here under the aspect of CES, are also a reflection of nature and thus representative of biodiversity and its inherent values.

The main difference between the two clusters is the photo section and scale. The cluster "landscape aesthetics" depicts the river much more frequently, while "green nature" focuses on the vegetation parts. Furthermore, close-ups are more common in the "green nature" cluster, whereas the "landscape" cluster tends to show panoramic photos. This distinction was previously observed by Lee et al. (2019), but the authors labelled the cluster with the detailed photos "existence" (Lee et al., 2019). We characterize this cluster of photographs as "green nature" in order to more clearly refer to the instrumental nature of the values represented in them, whereby the mere observation and subsequent photographing of the vegetation provides an added value to the photographer.

The instrumental nature of values is also represented in the cluster "landscape aesthetics", however, with the focus on the river. The open view from the park to the river with Haifa and the Carmel mountain in the background is reflected in the keywords of the "landscape aesthetics" cluster (e.g., "sky", "water", "cloud", "river", "morning", "sunlight"). Earlier research pointed to the positive association of viewshed area and open landscapes with CES and negative relationship between forest cover and CES supply (Schirpke et al., 2016; Van Berkel et al., 2018). This implies that especially the open areas of the park are highly associated with the flow of CES, which was also stated in the interviews when the respondents named open space as one their preferred elements in the park. This finding is also in line with studies on which landscape features are associated with tranquillity, according to which such photos had the highest proportion of tranquillity in which water bodies, an

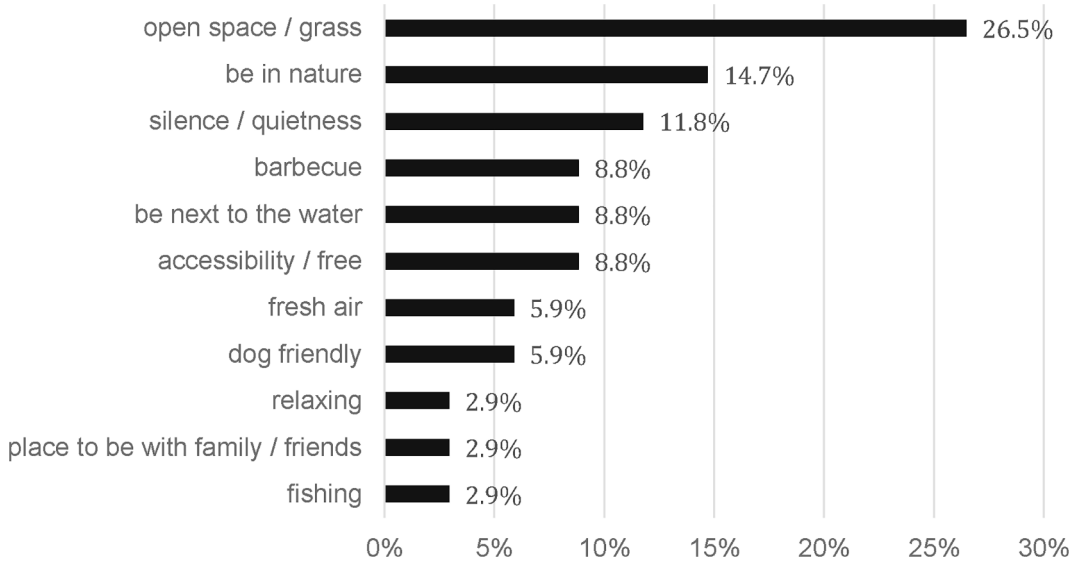

Fig. 6. Statements of the respondents about their favourite features of the Kishon park.

open view and a dominant sky were depicted (Wartmann et al., 2019). This may also be due to the fact that the openness of the landscape makes people perceive the (home) city of Haifa in the distance. We discuss this in the next section.

At first glance, it might be disappointing to notice that people do not seem to focus specifically on the sections of the successful restoration project, although a slim majority is aware that the area is a restored site. However, the share of more than 20% of nature-related photos ("green nature" and "landscape aesthetics") reflects a consistent trend: previous studies found similar shares regarding the relative proportion of nature photos, despite focussing on different scales and more pristine landscapes (Guerrero et al., 2016; Richards and Tunçer, 2018). This arguably implies that people do not perceive the secondary habitats created by restoration as nature of inferior quality, but as adequate nature in which they find the natural experiences they are looking for. This aspect could be further investigated in the future through specific questions in surveys. Yet, the recovering life in the Kishon river (e.g. turtles, water birds, fish and macroinvertebrates) can be difficult to fully appreciate for non-experts, as there are also no indications or signs on the site that could provide orientation for visitors. Considering the vast extent of the pollution of water, riverbed and surroundings only two decades ago, it could also be possible that people simply did not expect to find so much nature. Other studies using social media image recognition in application to ecosystem services have found that if the presence of a beautiful spot of nature is expected, the share of photos with nature-related content can be substantially larger, e.g., 44% in Lee et al. (2019). Hence, HaKishon Park may be best described as a multifaceted landscape that offers space for diverse experiences, including social activities and experience of nature.

4.3. Social dimension within the photo clusters – Relational values

The uneven distribution of the photo content among clusters shows that the opportunities for social interaction in nature play a primary role and are not limited to the pure observation of the natural environment identified in the previously discussed clusters. Four clusters are not exclusively focused on individual physical and experiential interactions with nature but rather focus on people and their relationships ("picnic & miscellaneous", "self-portrayal & posing", "social relation" and "relaxation & joy"). The interactions shown in those clusters all represent personal, intimate, everyday activities: showing oneself, eating, relaxing, and surrounding oneself with friends and family. These individual everyday activities in nature suggest that the area is more likely to be visited by residents than by tourists, which is supported by the survey results. Thus, it can be concluded that the restored site offers the local population the opportunity to integrate nature experiences into their regular leisure activities.

A closer look at the relational value clusters shows that they can be principally divided into individual interactions with nature ("relaxation & joy" and "self-portrayal & posing") and group-based interactions with nature ("social relations" and "picnic & miscellaneous"). The number of individual portraits and photos of pairs is slightly higher than group photos. Individual interactions are also more closely nested in the dendrogram whereas the position for the two group-based interactions is less distinct. Here, individual interactions with nature emphasise personal, individual or emotional situations of people by showing themselves in the pictures surrounded by calm nature, which in turn gives the restored landscape the capacity to evoke these feelings (e.g. happiness, relaxation, joy), like it is described for other landscape types (Norton et al., 2012; Wartmann et al., 2018; Wartmann and Purves, 2018).

In the present case, we also go so far as to assign the cluster *"Self-portrayal and posing"* to the group of relational values. Although at first glance there seems to be very little relation to the surrounding nature, these activities are self-presentations in the chosen and surrounding nature. Portraits in social networks have been designated as a medium to represent one's authenticity (Bayer et al., 2020), self-expression, self-portraiture (Iqani and Schroeder, 2016) and can be seen in the tradition of self-portraits since the invention of photography (Iqani and Schroeder, 2016). They can also be related to identity or sense of home, especially if the city of Haifa is depicted in the backgrounds of the photos. Since the present cases are self-portraits on the restored Kishon, they can be interpreted as an elementary part of people's self-perception to nature and thus as relational values. Distinguishing the individual feelings associated through and with the landscape and attributing them to precise scenes is doubtless the subject of further research and cannot be adequately explored here.

The presence of group-based interactions in two clusters shows that the restoration site is also used as a meeting place for family and friends and thus, as defined in other studies (Brown and Brabyn, 2012; La Rosa et al., 2016; Pascual et al., 2017; Plieninger et al., 2013), provides the capacity for social cohesion. Photos of family and friends were previously defined as a "sense of home" (Chen et al., 2018). However, we do not make this distinction, but rather subsume them, as well as other related landscape values such as "community attachment" and "memory" (Chen et al., 2018), under *social relation*.

Since freshwater resources are scarce in Israel, access to this resource plays an important role in nature-based recreational activities (Akron et al., 2017). A relevant contribution of contact with nature is the reduction of stress levels in the population and thus the maintenance of social health (de Vries et al., 2013; Hofmann et al., 2018). Thus, the accessibility of the resource through restoration has made the benefits available to more people. The right and opportunity to make use of natural resource has also been discussed under the aspect of equity in human-nature relationships (Schröter et al., 2020), which underlines the democratic element of natural areas.

4.4. Aspects of restoration management

With the restoration of the Kishon River and the consequential development of the HaKishon Park, it has become possible for the urban and suburban population of Haifa to experience CES and associated values in this location. The restoration has brought clear benefits for the ecosystem and for people. Pollution has been reduced, habitats have been created, biological life has returned and the Kishon is no longer a main contributor of pollution to the Mediterranean Sea (UNEP, 2019; UNEP/MAP, 2001). In addition to the important social values, which, in terms of relational values, show a high level of benefit to the users, the open areas of the landscape structure are particularly relevant to the users, indicated through the cluster "landscape aesthetics". This is also reflected in the free text fields of the interviews, in which the open, accessible landscape is mentioned.

Concerning restoration management, two main observations of our study can provide information for restoration management: first, the open landscape seems to be one key feature of CES flow. Secondly, the temporal use of the area, which is not evenly distributed over the year and week, but mainly takes place in spring and autumn and on weekends and holidays has potential for use restrictions with limited societal impacts. Use restrictions can be applied spatially or temporally to allow the greatest possible protection for developing natural areas and the least restrictions on human use. In areas where a high or frequent user density is not desirable, e.g. because sensitive habitats for certain species need to develop, a management approach involving the planting of a denser or higher vegetation structure could help to prevent the attractiveness of vistas to protect the areas from user access. This might be important as earlier research has shown that restoration activities have the potential to increase visitation rates, as a result of increased water quality for CES purpose (Sinclair et al., 2018).

In this context, the Kishon river restoration site is highly suitable to demonstrate to society the positive effects of restoration on biodiversity and ecosystem function (e.g. return of biological life in the river and the Mediterranean Sea). Since people here, experience the co-benefit of restoration for themselves, CES can act as a key driver for green

stewardship and pro-environmental behaviour (Andersson et al., 2014), thus underpinning social legitimacy of such cost-intense projects (Angradi et al., 2018; Daniel et al., 2012). The potential for environmental stewardship is further enhanced when looking at the proportion of relational values and instrumental values from the perspective of place attachment (Verbrugge et al., 2019). Fifty-eight percent of the posts use place as part of one's self-expression and therefore identity compared to 42% of the posts that show how place supports the performance of certain activities.

Yet, the need for flanking educational actions is apparent, informing visitors about the ecological success of the restoration of the Kishon, as well as basic infrastructure for waste disposal or sanitary facilities, e.g. to avoid littering and maintain the flow of CES.

4.5. Constraints and opportunities of the approach

There is general criticism of the use of content from social networks as to the numbers of users of social media, the imbalance of age class and gender between social media users and the total population. This criticism, however, does not fully apply to our study area. Roughly around the time of the field work and data collection for this study in March 2019, a Pew Research Center survey ranked Israel as the world's leader in social media use (77% of adult population) (Pew Research Center, 2019). At the time, Instagram was used by an estimated 49% of the total population (Statista, 2020). During our field work, 32.1% of the population accessed Instagram at a monthly or higher frequency with similar number among different age classes (NapoleonCat, 2020). Furthermore, social media users can be seen as an additional information group (Chen et al., 2018; Langemeyer et al., 2018) that is often not represented in organized visits for local residents to the restoration projects that are announced in the regional press, where the social perception of river restorations are addressed. In addition, the willingness to share one's emotional attachment to a place may be low in traditional surveys (Brandenburg and Carroll, 1995; Verbrugge et al., 2019). We acknowledge the fact that socio-demographic information about social media users is lacking in our dataset, which prevents for formally testing the extent to which our sample of users is representative of the general or local population. This is a well-known limitation of social media data. Such issue may limit the usefulness of the results for policy implementation. However, the observations made above regarding the use of Instagram in Israel, age distribution of users, and social media users as information group, suggest that there is still value that can be gained for policy insights from our analysis.

The presented approach of automated image analysis and subsequent cluster analysis has major benefits compared to manual label assignment. The method is objective in the assignment of labels, nonetheless, when manually checking the dataset, we also found incorrect labels assigned to the photos, what we mention earlier for the assignment of rowing and angling. This shortcoming has been addressed earlier (e.g. Lee et al., 2019). Yet we need to emphasise that misclassification occurred only very sporadically, which could be due to the comparatively small data set. The automated method is also more time efficient during data handling, mainly depending on the performance of the processor. These features offer the possibility to test the approach repeatedly and for restorations in different regions of the world what we currently prepare at the catchment scale with a data set comprising control and impact sites. As Daniel et al. (2012) have shown, the differences in landscape aesthetics between groups were different for cultural landscapes, but not for natural and near-natural landscapes. One important point is that human-nature experiences are highly individual and subjective and can only be captured in approximate terms from the outside. With current methods, these relationships can only be captured to a limited extent. The degree to which these individual feelings can be quantified with social media data and user responses should remain subject to further research. Here, we present an approach of how such data might be evaluated and might help derive quantifiable responses of humans. To what level such experiences like "selfies in nature" can be reliably linked to meaningful cultural experiences and thus ES requires further studies involving also scientist for social sciences.

Participants in the survey expressed the opinion that an overpopulated park reduces their positive experiences in the park but this could not be confirmed through the photo analysis, due to the temporal resolution of the photos, where even more photos were present at the weekends and because of the positivity bias norm in relation to the content of social media posts (Bayer et al. 2020), which means that people tend to upload content with more positive than negative connotations. This type of limitation has also been previously addressed (Angradi et al., 2018). The photo analysis was here not suitable for identifying a threshold when people perceive the park as too crowded. A subsequent sentiment analysis of the text associated with the tags or titles of the photos might help to address this question, also to gain additional information on the motivation of the photo (Ghermandi et al., 2020a,b). However, in our data set there were four different languages present in user captions and tags (Hebrew, English, Russian, Turkish and unexpectedly no Arabic), which would have made a sentiment analysis complex and its benefits not commensurate with the relatively small size of the dataset of tagged photographs (about a quarter of the full dataset).

Further research should focus on several aspects which remain challenging. The rare CES related activities, which are not specific enough to end up in a separate cluster, should be identifiable. Detailed information about CES related activities and associated values are valuable sources for planners. It should be tested whether reducing cluster sizes would have a positive effect on the content of the individual clusters in terms of uniqueness, and how appropriate the distinctions would remain (Lee et al., 2019). Another aspect touches indicators and nomenclature of CES and associated values identified with the clustering method, as there is always a certain amount of subjectivity present, which is a general challenge in CES research (La Rosa et al., 2016).

5. Conclusion

Our study demonstrates that visitors of secondary habitats created by river restoration experience diverse CES and associated values. We reach this result with a cost-effective technique that does not entail time and resource-consuming surveys or manual label assignment.

Our results were contextualised and the added value of relational values has been demonstrated. We, therefore, conclude that in future developments and planning of restoration, the added value for society should be taken into account regarding the choice of location, access to the site and expansions of existing sites, also to ensure that the values associated with the area can be perceived even in times of higher demand.

With a management design that includes spatial and temporal access restrictions to protect the recovering biodiversity, to manage visitor flows, the co-benefits for nature and society can be preserved without overuse of the sites. Accompanying measures (e.g. information boards) could further increase the value of the restored site and the sensitivity of the population towards environmentally friendly behaviour. However, the measures should also involve specific infrastructure (waste disposal, permanent public toilets) to sustain the opportunity of experiencing the flow of CES for the population.

6. Responsible dealing with user data

For data processing, the user ID data has been made anonymous, so that no conclusions can be drawn about the personal data of the users. Data processing was exclusively carried out with metadata, where no conclusions were drawn about user ID or user behaviour. At no time photos of users were shown, neither at internal nor at scientific presentations. The photos were not stored, as some of them show personal data.

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. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecoser.2021.101317.

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