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Research Article

Investigation of cultural ecosystem services supply in a river landscape: a case study in the Lower Rhine area using social media images

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Abstract

River landscapes have an important function in the landscape in terms of coastal use and the opportunities they provide and they offer different cultural ecosystem services (CES). CES have a significant impact on human welfare in terms of the recreational, aesthetic and spiritual benefits these generate for people. However, the modelling and analysis of these services is more limited versus other ecosystem services due to their intangibility and subjectivity which creates unique challenges. Recently, social media data have provided an opportunity to generate spatial models of CES, offering significant cost and time advantages. Nevertheless, the usefulness of these novel data sources still requires more investigation versus more traditional survey techniques. This study aims to understand the variety of information provided by the images that users upload publicly on a daily basis to social media in a urban/rural setting. Specifically, CES provided by the open and green spaces around the Lower Rhine (Nederrijn) in Wageningen were studied using images uploaded to the social media platform Flickr. A photographic survey was then conducted to compare the utility and accuracy of these new data versus traditional techniques. In doing so, spatial data, ratings and survey evaluations related to the photographs were digitised, classified and integrated with land cover features. The results show that there is a good consistency between the two sources of data and that a wide range of CES measures can

be established using these novel data sources. More work is now needed in developing spatial indicators of CES relevant to local assessments, such as the one carried out in this study.

Focusing on the Lower Rhine region as a case study, we used the Flickr digital platform to address the following three key questions:

(1) What is the spatial distribution of CES?

(2) Do users who post on the Flickr platform fully represent the cultural identity of the community and visitors in the region?

(3) Which land-cover types of the Lower Rhine region are most appreciated for CES and what are the aesthetic preferences of visitors and experts that correspond to this?

Keywords

Cultural Ecosystem Services, Flickr, kernel density, visitor survey, river landscape, Lower Rhine, Wageningen

Introduction

River landscapes are functionally important within the scope of three criteria: climatic, settlements and recreational in cities and their surroundings (Karakoç 2019). In terms of climate, river valleys have different characteristics compared to their surroundings in terms of climatic events, such as sunbathing, temperature, humidity and aspect formation due to their structure. River valleys show different characteristics in terms of daily warming and cooling. River valleys are very suitable areas for settlement as they provide advantages for transportation, as well as ecological and aesthetic features. On the other hand, various environmental problems occur in the valley systems due to misapplications. In terms of settlements, rivers provide natural conditions (such as moisture, soil) for plant life and agricultural production in the land. They are also natural drainage channels for wind and water. Visually, they have more natural formations than other landforms. They provide transportation and infrastructure convenience (Cengiz 2007). River corridors passing through the city provide important contributions to cities with their recreational potential (Sarıçam and Hepcan 2015). In addition, river shores create suitable environments for recreational use due to their natural beauty (such as water, topography, rich plant communities) (Aylward et al. 2005, Cengiz 2007, Raymond 2009, Posthumus et al. 2010, Rodrigues 2015, Wantzen 2016). Amphitheaters, walking paths, bicycle paths, botanical gardens and playgrounds are examples of these environments (Cengiz 2007). The regional recreational quality is linked to landscape aesthetic quality (Chhetri and Arrowsmith 2008), hereby the maintenance and protection of landscape aesthetic quality effects the recreational quality. River landscapes are generally considered as important locations for recreational activities, such as recreational fishing, kayaking, cycling and hiking (Raymond 2009, Posthumus et al. 2010, Sanon et al. 2012). River landscapes are

also home to festivals, religious sanctuaries and rituals (Lokgariwar et al. 2013). According to the Millennium Ecosystem Assessment (MEA 2005), both landscape aesthetic quality and recreation are categories of CES.

Currently, ecosystems are going through drastic changes as climate change and land degradation affect the stability of these living systems and their capacity to contribute to human well-being. River landscapes, in particular, will see large changes in Europe. Determining the benefits provided to humans from nature in a systematic way can help protect and manage ecosystems in a sustainable manner. For this reason, measuring the services generated by ecosystems offer an important way to understand the relationships between people and nature. Ecosystem services are defined as “the contributions of ecosystems to benefits used in economic and other human activity” and can be divided into regulating, provisioning and cultural ecosystem services (UN 2021). These capture the services of nature ranging from flood regulation in a watershed (regulating service), the input into food production (provisioning service) and, finally, the positive contribution to human culture. Cultural ecosystem services that provide aesthetic and spiritual acceptance and satisfaction, as well as recreation and intellectual development have a significant impact on well-being (Van De Berg et al. 2005, Albayrak 2012).

Landscapes are divided into two basic classes: *natural* and *cultural landscapes*. A correct understanding and sustainability of cultural landscapes are possible with a good understanding of the landscape’s benefits and services, namely CES (Gómez-Baggethun et al. 2010, Holland et al. 2011, Casalegno et al. 2013, Bachi et al. 2020). A better understanding is also possible with spatial analysis. In recent years, mapping CES has been a widely used method, especially in conservation and land management plans. In order to understand and manage CES correctly, it is necessary to understand human movements and preferences and at this point, social media data have come to the fore (Raymond et al. 2014, Anthem et al. 2015, Bark et al. 2016, Heikinheimo et al. 2017, Zhang et al. 2020).

Nowadays, social networks and social media have started to be used as a methodological tool. In recent years, new approaches have been developed by associating the use of social media photos with different environmental factors (Oteros-Rozas et al. 2018). Many image-sharing platforms such as Flickr, Twitter, Facebook, Instagram etc. have an important and useful cultural diversity as they include user groups with different characteristics such as age, gender, occupation etc. (Guerrero et al. 2016). The Flickr platform has one of the most useful sources of information. According to Havinga et al. (2021), the location of images and associated metadata, including tags and descriptions, have now been widely employed in ecosystem service research (Wood et al. 2013, Van Zanten 2016, Tenerelli et al. 2016, Richards and Tunçer 2018). Landscape photographs reflect the interaction of physical and anthropogenic features between people and the environment, thus providing a fundamental understanding of the values that landscapes provide to people as a whole (Stephenson 2008).

According to Havinga et al. (2020), people especially use the Flickr photo-sharing platform to show their appreciation for the aesthetic beauty of the landscape (Van Zanten 2016) and

the Flickr platform has been used in many studies to measure the aesthetics of ecosystem services (Tenerelli et al. 2016, Yoshimura and Hiura 2017, Figueroa-Alfaro and Tang 2017). Landscape aesthetic receives considerable attention in the growing literature regarding CES (Dramstad et al. 2006, Marull et al. 2010, Tengberg 2012, Danial 2012, Frank et al. 2013, Andersson et al. 2014). Still, the representative nature of these data is often questioned with Flickr users said to be biased towards older white males (Ghermandi and Sinclair 2019).

At the same time, survey methods are very useful tools to measure CES. There are a number of survey methods available to measure and collect CES data (Anthem et al. 2015, Bark et al. 2016, Willcock et al. 2017). Visitor surveys can collect structured data about the same variables directly from the visitors (Raymond et al. 2014). In the current digital age, survey methods and photo content analysis in social media platforms are being used in many different contexts for understanding CES (Moreno-Llorca 2020). Nevertheless, comparisons between the two are generally rare in an ecosystem service context (Sinclair et al. 2020). Moreover, in riverain landscapes, only a few case study examples exist, although these are particularly valued for their aesthetic and recreational purposes, while being threatened by environmental change (Hale et al. 2019).

The increase in social media platforms that provide data-sharing will contribute to the development of methods for mapping CES and measuring people's aesthetic appreciation. However, users sharing on these platforms may not fully represent the cultural identity of the community in the region. The aim of this study is to interpret the photographs, from people in the Lower Rhine area near Wageningen, the Netherlands by using surveys and collecting social media data to examine the utility of these novel data for CES assessments. Social media photos were used to examine the spatial distribution of CES, their relationship to land cover and to compare to surveyed preferences from in-person interviews.

Material and Method

Study area

In this study, the Lower Rhine River and the boundaries of Wageningen City have been chosen as the study area, which covers 75.16 km^2. Within the scope of cultural landscapes within the boundaries of the area, there are urban settlements of Rhenen, Wageningen, Renktum, Randwijk, Zetten, Opheusden and Kesteren; in addition, there is a Historical Brick Factory, Ironwork Remains Outbuilding Remains as historical and touristic landscapes. The Veer car ferry is still in active use (Fig. 1).

The Lower Rhine River and its surrounding natural areas and the Blauwe Kamer Nature Reserve can be shown as places that highlight the natural landscape of the area. The summer dyke was lowered in 1992 and, as a result, the area is flooded regularly. Willow and wetlands have formed in various places. Over 200 species of birds and 300 plant varieties are found in the area (Utrechtslandschap 2022).

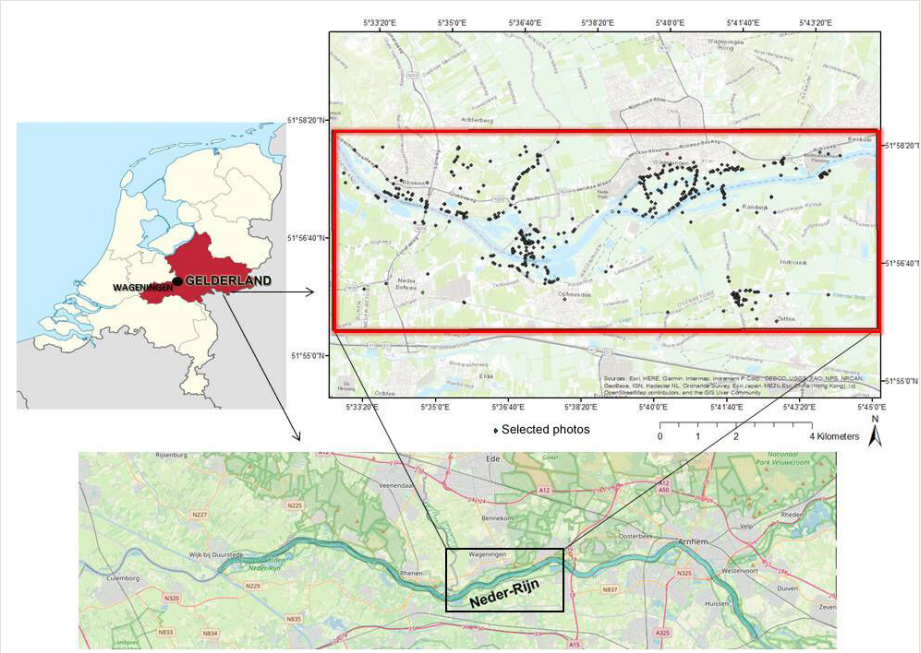

Figure 1.

Location of the study area (Open Street Map 2022).

Method

Within the scope of the study, a 4-stage method was followed in order to measure the cultural contributions of open and green areas of the Lower Rhine region surrounding the city of Wageningen. In the first step, Flickr data were collected and classified into CES categories according to expert judgement. In Step 2, spatial analysis was conducted including kernel density estimation of CES categories and a comparison to CORINE land-cover maps. The CORINE Land Cover classification system is an EU landcover map of five basic classes and 44 subclasses. In this study, CORINE 1st class and 3rd class categories were used. In the 3rd step, photographic surveys were prepared and discussed with people in the area to understand the representation and accuracy of CES classification, based on Flickr. In the 4th and last step of the study, spatial distribution analysis was conducted, with the relationships between photographs and land cover discussed in line with the results of the survey. Fig. 2 shows overarching framework of the method with all of the individual methods are integrated.

Data download

In the first step of the study, geo-tagged images within the study area were downloaded from the Flickr website using its Application Programming Interface (API). The API interface was accessed through the statistics-based software R 4.0.3. with the *photosearcher* R

package. Using the packages, metadata of the images were downloaded, including latitude, longitude, number of views, number of likes and urls to the images hosted on the platform. Images that were incorrectly positioned, without geotags, close-ups of people, plants or animals, as well as brands and logos or images of poor quality were excluded from the evaluation. The photos downloaded via the Flickr website were then classified according to their CES value, based on the expert judgement of one of the authorship team. The classification was selected and based on the categories proposed by the MEA 2005, Albayrak 2012, Clemente et al. 2019, Retka 2019 and eight different CES categories were determined (Table 1) .

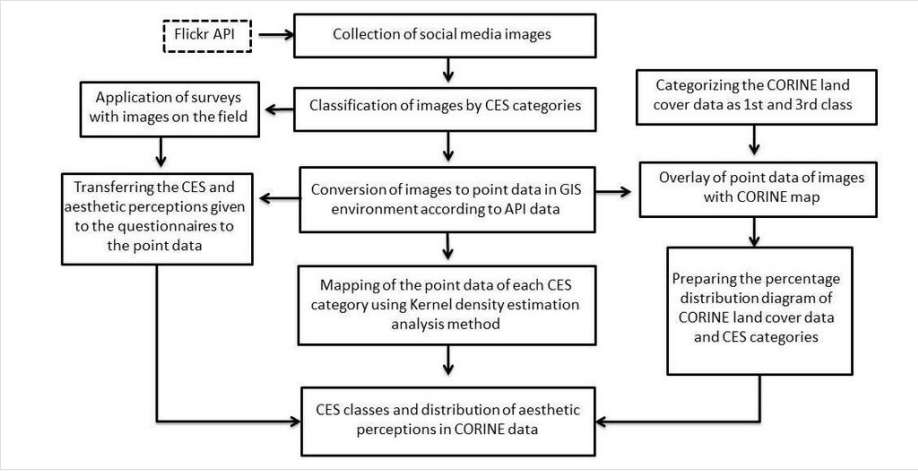

Figure 2.

Flowchart of method.

Table 1.

Categories of CES.

Categories of Cultural Ecosystem Services	Examples
Landscape Appreciation	Wide large view of landscape pictures.
Historical	Historical infrastructure (buildings, ruins, bridges etc.).
Artistic and Cultural Expressions	Pictures represent people in artistic activities, cultural activities or products.
Natural Structures	Specific and well-defined landscape structure (waterfall, lake, cave etc.).
Religious, Spiritual or Ceremonial Activities and Monuments	Church, rituals etc.
Research and Education Activities	Education activities or equipment.
Recreation	Groups of people, doing sports with specific equipment (bike, skate etc.).
Others	Not fitting other categories.

Spatial analysis

The photos downloaded and selected with their geographic coordinates were converted into point data using ArcMap 10.3 software. Kernel density statistics were used in the analysis of the most concentrated points of CES in the area and their distribution. The Kernel density estimation model, which is frequently applied through GIS, consists of a series of classical algorithms that perform pattern analysis. This method is comprised of searching and exploring general functions and common types of connections in datasets. The estimation model shows the density of points falling within a defined diameter area and the density that changes with the distance from the source of the points (Schlkopf et al. 2002). The kernel density estimation model was used in order to determine where the spots of each flickr photo, selected within the scope of this research, are concentrated and where their potential distributions can be concentrated spatially (Suppl. material 1).

In the spatial analysis, CES distributions were examined using the GIS Kernel Density Estimation method and the place of CES distributions and aesthetic perceptions in CORINE land-cover classes were determined. The Kernel Density Estimation method is used for spatial analysis on ecosystems (O'Brien et al. 2012, Gülçin 2020, Abbas Awad and Ali Abed 2021, Science 2022). The Kernel Density Estimation method was used to determine where CES are concentrated and where their potential distributions can be concentrated spatially (Härdle et al. 2012). Following this,comparisons were made with the CORINE land-cover data andCORINE 2018 land-cover classes were downloaded from the PDOK (2021), the Dutch national high-quality geographic data platform. CORINE land-cover data are used to interpret point data correctly by associating it with the spatial condition. As a result, it was determined which CES category focusing on which land-cover class came to the fore (Suppl. material 2).

Survey

In the 3rd stage of the study, the local people and visitors were asked to add five randomly selected photos to the most appropriate CES category, based on the photos downloaded and selected via the Flickr website. A total of 250 photographs were randomly shown to 50 people and they were asked to put the photographs in the most appropriate CES category and to rate them (1-10 scores) in terms of their aesthetic appeal.

Comparisons between data sources

At this point, the preferences of both the experts, people surveyed in the area and the online users of Flickr were compared to understand the accuracy of the Flickr data. Therefore, the relationships between the CES measures identified using Flickr and the spatial analysis were statistically analysed using SPSS 15.0, R-3.6.3 and ArcGIS 10.3 software. It was determined by which land-cover type the photographs showing the prominent CES in the area were categorised.

Results

Data set

A total of 10,090 Flickr images in the study area were downloaded for the period January 2010 to January 2021. Amongst the photographs obtained from the field via the Flickr platform, 659 geographically-tagged photographs were evaluated as suitable. Fig. 1 shows the spatial location of the selected photos considered in the dataset. Each photo's geographical coordinates allowed us to produce, using ArcMap 10.3 software, maps of the CES distribution. This density analysis highlighted a number of hotspots for CES. These high density areas represented up to CES in one place. The northernmost area of the region seems to provide more areas where different CES are valued simultaneously. Almost all spots with higher CES diversity are located between Wageningen city centre and the Lower Rhine.

Spatial distribution

The kernel density functions show whether the existing data are clustered or whether the data are scattered or random. Fig. 3 also shows the heat spots of the photos using the kernel density method, highlighting the areas with the highest and lowest photo densities in the region. If the CES categories are separated, different hotspots are visible (Fig. 4).

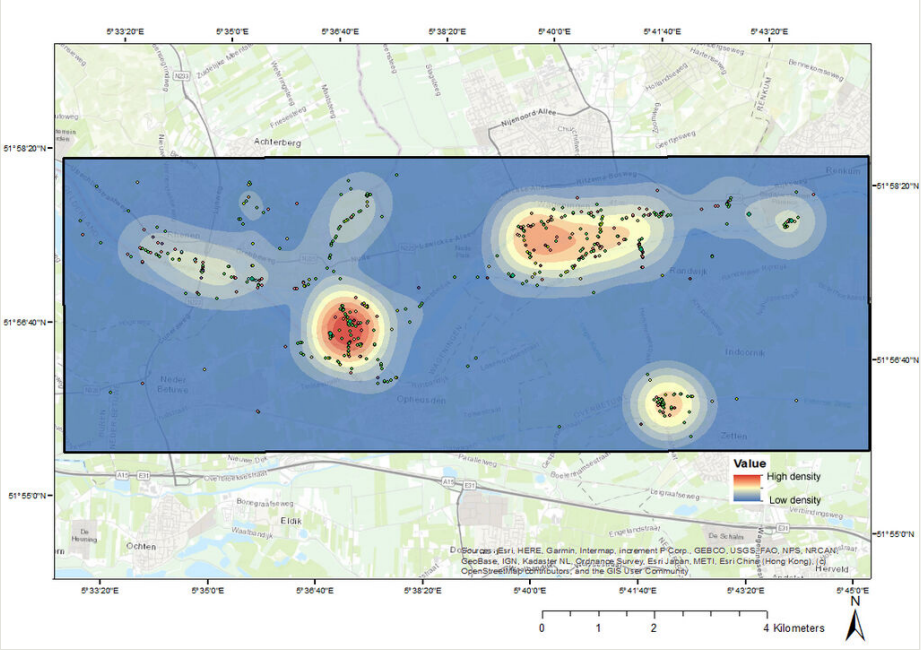

Figure 3.

Location of selected Flickr photos considered in the dataset (n = 659) with a kernel density function highlighting concentrations of CES.

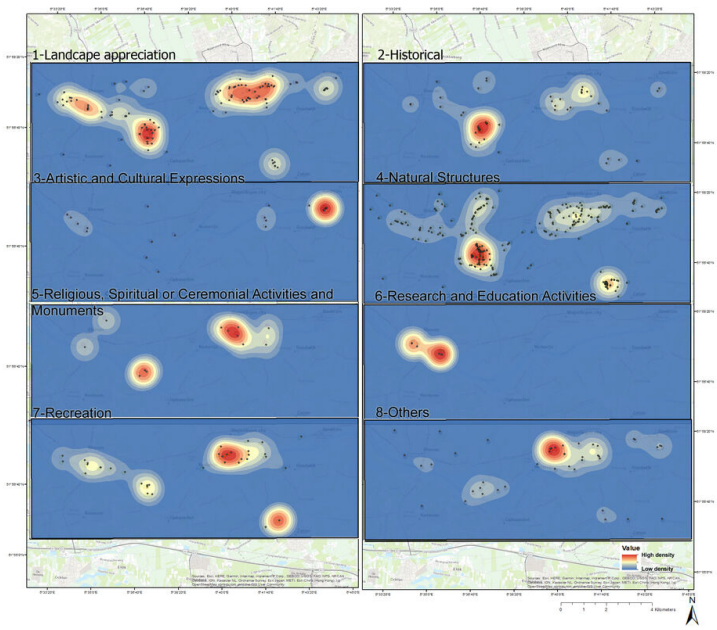

Figure 4.

CES categories and their distribution in the research area (kernel density).

CES categories 1 (Landscape Appreciation) and 4 (Natural Structures) are densely clustered (high density) in the port area of the Wageningen District, which is close to the city centre. The lowest aggregation (low density) in CES categories 1 (Landscape Appreciation), 3 (Artistic and Cultural Interactions) and 4 (Natural Structures) was observed in Renktum, in the city centre and around the paper mill, on the Utrecht/Gelderland border and in agricultural areas. Cluster formation in other regions shows average values. In all categories, natural structures stand out. Sample photos are presented in Fig. 5. In terms of CES categories on the area, the highest density was observed in the category 1 (Landscape Appreciation) and 4 (Natural Structures).

According to the CORINE 2018 land-cover map comparison, it can be observed that pastures, meadows and other permanent grasslands under agricultural use and natural grassland categories have the highest density of CES-related Flickr images. At a more detailed level of land-cover, it is observed that the forest and semi-natural areas and agricultural areas are the most common land-cover type in each CES category (Fig. 6).

Survey analysis

Within the scope of the survey, five randomly selected photos from 659 photos were shown to the local people and visitors and the photos were presented in accordance with the classification selected for this study. Participants were asked to select a separate category for each of the five photographs. In addition, the participants were also asked about the

aesthetic ratings of the areas where the photographs were shown and how long they stayed in these areas.

Figure 5.

Sample photos representing different CES categories from the research area (1- Recreation, 2-Historical, 3-Research and education, 4-Landscape Appreciation, 5- Artistic and cultural expressions, 6-Religious, spiritual or ceremonial activities and monuments, 7-Natural Structures, 8-Others).

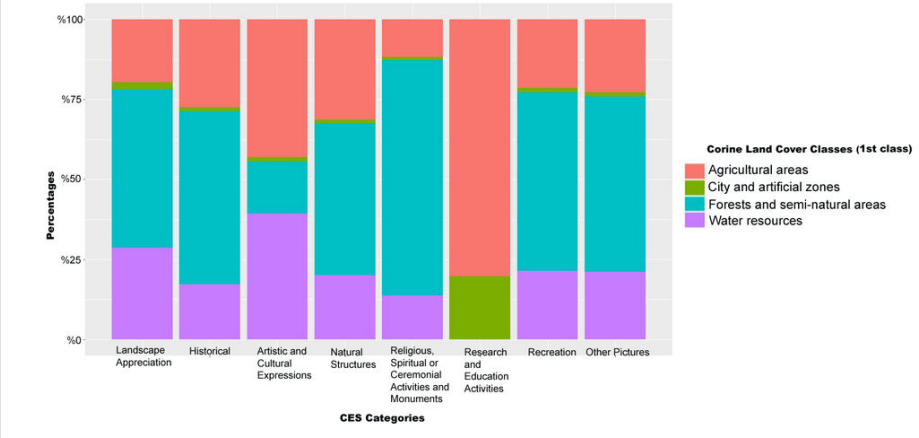

Figure 6.

Distribution diagram of CES categories and CORINE land-cover classes with percentages

According to the survey results, the highest evaluation areas according to participants' results were amongst the Natural grassland land-cover types and the least important areas

were the Industrial or commercial units and public facilities land-cover types. In terms of CES categories, it was determined that the most preferred photographs were in the Natural Structures category and the least preference was made in the Research and Education category. Within the scope of the study, CES classifications, aesthetic perceptions and their distribution on CORINE land-cover classes were examined between the answers given by the participants and experts. ggplot and geom_density packages in R-4.0.3 software were used in plotting the data.

Within the scope of the study, CORINE land-cover classes were handled according to the five basic classes in the 1st category (City and artificial zones, Agricultural areas, Forests and semi-natural areas, Water resources) and their distribution was examined (Fig. 7). When the evaluations were made for each CES category, the highest aesthetic perceptions made by the participants and experts in Agricultural Areas, which are one of the five basic classes and were given to the CES classes in the categories of Historical, Natural Structures and other pictures. The lowest and least-liked photographs were observed in the categories of Artistic and cultural expressions, Natural Structures and Other pictures.

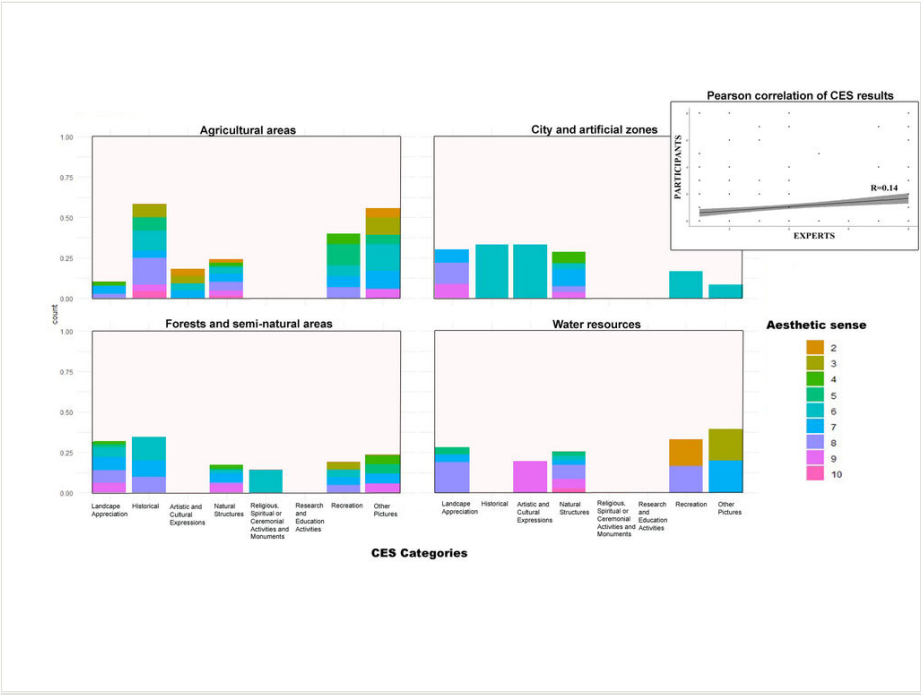

Figure 7.

CES classifications, aesthetic perceptions and their distribution on CORINE land-cover classes.

In the city and artificial zones of the CORINE category, the most liked and highest rated photographs by the participants and experts judgements were included in the CES

categories of Landscape Appreciation and Natural Structures. The lowest counts were in the Natural Structures category.

When Forests and semi-natural areas of the CORINE category are examined, the photographs with the highest count were in the categories of Landscape Appreciation, Natural Structures and Other pictures. The lowest count was given in the Recreation category.

Considering the Water Resources of the CORINE category evaluations, in the CES categories, the photographs in the Artistic and cultural expressions and Natural Structures, received the highest aesthetic count. The lowest aesthetic count was found in the Recreation category.

The CES selections of experts show a positive correlation (*Pearson's r* = 0.14, $p < 0.001$) with survey participants' selections. However, the aesthetic perceptions of the participants with the experts on the photographs show a great deal of similarity with each other. It was determined that the experts and participants gave high scores, especially in the CES categories of Landscape Appreciation, Natural Structures and Recreation.

Discussion

River landscapes are important for biodiversity and ecosystem services (Tockner and Stanford 2002, Russi 2013, Tomscha et al. 2017) and offer diverse CES (Thiele et al. 2020).It can contribute to the landscape planning in terms of the features offered by the river landscapes (Thiele et al. 2020) and, in recent years, it is known that social media data have accelerated the planning of CES. Although social media data have some limitations, social media data provide a useful tool for quickly quantifying CES at regional scales (Hale et al. 2019).

Within the scope of this study, solutions were sought for three different research questions. The spatial distribution of CES in the area was primarily questioned. CES categories 1 and 4, which are concentrated in waterfront recreational areas close to the city centre, are closely related to the cultural structure and visitor profile of the region. In the photographic surveys conducted in the field, it was observed that the audience who visited the region consisted mostly of university younger people and nature-loving pensioners.

In their study, Şişman et al. (2019) stated that the frequency of participation in recreational activities increased in natural areas close to the city (Karaşah 2017) and the majority of urban people visited urban green areas at least once a year (Song et al. 2015, De Valck et al. 2016). Şişman et al. (2019) stated that participants between the ages of 18 and 24 prefer to spend time in natural areas. Demirci Orel and Yavuz (2003) and Talay et al. (2010) also found in Karaşah (2017) studies that, as the age of the users increases, their preferences to spend more time in natural areas than in cities also increase. It is quite difficult to access all the details of the user profiles of the owners of the photos downloaded from the Flickr platform, but when examined in general, it is determined that the profiles belong to young people intensively and a small number of retired, but nature aficionados

have Flickr profiles. The reason for this is that this age group either does not know the Flickr platform or does not prefer to use such internet environments actively. It can be stated that this research largely reflects Flickr users, local people and visitors.

What memory is for individuals is also culture for society (Triandis 1994). The useful products of culture constitute the cultural values and identity of society (MEA 2005). When the social media photos were examined, it was observed that the visitors of the area took photographs of the points reflecting their cultural and artistic identity (such as church, artistic activity), as well as the natural landscape of the area. It is clearly seen that Flickr photographs reflect information about the cultural identity of the area, as well as providing tourist information to visitors about a field of interest.

In this study, when the social media images and the results of the experts in terms of CES were examined, it was observed that the highest score was collected in the images belonging to the 'Natural Structures' category. It is possible to say that the dominant natural landscape features of the research area as a river landscape and the fact that it has a recreational function to a large extent supports this scoring. The visual diversity of the research area also strengthened the aesthetic feature of the area. When the results of the aesthetic preferences of visitors and experts covering the land cover and aesthetic values research question are examined, the most prominent areas in all CES categories and aesthetic evaluations were Natural areas. In terms of history, education, culture and spirituality, it is observed that Agricultural areas are important as well as Natural areas. The highest CES potential appears to be concentrated around the Lower Rhine River and the Nature Reserve.

According to Keeler et al. (2015) people have been observed to travel further for high-quality ecosystems (e.g. lakes with cleaner water). The fact that the research area is located very close to the city centre is an advantage for users to access the area. The land-cover classes of pasture, broad-leaved forest and water courses received high offered CES scores (Thiele et al. 2020). In this context, forest areas and water courses, which are considered in the CES category of ‘Natural Structures’, have received high aesthetic scores in the research area. In the kernel density map, it has been estimated that there are various reasons for the distribution of people around a single focal point in their spatial preferences. This research did not focus on access or accessibility to CES values in the region. However, one of the reasons why the potential distribution is concentrated around the Lower Rhine and shows a homogeneous distribution is the adequate transportation network in the study area.

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Author contributions

Author Contributions Statements

B.Tülek conceived of the presented idea.

B. Tülek developed the theory and performed the computations.

B. Tülek verified the analytical methods.

B. Tülek performed the field works.

B. Tülek wrote the paper.

B. Tülek contributed to the final version of the manuscript.

B. Tülek discussed the results and commented on the manuscript.

Conflicts of interest

The author whose name is listed in this article certifies that she/he has NO affiliations with or involvement in any organisation or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaux; membership, employment, consultancies, stock ownership or other equity interest; and expert testimony or patent-licensing arrangements) or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Supplementary materials

Suppl. material 1: Appendix 1 doi

Authors: Tulek, B.
Data type: Explanation and formula
Brief description: Kernel density estimation method.
Download file (54.97 kb)

Suppl. material 2: Appendix 2 doi

Authors: Tulek, B.
Data type: Map
Brief description: CORINE land-cover map and classes.
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