Mapping tranquil landscapes with social media data. A case study in the context of sustainable transformation

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Key words: Flickr, Landscape, Social media data, Spatial transformation, Tranquillity mapping

SUMMARY

Landscapes promote health and have a therapeutic effect on people. These effects can stem from multiple factors, including the tranquillity that a landscape exudes. In this respect, it is reasonable to nuture such effects and to preserve landscapes that provide an atmosphere of tranquillity. For this purpose, however, it is necessary to identify and locate such places.

Collecting on-the-ground data across large areas is costly and time-consuming. We therefore use data from the photo-sharing platform Flickr to examine where people experience tranquillity in two rural areas in Germany. The study shows that social media data can provide a complement to spatial data from official bodies, since they indicate accessible places where tranquillity is consumed. However, they neither disclose the most tranquil places in an area, nor do they lead to complete spatial coverage.

We discuss the method against the background of renewable energies' expansion in the Pfälzerwald region. The discussion shows that the method needs to be improved significantly before it can provide reliable results that can be drawn for use in spatial planning. Nevertheless, we believe that the idea of utilising data from social media to make hidden recreational uses visible is worth bringing into practice at an early stage. In this way, we want to raise awareness of the benefits that geospatial information can provide in shaping pathways to regional sustainability.

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1. INTRODUCTION

Landscapes offer many values for the individual and for society. Among others, they can have a therapeutic effect supporting the mental and physical well-being of social groups such as the elderly (Milligan et al. 2004, cf. Rathmann 2021). If this value is utilized for tourism, for example, it can provide an economic stimulus for regional development (cf. Conradson 2017, Pedoo 2017). Furthermore, health-oriented tourism can be designed in a way that is ecologically compatible (Grell 1994). In this respect, landscape and its health-promoting effect can support all three pillars of sustainability (social, economic and environmental) and thus play a noteworthy role in the sustainable transformation of a region. Against this background, it has been argued that more attention should be paid to the therapeutic effect of landscapes in governance and policy (Bernat 2019: 93).

This effect can be based, among other things, on the tranquillity landscapes offer (Kaplan 2001, Velarde et al. 2007). In Germany, this leads to demands for instruments that support the protection of places of tranquillity and go beyond the legally regulated noise control (e.g. BUND 2013). If tranquil places are to be protected or developed, one must know where they are located. Tranquillity is to a large extent a subjective variable that depends strongly on individual perception (Brehme et al. 2018: 111). Information about places of tranquillity therefore mostly is collected *it situ* through direct surveys, such as interviews (cf. Jackson 2008). However, such an approach is cost-prohibitive when investigating large areas.

The objective of this paper is to provide an estimate of the potential for mapping tranquillity with low-cost measures. For this, we use metadata of geolocated photographs from the social media platform Flickr to investigate where tranquillity is experienced. Social media is increasingly utilized for different aspects of landscape research (e.g. Purves 2011; Van Zanten et al. 2016; Langemeyer et al. 2018; Havinga et al. 2021; Stemmer et al. 2021). Especially in the United Kingdom, they have been applied for identifying and mapping tranquil places. The methodology we employ is inspired by Wartmann et al. (2019) and Wartmann & Mackaness (2020), who examined tranquil landscapes in Scotland. We adopted it for two rural regions in Germany, Pfälzerwald and Nagelfluhkette.

In the following, the methodology is explained and the findings of the study are presented. Key challenges that arise from applying this methodology are subsequently discussed. The approach is reflected in the context of renewable energies expansion and serves as an example of the positive impact that geospatial data innovations can have in supporting sustainable regional transformation. In our use case, these benefits arise from the need for relevant

information on tranquillity consumption in order to address recreational needs appropriately in spatial planning and in the siting of wind farms.

2. METHODOLOGY

On Flickr, users share photographs and add metadata such as tags and coordinates that describe these photos. Downloading data from an online platform where all persons registered are allowed to post their photographs enables the efficient harvesting of data from multiple users. We downloaded data over a period starting from January 2004 until June 2021 through a Python script for the Flickr API, the platform's programming interface. Only geotagged photos that were within a bounding box that encompasses each study region were considered. We cleaned the dataset by deleting larger amounts of uploads from one user at the same coordinate. The bounding boxes were then divided into a grid with a cell size of 1x1 km. This size was chosen to reflect a larger landscape unit and not just the location where the photograph was taken.

To select a dataset containing geolocated photographs with tags related to tranquillity, we employed key word filtering. Only photographs that were tagged with at least one term from a list of key words were chosen. We compiled this list using key words published in Wartmann & Mackaness (2020: 671).

The list includes *tranquil/tranquillity* and terms like *calm/calmness*, *peaceful*, *serene* and *silence*, which are semantically close to tranquillity (cf. Hewlett et al., 2017; Chesnokova et al., 2019). Additional key words were added that survey respondents in Scotland felt were related to tranquillity (Wartmann & Mackaness 2020: 671). The list was complemented by German synonyms of the English key words. Since the characteristics of the studied landscapes in Germany and Scotland differ and landscape imageries are culturally distinctive (cf. Hu 2020; Kangler et al. 2021; Walsh 2021:45), we made further refinements. After checking our data for further notions related to the concept of tranquillity, we added terms such as *himmlisch* (*heavenly*) and words that we believe may be associated with tranquillity like *Gipfel* (*summit*) or *Gemse* (*chamois*). In our opinion, these words also indicate tranquillity, as they refer to the remoteness of the place where the photograph was taken. We included the activity *Wandern* (*hiking*) because we assume that it is an outdoor activity that people do seeking tranquillity in the study areas (cf. Marafa 2018). Furthermore, we removed expressions from the Scottish key words list that are obviously of lesser importance in our study area, such as *loch* or *tide*. Based on this groundwork, a list of 167 key words (84 German and 83 English) evolved.

Through visual comparison, we checked that photos with relevant key words but in a different context were not included. For example, the term meadow was associated several times with photographs showing football matches. In addition, we eliminated landscape elements from the Scottish survey whose German equivalents occur within place names, since these were often used without being primarily related to tranquillity (e.g. to indicate the location of the

holiday or accommodation). This applies, among others, to *Wald* (*forest*), *Berg* (*mountain*) or *Bach* (*creek*), which are present in place names like Pfälzerwald, Bregenzerwald, Fischbach or Mittelberg. If such landscape elements were not used in a direct association with a place name, we continued to employ them as key words.

Locations where Flickr data with listed key words occur more often than all Flickr tags served as a proxy for places where people feel tranquillity. Yet, it is not sufficient to create a density map of locations tagged with relevant terms. "This merely creates a map that mirrors those places most frequently visited and photographed" (Wartmann & Mackaness 2020: 665). For that reason, we applied chi-expectation as a correction method (Hollenstein & Purves 2010; Wartmann & Mackaness 2020: 670). The chi (x)-expectation represents how unexpected an observed distribution (obs) of images is – in this study these were photographs with tranquillity-related tags – compared to all photographs of a sample (the expected distribution, exp).

$$\boldsymbol{x} = \frac{(\boldsymbol{obs} - \mathbf{exp})}{\sqrt{\mathbf{exp}}}$$

Processing and cleaning the Flickr data resulted in an class with 3384 point objects (representing the photo sites) for the Nagelfluhkette and one with 1820 objects for the Pfälzerwald. From these two object classes we calculated the chi-expectation surface in both study areas. For data processing and the visualisation of our results, we used the geographic information system QGIS. The visualisation served as a starting point for comparing the results with the Quietness Suitability Index (QSI, European Environment Agency 2014; see Nugent 2016) and for interpreting them.

The QSI offers information on the highest (QSI=1) and lowest (QSI=0) proportion of potentially quiet areas in Europe. The QSI builds on the assumption that anthropogenic noise has a direct distracting effect on quietness and that population density and land cover indirectly affect the way noise is perceived. The index indicates areas that are potentially quiet by linking existing noise models with land use data. "For various anthropogenic sources, the QSI combines different noise surfaces on the assumption that sound decays over distance" (Wartmann & Mackaness 2020: 663f.). In Germany, the QSI was largely developed using quantitative methods. These were supplemented in rural areas by local knowledge (EEA 2014: 17).

3. STUDY AREA

The study was carried out in two rural areas characterised by distinct landscape types.

The Nagelfluhkette is a mountain range in Bavaria (Germany) and Vorarlberg (Austria), bordering the northern edge of the Allgäu Alps. Its name derives from the rock type Nagelfluh. The nature park Nagelfluhkette covers a total of about 410 square kilometres of

which 247 square kilometres are located in Germany. It has a difference in altitude of 1400 metres in a relative small area. The highest summit in the nature park, which was established in 2008 (Bavaria) and 2014 (Austria), is the 1,832-metre-high Hochgrat. The city of Kempten (~50 000 inhabitants) to the north and the Eastern Lake Constance region with Bregenz (~ 30 000 people) and Dornbirn (~ 50 000 inhabitants) are less than 30 kilometres away. The city of Sonthofen (~ 21 000 inhabitants) is bordering the nature park to the east and is located within the bounding box that forms our study area. This area covers the German part of the Nagelfluhkette in the west and crosses the border with Austria over a stretch of about 30 kilometres.

The low mountain landscape of the Pfälzerwald (engl. Palatinate Forest) is the largest contiguous forest area in Germany. The highest mountain, Kalmit, rises 673 metres above sea level. The Pfälzerwald forms a substantial part (approx. 59 %) of the UNESCO biosphere reserve Pfälzerwald-Nordvogesen in Germany and France, which covers a total of 3105 square kilometres. UNESCO acknowledged the cross-border biosphere reserve in 1998 (cf. Germer 2018: 153). Pfälzerwald is located in the federal state of Rhineland-Palatinate and is surrounded by densely populated areas. Major cities such as Ludwigshafen (~ 170 000 inhabitants), Mannheim and Karlsruhe (both slightly over 300 000 inhabitants) are between 25 to 50 kilometres away. In the northwest, the district and the city of Kaiserslautern (~ 100 000 inhabitants each) border on the area. The inner parts of Pfälzerwald have been designated as so-called Stillezonen (tranquillity zones) through an ordinance (BRPfälzerwaldV RP 2020). In these zones, commercial facilities and unnecessary noise (e.g. due to events) are, with few exceptions, not permitted (Germer 2018: 154). The availability of official zones representing low-noise areas makes this region particularly interesting for the evaluation of our method.

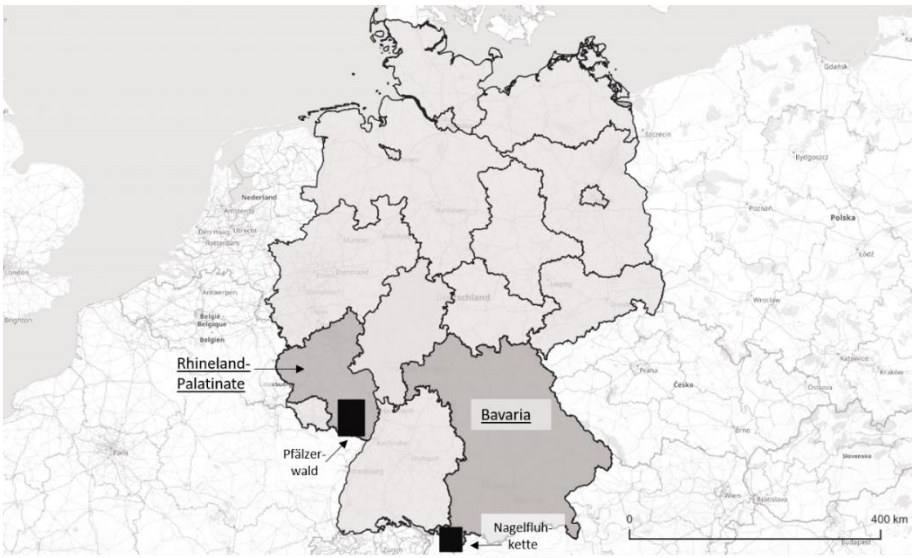

Figure 1 The location of the two study areas, Pfälzerwald and Nagelfluhkette, in Germany.

4. RESULTS

Tranquil places in the Nagelfluhkette

In the Nagelfluhkette, the results show a characteristic spatial pattern with places of lower tranquillity in the valleys, while areas of above-average tranquillity dominate in the mountains. The narrow valleys form important traffic arteries and are traversed by roads. Road traffic in Alpine valleys in general and in those of the Nagelfluhkette in particular are well-known and socially controversial sources of noise pollution (cf. BUND BY 2004; Lechner et al. 2020). This correlation is confirmed by a comparison with the QSI. Valleys are both hotspots of places with little tranquillity according to our calculations and of relatively high noise values according to QSI (figure 2). This correlation becomes particularly pronounced along Bundesstraße (federal highway) 308 and 19, which are important road links in the northern and eastern part of the study area.

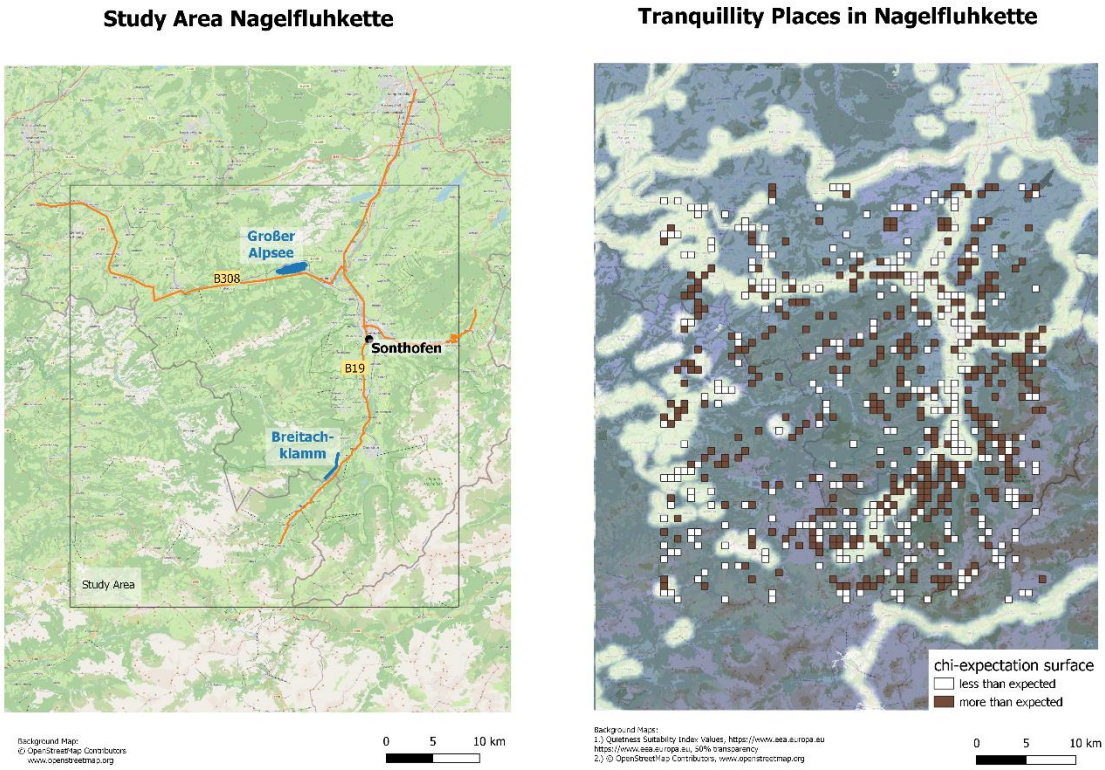

Figure 2 Nagelfluhkette: overview map (left); chi-expectation and QSI (right).

The map on the left provides an overview of the study area, indicating locations referred to in this paper. The one on the right shows the chi-expectation surface based on Flickr data. Less or more than expected chi indicates places that are more or less tranquil than average. The QSI and a topographic base map complement the chi-expectation layer. This compilation of spatial datasets from three different sources makes the above-mentioned relation between

topography on the one hand and perceived tranquillity (respectively measured silence) on the other hand visually apparent.

The map additionally reveals that our method detects tranquil places even in areas with high noise pollution (according to QSI). This applies, for example, to the Lake Großer Alpsee and the surroundings of Sonthofen in the north of our study area, although federal highway 308 runs in the immediate vicinity. This observation confirms previous findings (Wartmann & Mackaness 2020: 673) showing that Flickr data allows the identification of tranquil places in populated areas such as cities. Among the areas that have a particularly high number of tranquillity-tags are sites that are very popular with tourists, such as the Breitachklamm gorge. In these parts, places with above-average tranquillity are even found near Bundesstraße 19 (figure 5).

Table 1: Description of the layers displayed in figure 2 (map on the right).

chi-expectation layer	The white cells in the respective layer represent 1x1-kilometre-cells of below-average tranquillity, while brown cells indicate above-average tranquillity. In order to reduce the complexity, we have omitted the representation of the grids with an expected chi.
noise map layer (QSI)	The dark bluish areas indicate a low noise level according to the QSI, while bright areas reveal a high noise level. Areas with the highest proportions of potentially quiet areas have a QSI of up to 1, while the lowest ones tend towards 0. We set this layer to 50% transparent in order to display the map information of all three layers jointly.
base map layer (OSM)	The topographic map in the background displays streets, cities and other topographic elements. In this way, the visual connection between above-average tranquil places and topographical elements becomes concrete. For this purpose, we applied the OpenStreetMap (OSM).
The other figures in this paper use the same data and layers, but with modifications. Some maps display only one or two of the layers. Sometimes transparency is applied. Figures 3 and 4 additionally show Stillezonen (silence zones). In figures 4 and 6, the base map is coloured for clarity. In figures 5 and 6, we used a base map from the German Federal Mapping Agency (BKG).	

Tranquil places in the Pfälzerwald

In Pfälzerwald a high density of images with tags related to tranquillity are found in the periphery. Such areas are comparatively close to the surrounding cities, making the periphery accessible for many people. A correlation between good accessibility and places where people experience tranquillity has already been established by Wartmann (et al. 2019: 7). A low density of tranquillity places is found in the innermost areas of the Pfälzerwald, although these areas are obviously quiet according to the Stillezonen, the QSI and our own local experience (figure 3).

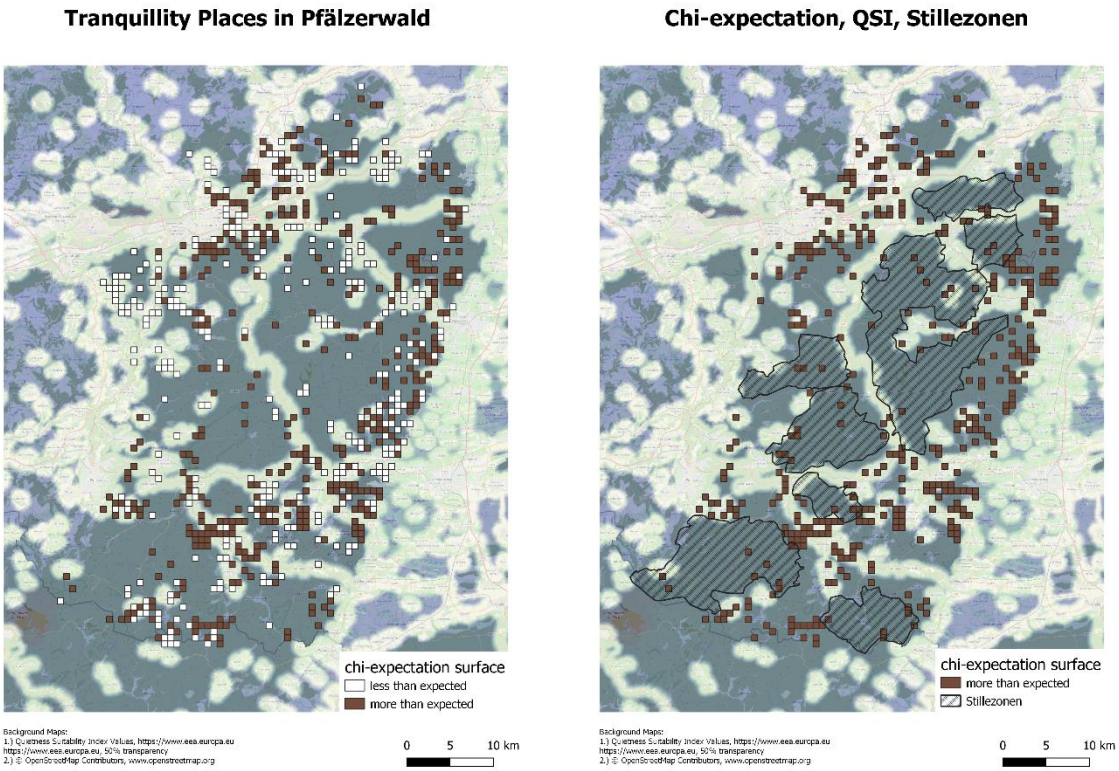

Figure 3 Pfälzerwald: chi-expectation, QSI and, added on the right, Stillezonen.

This spatial spread has to be understood in the light that on Flickr comparatively few photographs (with and without a key word from our list) are posted in remote, less accessible areas (cf. Wartmann & Mackaness 2020). Figure 4 indicates that the majority of the photos were taken at the periphery of our area. This illustration displays all the grid cells where photos were taken - both with and without key words for tranquillity.

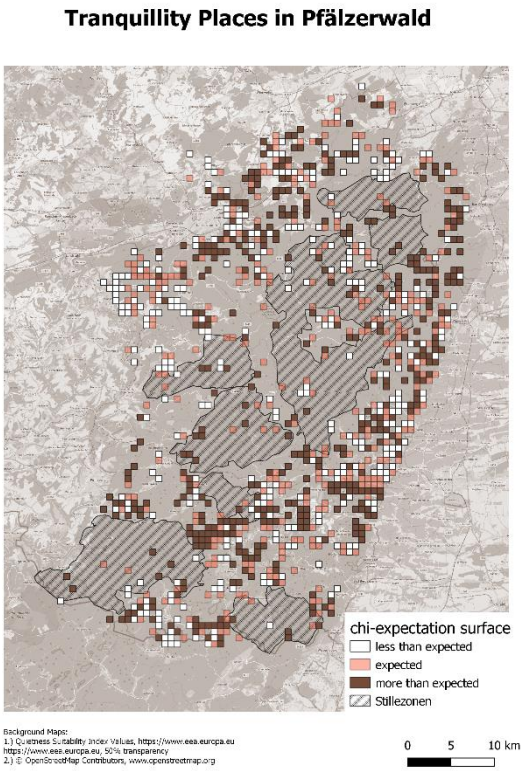

Figure 4 Grid cells where photos were taken.

5. MAPPING TRANQUIL PLACES WITH USER GENERATED CONTENT. ACHIEVEMENTS AND CHALLENGES

Achievements of the method

The places where we found an unexpected high number of photographs suggesting tranquillity are not among the most remote or tranquil sites of our study areas. Rather, they are tranquil places that are easily accessible to the public. This explains the high density of tags, which are located not too far from densely populated areas or in vincity of roads that bring people from these places to environments that are more bucolic. This correlation is found in both German study areas and has been proven in Scotland as well by Wartmann et al. (2019: 7) and Wartmann & Mackaness (2020: 677).

Like Wartman et al. (2019: 8), we therefore come to the conclusion that Flickr content can show where people consume tranquillity. This is in contrast to maps, such as the Stillezonen in Pfälzerwald, that display places where one can undoubtedly expect silence (Wartmann et

al. 2019: 8). This difference is particularly evident in the Pfälzerwald, in whose inner area, away from the surrounding cities, relatively few photographs have been taken.

Unresolved Challenges

We encountered a number of challenges when empolying Flickr data for tranquillity research. A fundamental set of challenges stems from the fact that our findings highly dependend on the choice of terms. By matching with the key words in our list, we ignore places that people perceive as tranquil but whose photographs have not been tagged with any of the listed headwords.

Additionally, it is likely that the number of tranquil places we found was distorted by the fact that we did not consider to a greater extent the spatial or semantic context in which these photographs were taken. This, for instance, becomes visible in figure 5, where a grid cell was classified as tranquil based on a single photograph tagged as *flowers*. This photograph was the only one taken in an area of one square kilometre covered by the respective grid cell. The map reveals that these flowers, which were captured at the location of the red dot in figure 5, grow in the immediate vicinity of the federal highway 19. The notion of *flower(s)* as a key term goes back to the findings of Wartmann & Mackaness (2020). But while the Scottish interviewees may have had a flowering Highland landscape in mind, our flowers were perhaps only tagged because they were particularly pretty or large or just at hand and the photographer may at the same time have been annoyed by the noise of passing cars. Such ambiguous contextual information is likely to have influenced our results, since we adopted several terms of this kind (e.g. *butterflies*, *birds* or *green*) without evaluating their context and its relevance to tranquillity.

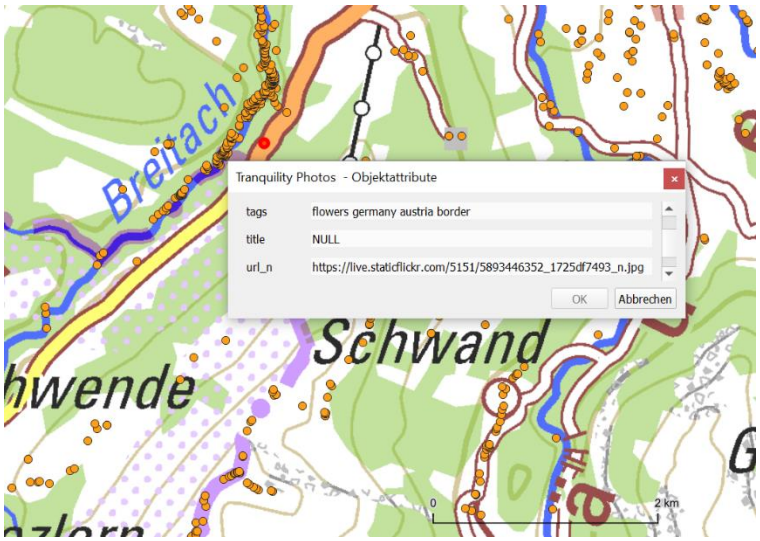

Figure 5 Tranquillity or coincidence? Flowers along a federal highway – an example for context as a key challenge in dealing with ambiguous key words in tranquillity mapping.

Further uncertainties arise from the fact that we included topographic elements such as *mountains* or *hills* in the key word list. We only omitted them if they were part of a place name, e.g. the villages of Ramberg or Rettenberg. Elements of this kind were associated with tranquillity by interviewees in Scotland. However, tagging photographs with the key word *mountains* in the alpine Nagelfluhkette or *hills* in the low mountain range Pfälzerwald is perhaps not primarily the result of tranquil experience. Rather, it is a fundamental aspect of the landscape, possibly chosen to bring the character of the landscape closer to people looking at the photograph.

The key word *hiking* leads to further challenges. Along popular hiking routes (figure 6) we found cases of the same hiker taking several photographs at short distances and tagging them identically. We had initially removed redundant photographs with the same coordinates and tags taken by one user. However, we had not taken this hiking-specific bulk uploads into account, which might have led to an overrepresentation of the perceptions of hikers. Since *hiking* served as indicator of tranquillity, this might even have led to an overrepresentation of tranquil places.

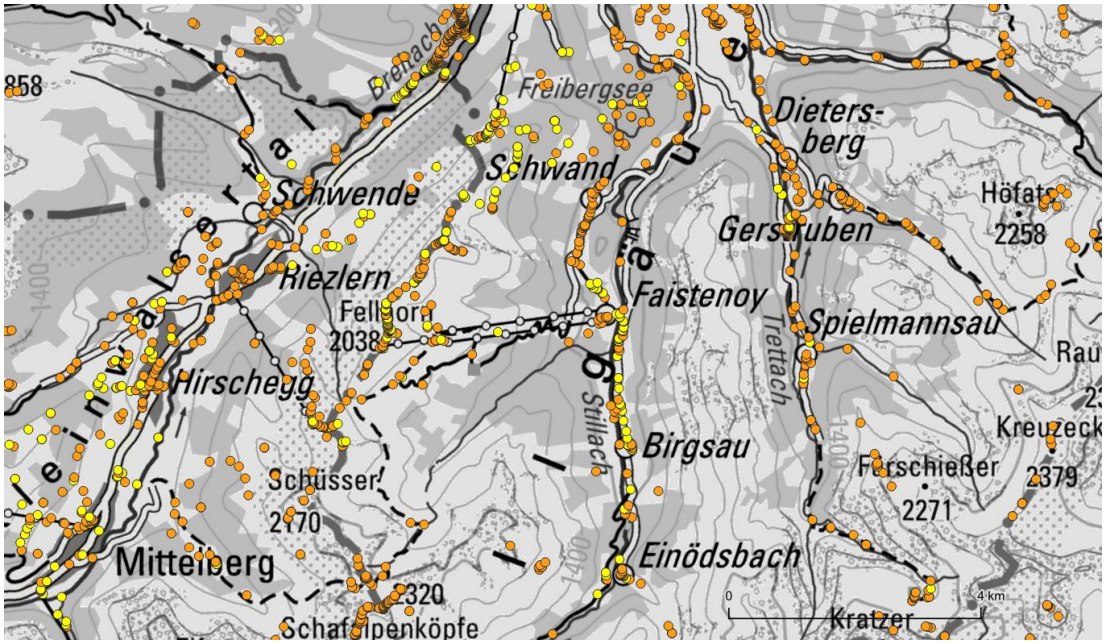

Figure 6 Hiking hotspots in the Nagelfluhkette: Yellow points represent photographs tagged with hiking. Orange points are photographs tagged with any other key word from our list.

Future improvement

Given the problems that result from key words such as *hiking*, it seems sensible to dispense with activities and limit oneself more to key words that are directly linked to the concept of tranquillity. Additionally, it is interesting for our research that Leeb et al. (2020) have recently developed a tranquillity map in Switzerland, which also builds on prior work from the UK (e.g. Jackson 2008). They do not apply social media data. However, since they mainly worked

in the German-speaking part of Switzerland, comparing with this study could further increase transferability of key terms to Germany.

Further ways to improve the method are offered by filtering and evaluating key words according to their spatial or semantic context. For example, tranquillity tags recorded in the immediate vicinity of roads could be selected based on Euclidean distance calculation with GIS software and subjected to further verification. A similar approach could be taken for photographs that have been tagged with relevant key words (e.g. *hiking*), but feature additional tags that do not fit the list of relevant terms (such as *hiking* in combination with *cycling* and *climbing*). In order to operationalise such a (non-) association with the concept of tranquillity, future research could develop weightings to indicate the extent to which an additional term weakens or strengthens the tranquillity impact of a given headword.

By combining such adjustments with different methods, the outcomes can probably be improved even further. For example, not only tags but also image content can be included in the interpretation of tranquil landscapes. Machine learning algorithms, for instance, could be trained on an existing dataset of landscape photographs that users marked as *tranquil* (Wartmann et al. 2019: 8; cf. Egarter et al. 2021).

Geospatial data on tranquillity – a digital response to an urging societal question?

Given the methodological challenges mentioned above, the results of our analyses are to be understood as tentative. Direct assistance as a basis for planning and decision-making cannot yet be derived from them. However, the objectives of our study are not limited to developing a robust methodology that will allow us to map tranquil landscapes. An overarching goal is to bring society closer to the positive stimuli that (geospatial) data innovations can have for transformations towards sustainability (cf. de Albuquerque et al. 2021: 159).

In our case, the current discussion in Germany about the siting of new wind energy facilities provided the impetus for this study. In recent decades, wind farms have significantly changed the appearance of low mountain ranges in Rhineland-Palatinate, such as the Hunsrück. As a biosphere reserve, the Pfälzerwald has so far been excluded from the construction of wind farms. To push energy transition, Rhineland-Palatinate's Prime Minister Dreyer said in early 2021 she would rule out wind turbines in the inner forest area, but not on the periphery of the Pfälzerwald (Lohmann 2021). The current coalition agreement of the Rhineland-Palatinate state government, which is valid from 2021 to 2026, has meanwhile manifested this idea (Koalitionsvertrag RP 2021: 27). It permits wind energy usage in the biosphere reserve's development zones (“Entwicklungszonen”, these are mainly located in the areas periphery), but restricts them to areas along roads, railway lines and on conversion sites. However, it is mainly on Pfälzerwald´s periphery and along its roads where tranquillity is consumed. For these areas no data on tranquillity beyond the QSI are available to date.

Partly because the German National Committee for the UNESCO programme "Man and the Biosphere" has expressed concern on the plans in the coalition agreement, the issue is

currently being discussed in the Palatinate state parliament – polemically to highly emotionally ("Polemisch bis hochemotional") according to the local press (cf. Dauscher 2021). In this heated environment, reliable and transparent spatial planning that can balance public concerns based on the best possible information is of great importance. Since wind farms can have a negative impact on the tranquillity experience (cf. Jackson 2008; Leeb 2020: 3), we believe that tranquillity maps of Pfälzerwald periphery could support spatial planning in balancing interests between energy and recreation demands.

Spatial data are omnipresent in formal and informal spatial planning in Germany (Zaspel-Heisters 2020: 4). This likewise applies to the siting of renewable energy installations (cf. Vetter 2018). Generally, the data used for this purpose originate from official authorities, e.g. the surveying offices of Germany´s federal states. However, these bodies do not offer data on perceived tranquillity. Developing new official data products, such as maps on tranquillity consumption, is likely to be costly and comparatively time-consuming. In the political and dynamic context referred to above, it is essential to avoid situations where the development of an information product takes longer than the decision-making process it could serve. This conflict between the demand for information and the ability to provide it is resolvable through data or information products based on social media, which are cheaper and faster to deploy. Working with user-generated content, however, requires that its potential, but also its limitations, are openly discussed with end-users such as planners, decision-makers and the public – even at an early stage. Since transition approaches thrive in "contexts that make actors reflect, rethink and reshape their thoughts and actions" (Loorbach et al. 2017: 615), it is advisable for scientists working on data innovations not to persevere in laboratory environments, but to actively engage in socially relevant debates (cf. Schaffert et al. 2021). These scientists have to face questions and criticism and use them to refine their product. Such criticism, for instance, could relate to the quality, reliability and representativeness of user-generated content (cf. Kim et al. 2012; Depietri 2021: 3). Proposing a method that allows tranquil places to be mapped, but which – as in our case – still needs to be optimised, will also provoke impatience in those who expect an immediate solution to the problem under discussion. However, in our opinion, this step into practice is necessary if social media-based data innovations are to take hold in spatial planning and in the siting of renewable energies.

What is more, social media offers the promising opportunity "to hear the voices of distinctive social groups, even those who do not formally participate in planning processes" (Lin and Geertman 2019: 69; cf. Stemmer et al. 2021). This is of particular interest in our case, as in the run-up to decisions for or against wind farms, the voices of the proponents and opponents are particularly loud. Moreover, these voices express opinions that are sometimes irreconcilable and hardened. Between black and white positions, however, there are likely to be numerous opinions held by people that do not participate in formal planning procedures. Due to their absence, their voices are likely to go unheard. Social media can help in filling this gap. A benefit in this context is that the landscape users who express themselves via social media probably do not form a homogeneous group that is pro or contra the expansion of renewable energies. Rather, it is likely that both supporters as well as opponents and the undecided parts of the population use photo-sharing platforms and the like – even if we know

nothing about their proportions. In this context, it is worth noting that social media data can provide an archive of landscape perceptions that has not been influenced by later developments. Similar to the digital flood memories mentioned in de Albuquerque et al. (2021: 159) such digital landscape memories could “empower hitherto invisible social groups to voice their personal and collective emotive connections to social and environmental phenomena, which could create a powerful pathway to change.” Since we chose a study period that began long before the current debates on wind energy usage in the Pfälzerwald, our data can reveal people’s emotive connection undistorted by later debates. Decision-makers, scientists and others could draw on these memories, not least as they allow an assessment of whether tranquil areas have diminished or shifted after wind farms have been built.

There is also a hope that by displaying tranquil places and potential wind farms together on maps, geospatial data or information could serve as a bridge (cf. Levin-Keitel et al. 2018: 8) to clarify the views of different groups and help find common solutions between energy and recreational demands. The relevance of maps and other geospatial information for cooperative planning and regional development has been demonstrated on several occasions (Kahila-Tani et al. 2019; Schaffert et al. 2020). In the tense atmosphere surrounding energy transition, however, cooperative working is a particular challenge. A prerequisite is to allow impartiality and tolerance towards other opinions, even if they are opposing the prevalent political agenda and the proposal of planners (cf. Avila 2018: 613; cf. Engels et al. 2019: 7). Working with geospatial information can at least help to develop a common understanding and minimise the differences between groups caused by terminology and language.

Finally yet importantly, the spatial representation of previously less prominent recreational uses, such as tranquillity, might enhance confidence in the work of the authorities. Direct engagement methods, such as participatory mapping, could invite locals to add their own tranquil places on maps that had been developed jointly from official (e.g. QSI or Stillezonen) and social media data. This would “yield more holistic insights” (Komossa et al. 2020: 8) and help in creating an atmosphere of mutual respect (cf. Schaffert et al. 2020). Participants in informal mapping workshops on wind energy siting could also share their story on recreational uses other than tranquillity. This would contribute to overcome the general lack of attention paid to recreational demands in the expansion of renewable energies in Germany, as criticized by Grebe (2019: 84).

The arguments above point to a crucial prerequisite when it comes to making good use of geospatial data and information in the context of energy system transformation: Innovations and the increased availability of data will not "automatically lead to improved decision-making and propel transformations to more sustainable futures”. Rather, they “must be presented in adequate formats for stakeholders and embedded into social decision-making processes with clear pathway to enable transformation” (de Albuquerque et al. 2021: 154). If data scientists and providers want to offer data products that accurately support pathways to transformation, they will need to develop a better understanding of these pathways and/or enhance their ability to work across disciplines.

6. Conclusion

Our study confirms findings of previous research stating that Flickr data neither reveals the most tranquil places in a landscape, nor do they result in a complete spatial coverage. Instead, the key advantage of social media data and analytics is their power to complement official data in locating tranquil landscapes by pointing to accessible places where people consume tranquillity.

A map of tranquil places can only be as accurate as the key words used for electing them. Against this background, we identified further need to enhance and verify the key words we selected to represent the concept of tranquillity. Also, by not adequately taking into account spatial and semantic contextual information, our quest for tranquil landscapes has been further skewed. However, ways to improve the method are clearly identifiable. An easy to implement first step is the more targeted selection of key words.

Given the limitations of our study, the resulting maps can only serve as a preliminary orientation. Further developments are necessary. However, as the protection and management of perceived tranquil landscapes in spatial planning suffers from the lack of information on such areas, cost-effective and time-efficient mapping is a helpful first step in filling existing knowledge gaps.

Using the example of land consumption by wind farms, we argue that disciplines that deal with the gathering and processing of spatial data should become more visible in socially relevant debates. Providing society with geospatial data and information of reliable quality is an established task of disciplines such as geodesy and geospatial informatics. In today's world, where more and more data is being collected from various sources and made available for scientific and practical applications, these skills are needed all the more. To communicate the potentials of geospatial data innovations to society, scientists need to leave their laboratory environment and disciplinary comfort zone and engage in debates that move people. At the same time, this courage is likely to be rewarded by critical debate, joint learning and the opportunity to utilize transdisciplinary competences for methodological progress.

ACKNOWLEDGEMENT

The article originates from the project *Raumintelligenz für die integrierte Versorgung von Seniorinnen und Senioren in ländlichen Quartieren* (Spatial Intelligence for the Integrated Supply of Senior Citizens in Rural Neighbourhoods), funded by the Carl Zeiss Foundation. In this project, we perform accessibility analyses that take into account the special needs of older people. We believe that tranquil landscapes are eligible as recreational destinations for older adults and hence deserve to be taken into account.

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