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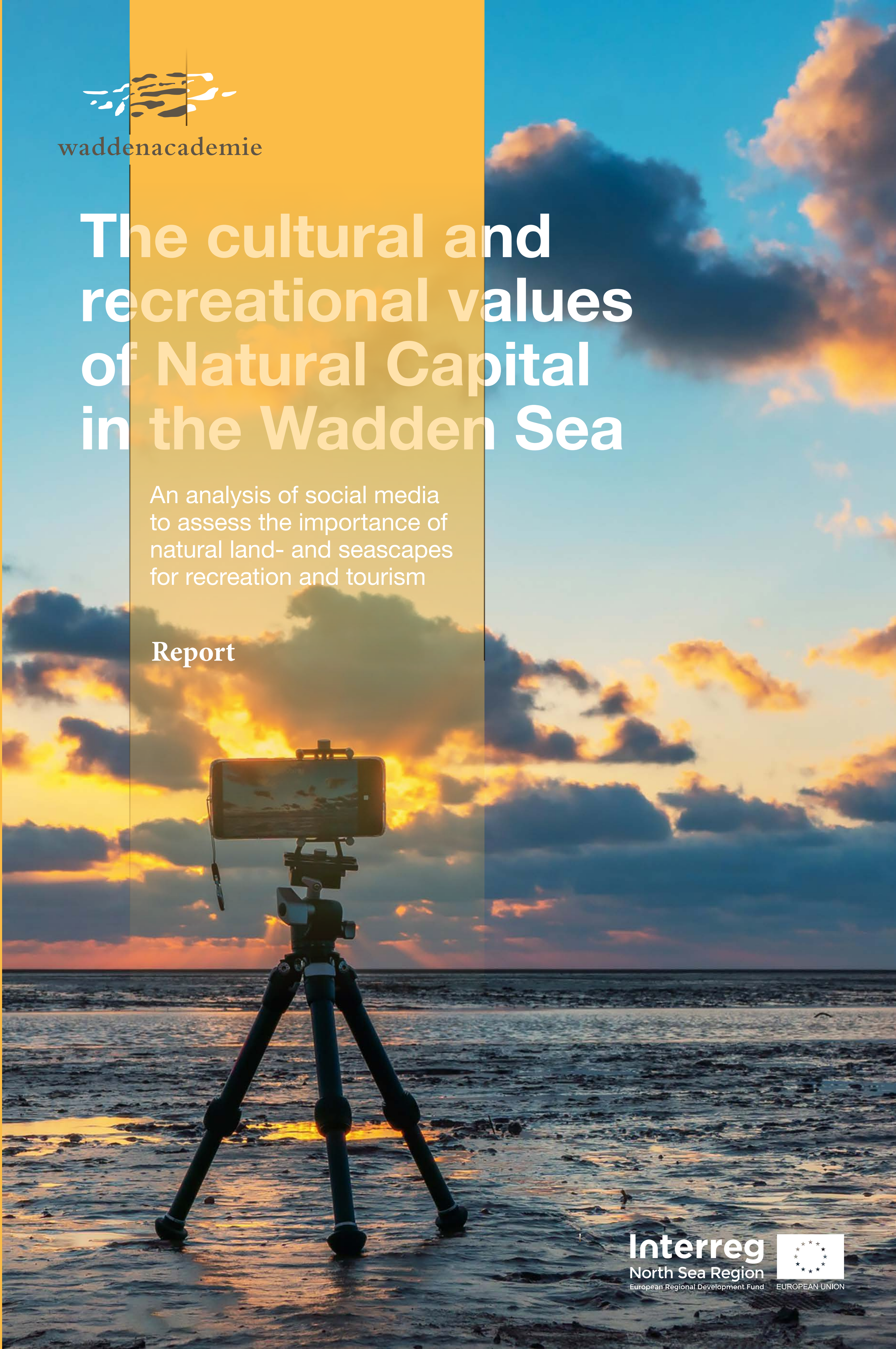
The cultural and recreational values of Natural Capital in the Wadden Sea

An analysis of social media to assess the importance of natural land- and seascapes for recreation and tourism

Report



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The cultural and recreational values of Natural Capital in the Wadden Sea

An analysis of social media to assess the importance of natural land- and seascapes for recreation and tourism

Report

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The Interreg VB project "PROWAD Link: Protect and Prosper: Benefits through linking sustainable growth with nature protection" aims to unlock the potential of natural areas as a driver for jobs and sustainable development in the pilot regions of the Wadden Sea (DK, D, NL), Geiranger Fjord (NO), Wash & North Norfolk Coast (UK). The project is co-funded by and carried out in the framework of the Interreg North Sea Region Programme under the Programme Priority 1 "Thinking Growth". The programme is funded by the European Regional Development Fund (ERDF) of the European Union.

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1 Introduction

Natural landscapes provide a range of cultural benefits to society, including aesthetically pleasing views, spiritual fulfilment, and outdoor recreation (MEA, 2005). These benefits often classified as cultural ecosystem services are hard to quantify due to their intangible and subjective nature. After all, the value assigned to cultural ecosystem services can differ from individual to individual, can change over time and space and is often not recorded in statistics (Bouma and van Beukering, 2015). Given their importance to society, however, it is vital that novel and innovative ways for assessing cultural ecosystem services are developed (Cheng et al., 2019).

Social media platforms, such as Flickr, Instagram and previously Panoramio, have opened up avenues of research that were previously unavailable, by allowing researchers to download large numbers of geo-tagged photos (Clements et al. 2010, Jin et al. 2010). Both the location and content of these photos offer a unique insight into both preferences and behaviour. Where traditional survey methods mainly capture stated preferences (i.e. what people say they intend to do or what they prefer), social media photos provide revealed preferences, as a social media photo can be seen as proof for a combination of actual behaviour and disclosed appreciation (Bubalo, van Zanten, and Verburg 2019). Social media data have proven to offer insights into the cultural ecosystem services generated by natural landscapes, expanding the knowledge basis generated by traditional survey methods (Richards & Tunçer, 2018; Zhang et al., 2020). By taking a picture of an object or situation that people encounter and by uploading the file, Flickr users assign a value to that object or situation and the place where it is located (Van Zanten et al., 2016). In the past years, several authors have demonstrated that with automated image recognition and classification software, large scale analysis of image content can be used to identify motivations for taking and uploading pictures (Tieskens et al., 2017; van Berkel et al., 2018; Oteros-Rozas et al., 2018; Lee et al., 2019).

Geotagged pictures and content analysis of such pictures has offered valuable data to study patterns in landscape preferences (van Berkel et al., 2018; Oteros-Rozas et al., 2018; Lee et al., 2019) and recreational use of the landscape (Gosal et al. 2019; Monkman, Kaiser, and Hyder 2018) and tourism and recreational hotspots (Wood et al., 2013). Most studies analysing patterns in nature-based tourism through social media data focus on a local scale and some focus on a global or continental scale, while studies on cross-boundary landscapes with a multilateral scope are currently still limited (da Mota & Pickering, 2020).

One important cross-boundary landscape in Europe is the Wadden Sea (Enemark, 2016). The Wadden Sea is a large area of tidal mudflats, saltmarshes and other ecosystems that are bordered by a large number of barrier islands. UNESCO recognizes the region as a World Heritage Site because of its unique intertidal characteristics. The region is spread over the northern coast of the Netherlands, the north-western coast of Germany, and part of the western coast of Denmark, making it the largest intertidal system in the world. The Wadden Sea attracts millions of visitors annually, and its natural characteristics form the basis for the livelihoods of tens of thousands of people in the region (Schep et al. 2021). The region has been inhabited by people for several centuries and it is the stage of a continued interaction between the natural landscape and the cultural use and appreciation of this landscape by local communities and society (Egbers, 2019; Döring et al., 2021).

Because of these socioeconomic and ecological interests, there is a need for integrated management of the Wadden Sea area, where the various values and uses of the area are all considered in spatial management decisions (Trilateral Wadden Sea cooperation, 2018). One way to support integrated management will be to spatially analyse the ecosystem services generated by the Wadden Sea (Schep et al., 2021). By mapping ecosystem services over the trilateral area, more informed spatial management decisions can be taken. Doing so identifies areas of high value for ecosystem services and will provide insight in the trade-offs between ecosystem services and other economic activities. Given the trilateral nature of the area, however, there is a lack of unified socio-economic and cultural datasets on the area. One of the aims of this study is to fill that data gap on uniform information on cultural ecosystem services, through the development of a dataset of landscape preferences in the trilateral Wadden Sea based on social media uploads. This dataset is then used to study the distribution of landscape appreciation and recreational use over the study area.

The main goal of this study is to identify spatial predictors for landscape appreciation and recreational use in the trilateral Wadden Sea area, approximated by the density of geo-tagged social media photos. We hypothesise a significant positive effect between the presence of land cover types that are characteristic for the Wadden Sea, such as dunes and intertidal flats, and landscape appreciation as measured by the density of uploaded pictures. Indications for such a relationship were already established in an earlier pilot study on the island of Terschelling (Wolfs Company, 2021). Additionally, we expect that the presence of recreational infrastructure such as biking and hiking routes lead to an increase in landscape appreciation. Finally, we study whether there are differences in spatial predictors for landscape appreciation over time and between local photographers versus domestic and international photographers. Such spatial predictors include land cover type, presence of recreational infrastructure and the presence of cultural landmarks such as churches, castles and lighthouses. In line with previous research (Ghermandi et al. 2020), we expect to find a difference in spatial predictors between photographers from different origins, with local photographers valuing other land cover types and being less influenced by recreational infrastructure.

The data generated by this study contains a lot of information that could not be adequately represented in this brief technical report. A selection of these results will be shared through an ArcGIS Storymap that allow the results to be shared online in a format that is easy to use for policy-makers, spatial planners and others interested in the data. Storymaps can be used to develop and share maps that focus on specific types of photo content, focus on specific regions, as well as a myriad of other options. Congruently, textual and visual components can be presented in conjunction with the maps to develop desired narratives and to share these with designated target audiences. The Storymap that is associated with this study can be accessed **here**.

This report is structured as follows. Chapter 2 describes the methods used in this study, including elaborations in the study area, data, spatial predictors and statistical modelling. The results are presented in Chapter 3, describing general patterns as well as the effect of uploader origin. Additionally, this section provides an interpretation and discussion of the results, addressing the land-cover effects and recreational infrastructure on landscape appreciation. Chapter 4 draws conclusions and elaborates on the implications for the management of cultural ecosystem services in the trilateral Wadden Sea.

2 Methods

2.1 Study area

For the purposes of this study, we chose a study area based on the boundaries of the Wadden Sea World Heritage site but also including coastal areas. These coastal areas included all Wadden islands, as well as areas up to five kilometres inland on the mainland adjoining the World Heritage site (Figure 1). This was done to incorporate the coastal nature that is characteristic of the Wadden Sea. The study area also includes the Ems, Weser and Elbe estuaries. In total it covers an area of 17,478 square kilometres along the coastline of the three Wadden countries, of which Germany harbours 9,917 square km, The Netherlands 4,788 square km, and Denmark 1,542 square km.

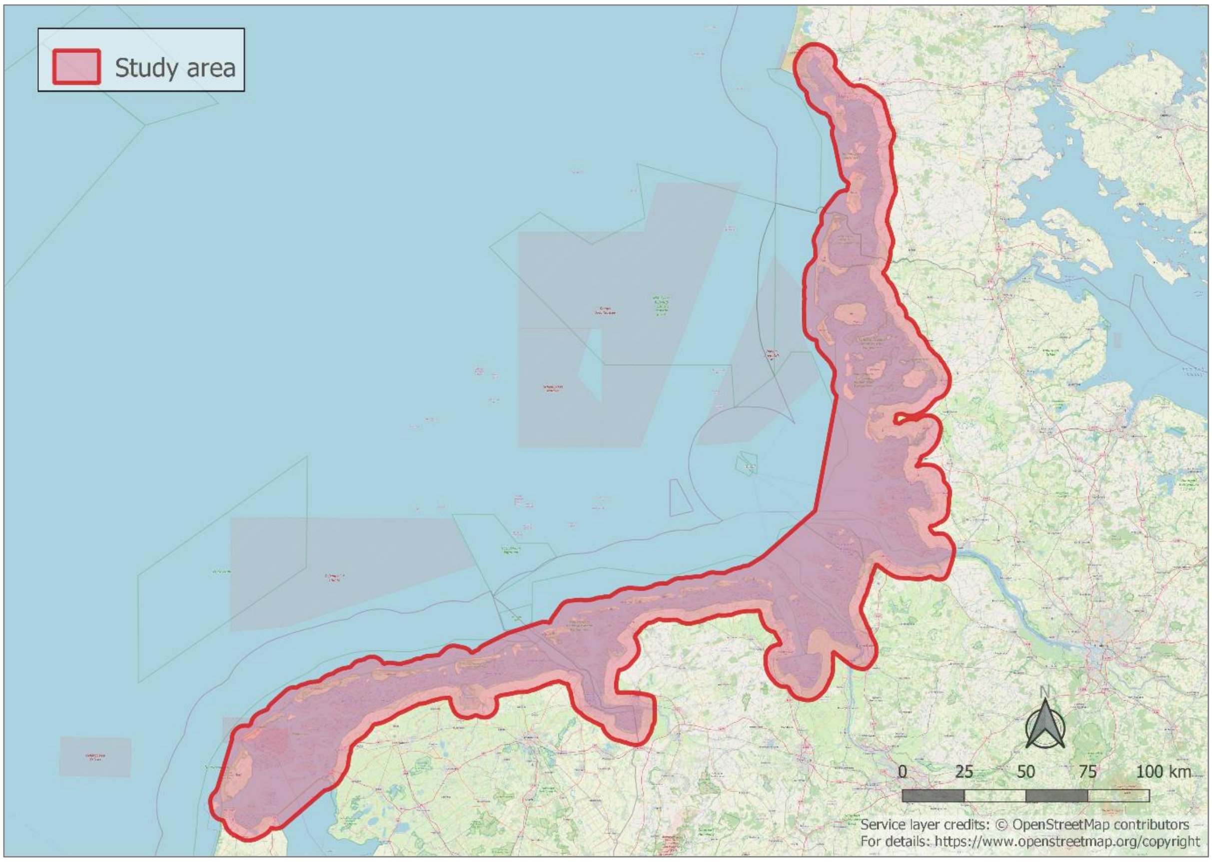


Figure 1 Extent of study area covering the trilateral Wadden Sea region.

2.2 Data

To study landscape appreciation as a cultural ecosystem service requires measuring something that is by definition intangible and can vary between people, societies and over time and space. For the purposes of this study we make a primary assumption that the number of Flickr photographs forms a suitable proxy for landscape appreciation (Tieskens et al., 2018). Flickr was used as it allows for the extraction of publicly available images, whereas platforms such as Instagram and Facebook do not provide this option. Images from the Flickr platform were downloaded using their public application programming interface (API) which allows for the download of images with their associated metadata. We applied the exact same method to download Flickr photo data through Python as explained in Tieskens et al., (2018). Associated metadata includes a range of information such as geolocation where the picture was taken, a unique ID of the uploader, and the time and date on which the photograph was taken (Tieskens et al., 2018). We downloaded all photographs taken in the study area from 2004, when the Flickr platform became available, up to and including 2019. Figure 2 details the distribution of distribution and density of nature photographs taken over the trilateral Wadden Sea region.

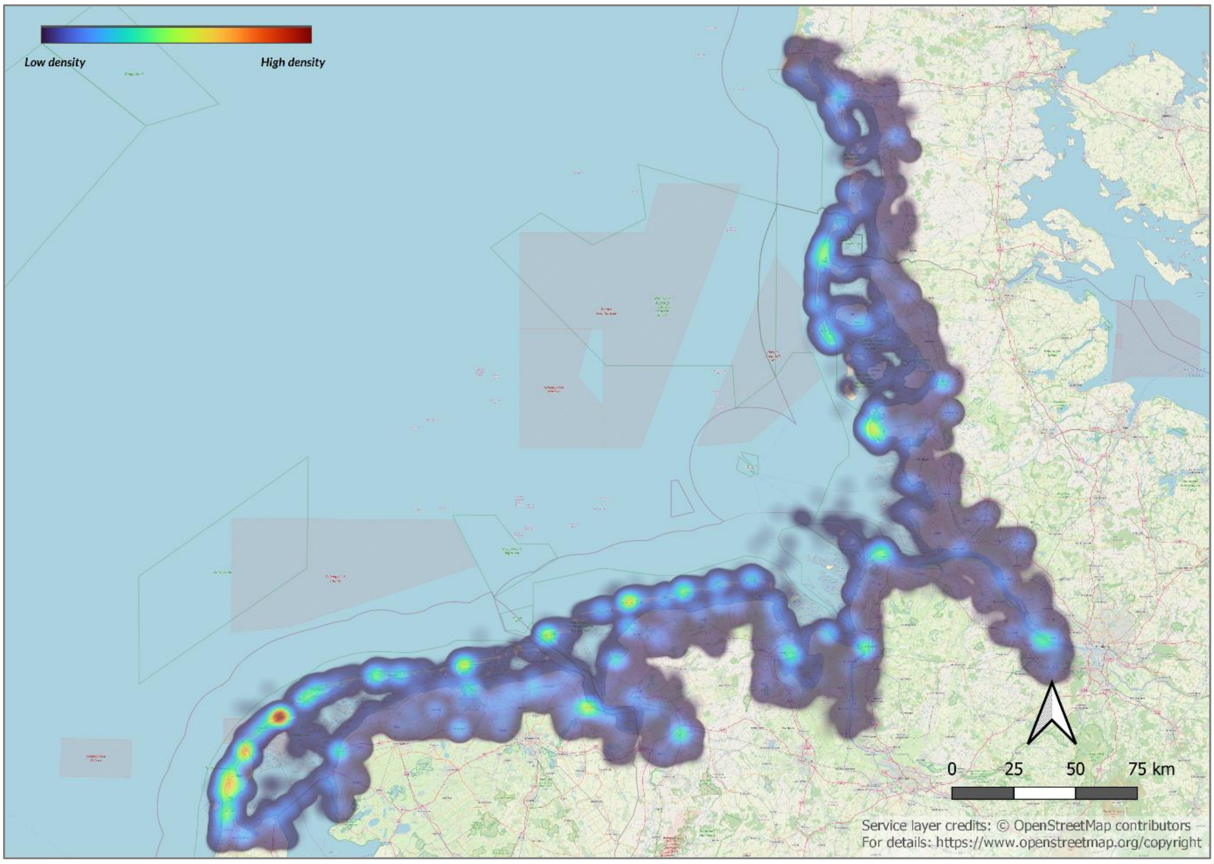


Figure 2 Heatmap highlighting the distribution and density of nature photographs taken over the trilateral Wadden Sea region between 2004 and 2019.

The accuracy of the geo-tags of pictures uploaded to Flickr was found to be anywhere between 0 and 167 meters, where photographs taken at less popular locations have less accurate geo-locations (Hauff, 2013). As we analysed Flickr photo density at a 1km resolution, the effect of inaccurate geo-locations was assumed to be negligible. As predictors for landscape appreciation are by definition different between land and sea we filtered our grid cells to only include geo-locations on land. Furthermore, we only analysed cells that included roads (based on Open Street Map data), as pictures are unlikely to be taken in areas that are inaccessible and these increased the number of zero counts in the data (Tieskens et al., 2018). After filtering grid cells, we analysed a total of 10,187 grid cells of 1 km^2.

To only consider nature-related photos in the analysis, we used the Google Vision API to perform a content analysis of all photographs extracted from Flickr for the study area. This automated object detection algorithm, developed by Google, was trained on millions of pre-labelled photos and assigned labels to each photo describing their content which were then classified manually as being nature-related when at least two labels were considered associated with nature (see Annex 1 for a detailed description of the content analysis). Only photographs that met this threshold were considered in the analysis which added up to a total of 11,924 nature photographs taken in the selected grid cells between 2004 and 2019.

Next, we made subdivisions of nature photographs based on the origin of the uploader.. The majority of unique photo uploaders (i.e. distinct users of Flickr), note that multipe photographs by the) in the trilateral Wadden Sea region reside in one of the three Wadden countries, as can be seen in **Error! Reference source not found.**. Note that multiple photographs by the same unique photo uploader could be considered in the analysis, as long as they were taken at least one kilometer apart or were taken on different days. Thus, the number of unique photo uploaders is lower than the total number of photographs considered. We determined the home location of each user through a user provided home location in their public profile. If a profile did not have a recognizable geographic home location we downloaded the 500 most recent photos of that user and determined the home location on by identifying the NUTS3[1] region that contained the most photo user days (days that photos were uploaded in that location per user).

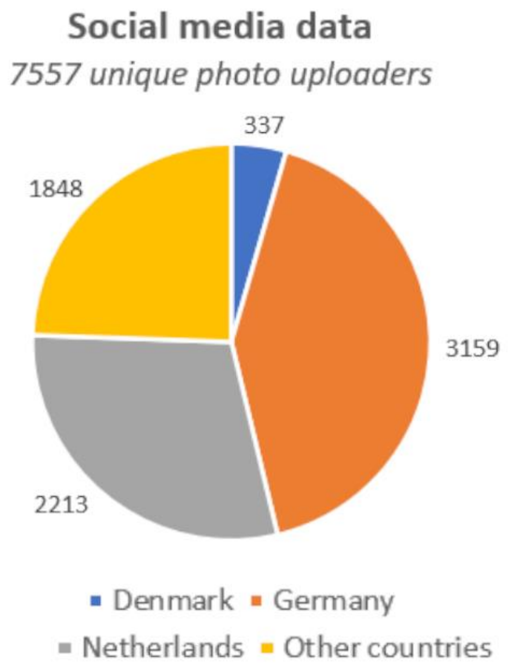


Figure 3 Country of origin of unique photo uploaders in the study area between 2004 and 2019.

[1] NUTS stands for 'Nomenclature of Territorial Units for Statistics' maintained by the European Union. The number indicates a level within this nomenclature corresponding generally to a territorial unit above the municipal level. See https://ec.europa.eu/eurostat/web/nuts/background for more information.

For the analysis, we identified local (photo was uploaded by someone who presumably resides in the same NUTS3 region), domestic (photo was uploaded by someone who presumably resides in the same country as the photo was uploaded) and international (all else) (Chen et al., 2016; Heikinheimo et al., 2017). Using this method, we were able to estimate the home location of users of 11,090 nature photographs (88% of all nature photographs). This amounted to 5,260 nature photographs for locals, 3,788 for domestic visitors and 2,042 for international visitors. Lastly, we analysed the number of photographs per square kilometer in contiguous natural areas, based on the Corine Land Cover classes[2]. With this data we aimed to identify where pressure from Flickr users was highest in the study area.

2.3 Statistical modelling

We used generalised linear modelling to explain the spatial distribution of Flickr photos with the spatial predictors and covariates. Our response variable (i.e. the number of nature photographs taken in a grid cell) consisted of non-negative discrete values. We used a negative binomial model with a log link function to account for the over-dispersed nature of our data. To account for regional unincorporated differences in our data (i.e. regional effects other than our control variables that affect our results) we incorporated a random effect for region in our model. One important regional difference that can be taken out by using this random effect are differences in the popularity of Flickr by country. Additionally, our dataset contained a large number of grid cells with a zero value for the number of nature photographs. A large number of these zero values could be the result of factors such as inaccessibility, with inaccessible islands having zero photographs not because of a lack of interesting landscape elements but only due to their inaccessibility. To objectively decrease the number of zero values and incorporate our random effect we utilized a zero-inflated negative binomial mixed effects model. This model consists of two distinct parts, with the first part predicting where zero values are expected using a logistic regression predicting non-zero values as a function of the presence of roads and accessibility. The second part of the model then functions as a normal general linear mixed effects model, incorporating only those grid cells where the logistic regression predicted a non-zero value. We utilized the 'NBZIMM' package in R to develop our model (Zhang & Yi, 2020).

2.4 Spatial predictors

To identify the effect of landscape types and recreational infrastructure on landscape appreciation by using regression models, we selected spatial predictors minimizing multi-collinearity *(*See Annex 2 for correlation matrix*)*. These predictors consisted of the most relevant land cover classes, recreational infrastructure and cultural landmarks (Table 1). For the land cover classes in the trilateral Wadden Sea area, we used the Corine Land Cover map of 2018 (European Environment Agency, 2021). For the

[2] Under natural land cover classes we classified all land cover types that fall under categories 3 and 4 of the CORINE land cover nomenclature guidelines, available here: https://land.copernicus.eu/user-corner/technical-library/corine-land-cover-nomenclature-guidelines/html/

agriculture land-cover class, we made a further distinction into three types of agriculture and two scale levels. To determine scale level, we utilized a landscape structure index ranging from 0 (large scale agriculture) to 1 (small scale agriculture) developed by Tieskens et al. (2017), cutting off at the median indicator value (0.35) to distinguish large and small scale. Land cover change over the period 2004 and 2019 affected less than 50 square kilometres which is negligible compared to the total study area of over 17,000 square kilometres, of which roughly 40% was land.

For recreational infrastructure, we used Open Street Map (Open Street Map contributors, 2022) data on hiking routes, biking routes, officially designated viewpoints and cultural landmarks (Table 1). These cultural landmarks included historical landmarks and places of worship as defined by Open Street Maps. Additionally, control variables were included to control for the effect of factors that can influence photograph density but that are assumed to not directly be related to landscape appreciation. These variables consisted of population density and accessibility, for which details can be found in Table 1.

Table 1 Spatial predictors used in the analysis and their description. The mean and standard deviation are based on the raw data values over the selected grid cells.

Predictor	Unit	Year	Data Source	Mean (Standard deviation) n=10,187
Corine Land Cover classes				
Grassland	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021)	33.20 (16.75)
Forest	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021)	1.47 (9.12)
Wetlands	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021)	2.53 (12.17)
Intertidal flats	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021)	0.46 (3.74)
Urban	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021)	0.07 (0.25)
Dunes, beaches & sand	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021)	0.26 (4.20)
Agriculture type and scale				
Cropland small scale	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021), landscape structure indicator (Tieskens et al. 2017)	19.21 (35.42)
Cropland large scale	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021), landscape structure indicator (Tieskens et al. 2017)	18.09 (33.91)
Pastures small scale	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021), landscape structure indicator (Tieskens et al. 2017)	18.83 (34.29)
Pastures large scale	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021), landscape structure indicator (Tieskens et al. 2017)	21.7 (35.97)
Complex forms of agriculture small scale	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021), landscape structure indicator (Tieskens et al. 2017)	0.20 (3.83)
Complex forms of agriculture large scale	Number of 100x100m cells within 1km grid cell covered by landcover type	2018	Corine Land Cover data (European Environment Agency, 2021), landscape structure indicator (Tieskens et al. 2017)	0.54 (6.25)
Recreational infrastructure				
Hiking routes	Number of 100x100m cells per 1km grid cell containing official hiking routes	2021	Open Street Map	2.95 (6.26)
Biking routes	Number of 100x100m cells per 1km grid cell containing official biking routes	2021	Open Street Map	6.33 (8.40)
Viewpoints	Number of viewpoints per 1km grid cell	2021	Open Street Map	0.02 (0.14)
Cultural landmarks	Number of cultural landmarks per 1km grid cell	2021	Open Street Map	0.12 (1.39)
Control variables				
Accessibility	Travel time (in minutes) to town with at least 50 thousand inhabitants	2019	Nelson et al., 2019	33.2 (16.75)
Population	Population per 1km grid cell	2018	JRC Geostat 2018 Population Grid (Batista e Silva, Dijkstra & Poelman, 2021)	216.91 (660.16)
Random effects				
NUTS-3 Region	Name of Nuts-3 Region	2021	Eurostat (2020)	N.A.

3 Results

3.1 Descriptive results

Photographs taken on the Wadden Islands were analysed to develop insights into what characterises islands, and how they differ from each other. This was done for all islands where more than 200 photographs were taken between 2004 and 2019, to ensure an adequate sample size. Adequate sample sizes were present for all five inhabited Dutch Wadden islands, nine of the inhabited German Wadden islands, and two of the inhabited Danish Wadden islands. Sample sizes ranged from 225 photographs for Wangerooge, up to 3483 photographs for Texel.

The origin of photo uploaders on the Wadden islands exhibited some differences, particularly between the three Wadden countries. As can be seen in Figure 4, for the German and Dutch Wadden islands the majority of photo uploaders was of domestic origin. However, for the Danish Wadden islands, there was only a small majority of domestic uploaders for Fanø, while for Rømø there was actually a majority of photo uploaders from German origin. When looking at individual islands some notable differences were found. Examples included a substantial proportion of German photo uploaders on Texel and high proportions of non-EU photo uploaders on Föhr, Wangerooge, Schiermonnikoog and Terschelling. There also appeared to be greater proportions of photo uploaders from European non-Wadden countries on the Danish Wadden islands, when compared to the German and Dutch Wadden islands.

Seasonality of photographs taken on the Wadden islands indicated a majority of photographs taken in the spring and summer, when compared to fall and winter (Figure 5). These results suggest that the islands are primarily visited in the warmer months, particularly in the summer months when beaches could be hypothesized to be a popular destination. Notable differences do exist between the islands, that could perhaps offer insights into the reasons for visiting different islands. Nearly three quarters of photographs taken on the islands of Juist and Rømø are taken in spring and summer, suggesting a strong dependence on tourist that visit the islands in the warmer half of the year for beach recreation. In contrast, nearly half of all photographs taken on Schiermonnikoog and Borkum were taken in fall and spring, perhaps suggesting a stronger importance of non-beach related forms of tourism and recreation.

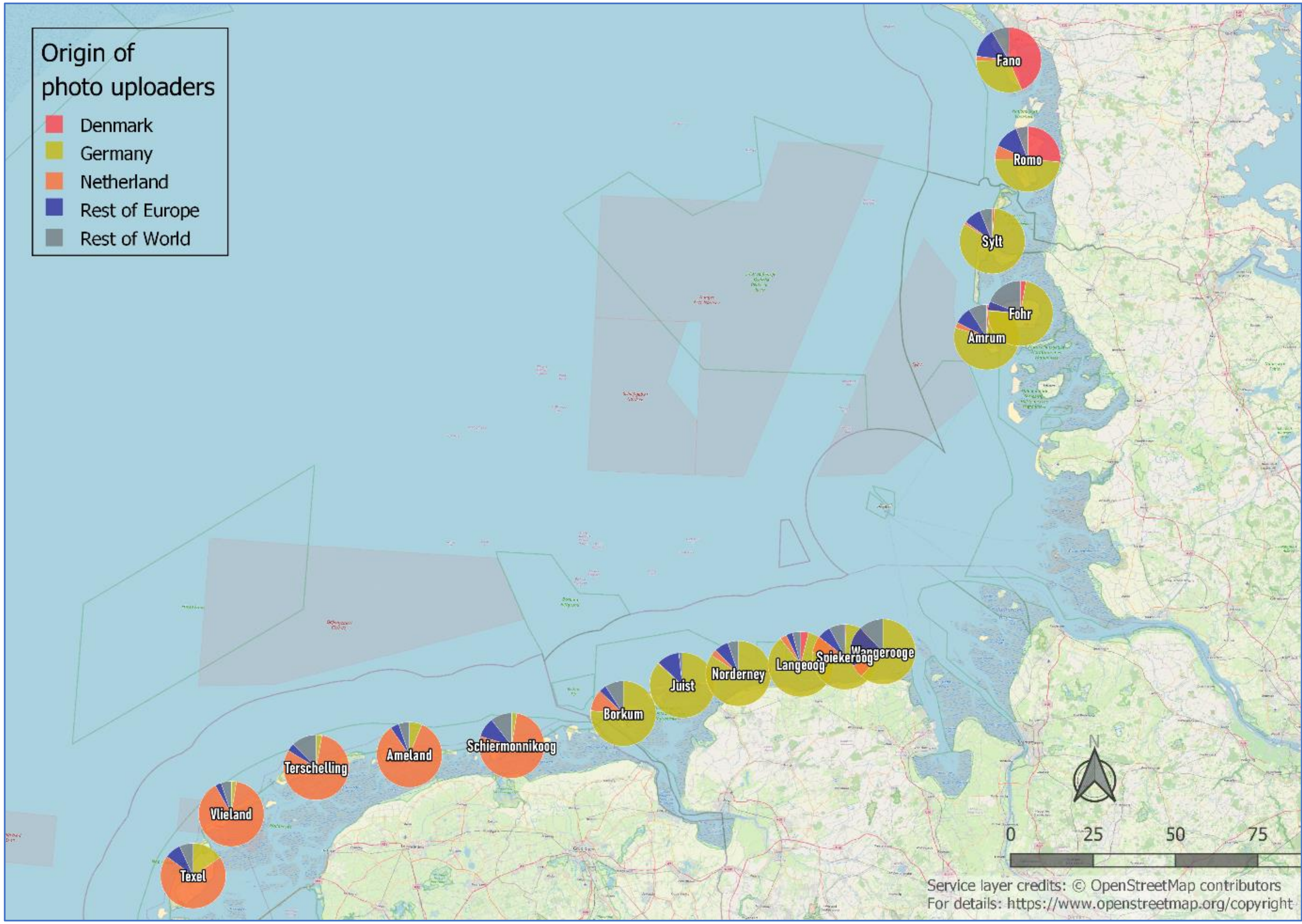


Figure 4 Origin of photo uploaders on the Wadden Islands

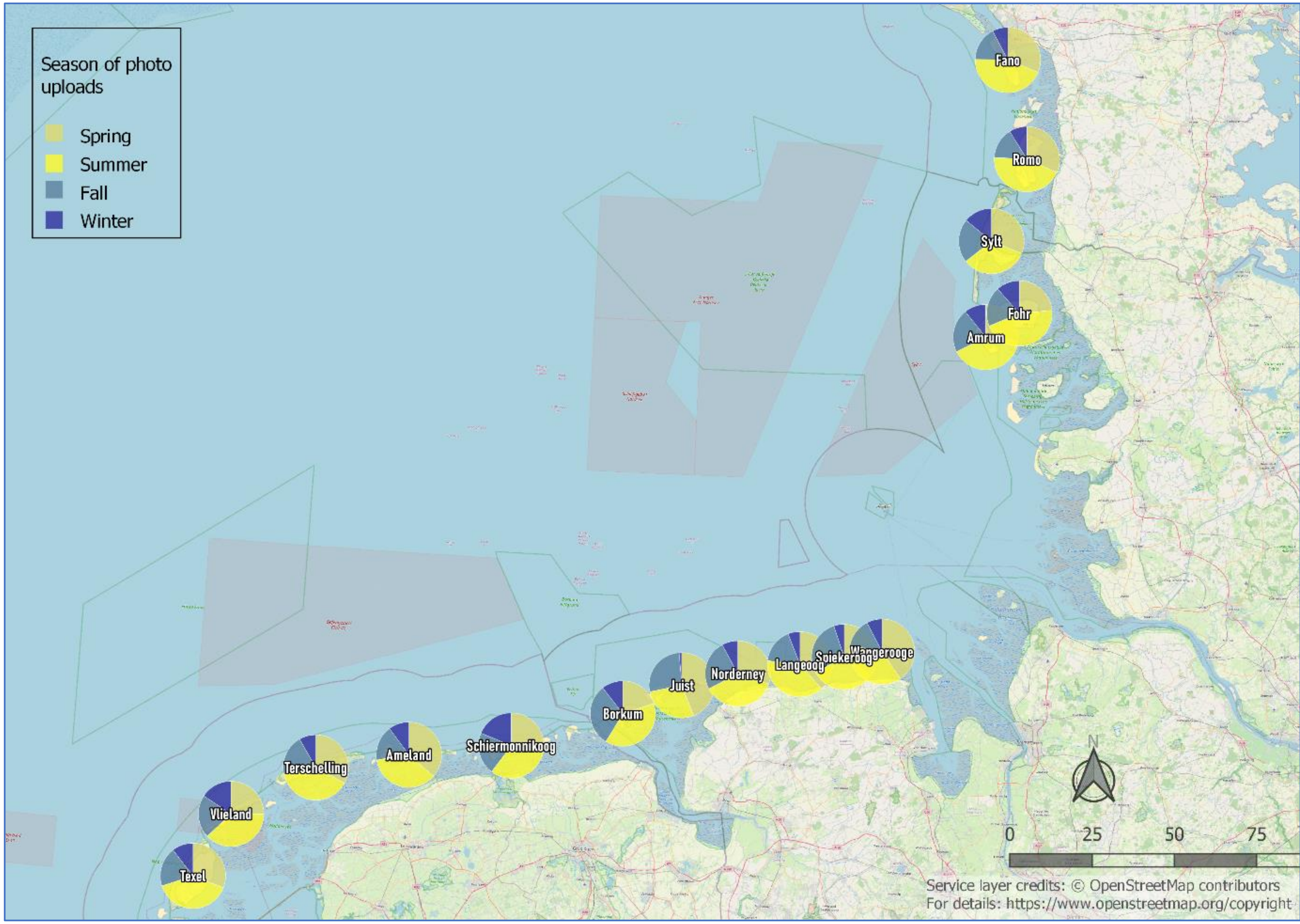
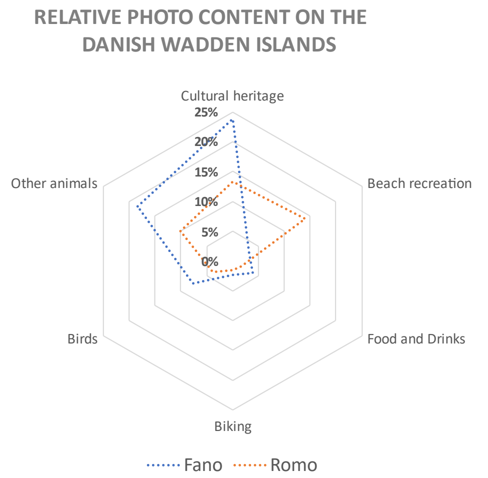
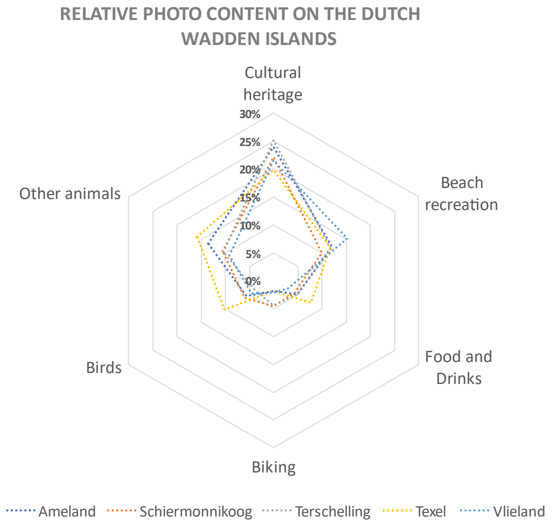


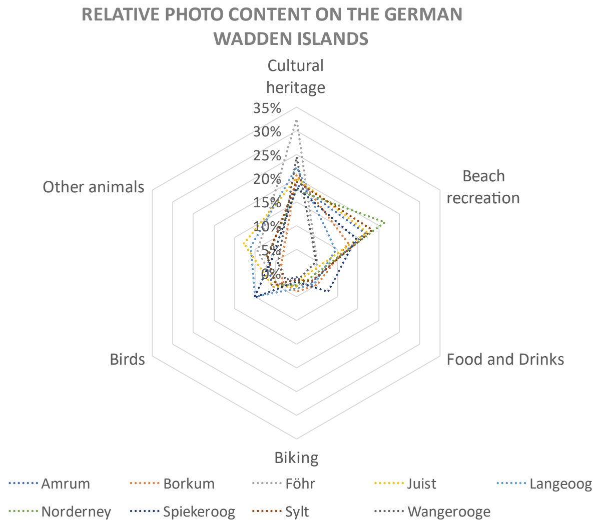
Figure 5 Season in which pictures were taken on the Wadden islands.

Photograph content was also analysed between the Wadden Islands and highlighted some interesting differences. Figure 6 provides spider charts that give an overview of the relative proportion of total photographs per island that contained content that matched with the specified categories. Though the pattern between islands is similar overall, certain categories of content appear to be more prevalent on certain islands.

Figure 6 Characterisation of photo content on the Wadden Islands. Only islands with at minimum 100 photographs taken over 2004-2019 were analyzed.







The most prominent example of varying photograph content can be observed between the Danish Wadden islands of Rømø and Fanø. The former exhibited a high proportion of photographs with content related to beach recreation, compared to the latter. On the other hand, Fanø exhibited a higher proportion off the other categories of content. This signifies that there can be notable differences between Wadden islands. To further delve into the differences between the islands it is recommended to explore the StoryMap (available here).

Lastly, we developed a pressure map highlighting the number of photographs per square kilometres taken in contiguous natural areas in the study area (Figure 7). Relatively speaking the highest pressure can generally be seen on the larger Wadden islands, particularly along the Dutch and German coastline. The StoryMap provides a navigable version of this map and can be used to study individual natural areas.

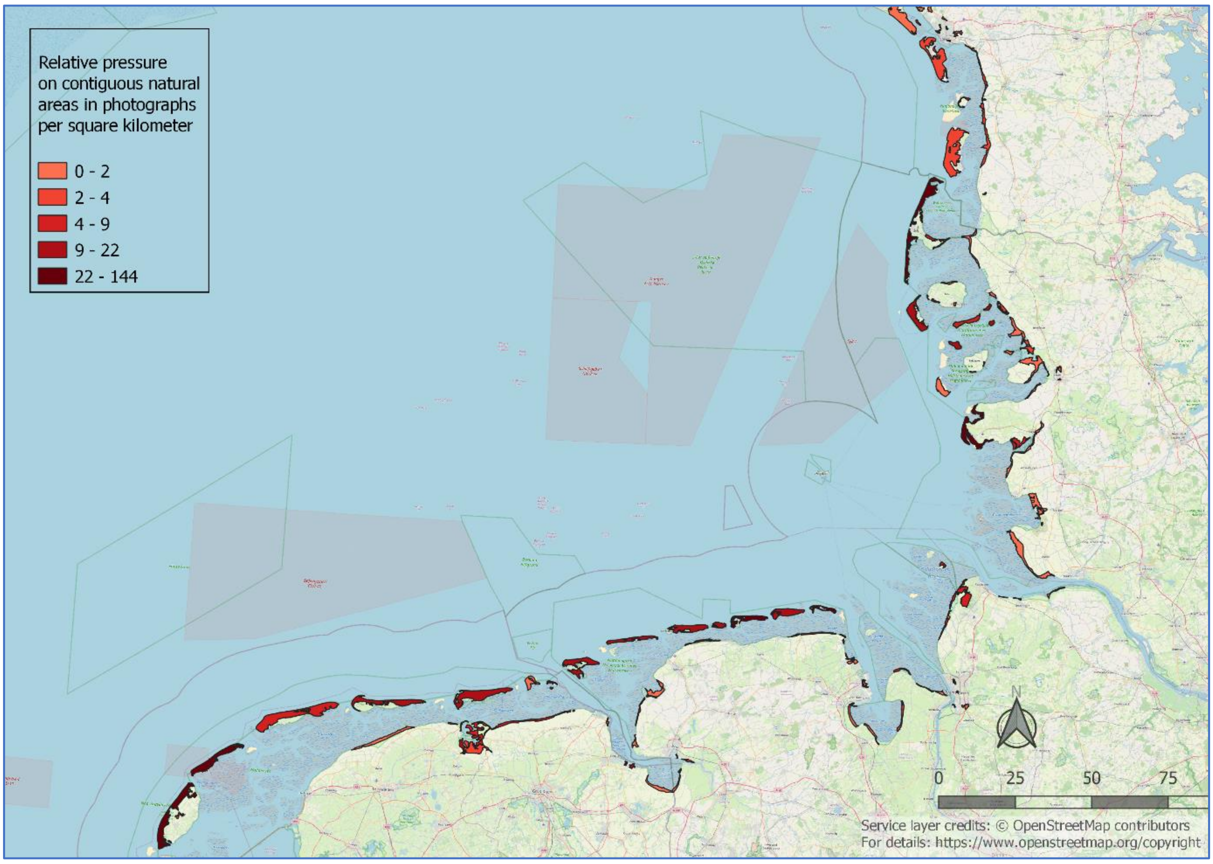


Figure 7 Pressure on contiguous natural areas by photo uploaders in the study area.

3.2 Spatial regression analysis: landscape characteristics and photographs

For the spatial regression analysis, we developed a model for explaining the effects of spatial predictors on the number of photographs taken over the Wadden sea region between 2004 and 2019 in the selected grid cells. This amounted to 11,924 photographs for the combined analysis, while totalling 11,090 for the analyses for visitor origin (5,260 for locals, 3,788 for domestic visitors and 2,042 for international visitors). Table 2 describes the relationship between the independent variables and the response variable (i.e. the number of nature photographs). This ratio describes the effect that a one-unit increase (See Table 1 for unit values for spatial predictors) in a given independent variable will have on the number of nature photographs, which we will refer to as the rate ratio. Values below 1 for the rate ratio indicate a negative effect on the number of photographs in a grid cell, while spatial predictors with a rate higher than 1 indicate a positive effect. These effects can be considered significant when the range between the high and low 95% confidence intervals do not overlap a value of 1.

Table 2 reveals a number of clear results regarding the effect of land cover types and recreational infrastructure. First, both control variables have a positive effect on the number of photographs taken in a grid cell. As expected, this indicates that our control variables describe factors that affect photo density, but are not directly linked to landscape appreciation, with their incorporation strengthening our model. Second, all predictors related to recreational infrastructure and cultural heritage exhibit a positive effect on the number of nature photographs. Hiking routes in particular appear to have a strong effect on the number of nature photographs. Third, there are positive effects of urban land cover types on the number of nature photographs taken. This might indicate a positive effect of urban green zones on nature photographs. Fourth, land cover types that can be considered as typical for the Wadden Sea region also have a positive effect on the number of nature photographs. These typical landscapes include dunes and beaches, as well as intertidal flats. Negative effects are found for wetlands and for all forms of agriculture (both small and large scale).

Table 2 Model estimations for spatial predictors of landscape appreciation as indicated by the presence and density of nature photographs. Significant rate ratios are highlighted in bold typeface

	Nature photos		
Spatial predictors	**Rate Ratio**	**95% CI low**	**95% CI high**
(Intercept)	**2.49**	2.16	2.88
Control variables			
Accessibility (travel time to >50k city)	**1.20**	1.09	1.32
Population	**1.03**	1.01	1.06
Recreational infrastructure and cultural heritage			
Biking routes	**1.10**	1.07	1.14
Hiking routes	**1.14**	1.11	1.17
Viewpoints	**1.05**	1.03	1.08
Cultural landmarks	**1.09**	1.07	1.11
Land cover types			
Dunes, beaches & sand land cover	**1.05**	1.02	1.09
Forest land cover	1.01	0.98	1.05
Grasslands land cover	1.03	0.99	1.07
Intertidal flats cover	**1.09**	1.05	1.14
Urban land cover	**1.05**	1.02	1.08
Wetlands cover	**0.89**	0.86	0.93
Agriculture types			
Large-scale complex agriculture	**0.96**	0.93	0.99
Small-scale complex agriculture	**0.94**	0.91	0.98
Large-scale cropland (permant and seasonal)	**0.77**	0.74	0.80
Small-scale cropland (permant and seasonal)	**0.75**	0.71	0.79
Large-scale pastures	**0.86**	0.82	0.89
Small-scale pastures	**0.81**	0.77	0.85

3.3 The effect of uploader origin

Results for the models describing nature photographs taken by uploaders from different geographical origins largely follow the patterns that were found for the general model, though there are some notable differences between the uploader groups, as can be seen in Table 3. First, the effect of viewpoints on the number of nature photographs taken is significant and positive for domestic and international visitors to the Wadden Sea, while no significant effect is found for local visitors. Second, the urban land cover class exhibits a significant positive effect on the number of nature photographs taken by local visitors. However, for international visitors there is a significant negative effect of urban land cover on the number of nature photographs taken. Third, as is also shown by the overall model presented in Table 2, all forms of agriculture have a negative effect on the number of nature photographs.

Table 3 Model estimations for spatial predictors of landscape appreciation as indicated by the presence and density of nature photographs. Significant rate ratios are highlighted in bold typeface

	Nature photos – local visitors			**Nature photos – domestic visitors**			**Nature photos – international visitors**		
Spatial predictors	**Rate Ratio**	**95% CI low**	**95% CI high**	**Rate Ratio**	**95% CI low**	**95% CI high**	**Rate Ratio**	**95% CI low**	**95% CI high**
(Intercept)	1.07	0.77	1.50	**1.70**	1.48	1.96	0.85	0.63	1.00
Control variables									
Accessibility (travel time to >50k city)	1.15	0.97	1.37	**1.17**	1.06	1.28	**1.35**	1.27	1.50
Population	1.02	0.98	1.05	1.01	0.99	1.04	**1.02**	1.02	1.06
Recreational infrastructure and cultural heritage									
Biking routes	**1.09**	1.04	1.14	**1.11**	1.08	1.14	**1.15**	1.11	1.17
Hiking routes	**1.11**	1.06	1.16	**1.11**	1.08	1.14	**1.13**	1.10	1.14
Viewpoints	1.00	0.97	1.03	**1.06**	1.04	1.08	**1.07**	1.06	1.08
Cultural landmarks	1.00	0.98	1.01	**1.09**	1.08	1.10	**1.11**	1.07	1.09
Land cover types									
Dunes, beaches & sand land cover	0.98	0.93	1.03	**1.03**	1.00	1.06	**1.07**	1.05	1.09
Forest land cover	1.02	0.97	1.07	1.02	0.99	1.05	**0.94**	0.91	0.96
Grasslands land cover	0.99	0.94	1.05	0.99	0.96	1.02	**1.02**	1.00	1.05
Intertidal flats cover	0.96	0.89	1.03	**1.07**	1.03	1.11	**1.16**	1.07	1.12
Urban land cover	**1.16**	1.11	1.21	1.01	0.98	1.04	**0.99**	0.95	0.99
Wetlands cover	**0.77**	0.70	0.84	**0.91**	0.88	0.95	**0.89**	0.88	0.93
Agriculture types									
Large-scale complex agriculture	**0.94**	0.90	0.98	**0.95**	0.92	0.98	**0.94**	0.93	0.97
Small-scale complex agriculture	0.92	0.85	1.00	**0.94**	0.90	0.98	**0.93**	0.91	0.96
Large-scale cropland (permant and seasonal)	**0.78**	0.72	0.84	**0.83**	0.80	0.86	**0.74**	0.72	0.78
Small-scale cropland (permant and seasonal)	**0.76**	0.69	0.83	**0.78**	0.74	0.82	**0.65**	0.63	0.69
Large-scale pastures	**0.85**	0.80	0.92	**0.85**	0.81	0.88	**0.80**	0.78	0.84
Small-scale pastures	**0.73**	0.67	0.79	**0.85**	0.81	0.89	**0.76**	0.74	0.81

3.4 Land-cover effects on landscape appreciation

We found a negative effect of all forms of agriculture on landscape appreciation in the trilateral Wadden Sea. This effect was visible both in our general analysis, in the analysis of the three different time periods, and for all visitor groups. It aligns with earlier studies that generally found a preference for natural landscapes compared to agricultural landscapes (van Zanten et al., 2014). We suspect that this effect might be even stronger in the coastal Wadden Sea region when compared to inland regions, given the presumed greater dependence of livelihoods on the natural landscapes and the sea in coastal regions. The preference of natural landscapes over agricultural landscapes is further supported by the positive effect that was identified of landscapes that are typical of the Wadden Sea region, namely intertidal flats, dunes and beaches. This pattern seems to support the uniqueness of the Wadden Sea region and aligns with the findings of earlier stated preference studies into visitor preferences for nature in the Wadden Sea. Sijtsma et al. (2012) found that tourists are mainly drawn to the islands in the Wadden Sea, and that one of most attractive aspects of the landscape is the openness and vastness of the region. Our results offer support to this notion, with the positive effect of vast and open landscapes such as dunes and beaches as well as the intertidal flats bolstering landscape appreciation as we have demonstrated. Additionally, this study has developed a spatial database that can highlight where areas of high importance for landscape appreciation are located.

Another noticeable effect was that of urban land cover, which was positively related to the number of nature photographs taken by local visitors but negatively related to the number of photographs taken by international visitors. One the one hand, this seems to suggest that international visitors are drawn to natural landscapes and flora and fauna that are found outside the urban centres in the Wadden Sea region. On the other hand, local visitors are more likely to photograph natural subjects in urban areas as well, possibly due to photographing natural elements in their direct surroundings. With regard to forests and grasslands there were no significant effects found in the general model, with only the number of nature photographs taken by international visitors appearing to decrease in forested landscapes while being positively affected by grasslands. This further suggest that international visitors in particular are drawn to the Wadden Sea region because of vast and open landscapes. Finally, it appears that wetlands have a negative effect on landscape appreciation. This seems counterintuitive, as wetlands such as salt marshes could be considered a typical Wadden Sea landscape. The negative effect might be caused by the inaccessibility of wetland areas to photographers, since these areas are often partially submerged making them difficult to access. Moreover, accessibility is often constrained as wetlands are also frequently classified as protected areas.

3.5 Effects of recreational infrastructure on landscape appreciation

Hiking and biking routes both exhibit a positive effect on landscape appreciation for all models that were analysed. The positive effect of viewpoints was only significant for domestic and international visitors but not for local visitors. This might suggest that such viewpoints are mainly attractive to visitors that are less familiar with the surroundings as they might be directed to such points by guides and tourism brochures. Cultural landmarks overall had a significant positive effect on the number of photographs taken, which support findings from other studies that indicate a beneficial effect of cultural landmarks on landscape appreciation (Tieskens et. al, 2018). These results suggest that investments in infrastructure for tourists and in maintaining cultural landmarks can sustain and improve landscape appreciation in the Wadden Sea area.

4 Conclusion

What people value in the landscape can differ between regions and between cultures (Ren, 2019). To ensure that landscape values can be maintained, it is important to be aware of what society values in landscapes. Doing so requires context-specific studies that analyse a set of landscape characteristics. In the present study, we looked at a selection of landcover types based on the Corine Land Cover dataset for 2018. We identified a number of significant effects on landscape appreciation resulting from the presence of land cover types. Differing effects of landcover types were also found between visitor groups, indicating differences in preference between local, domestic and international visitors. Generally, we found that the presence of the vast and open landscapes typical of the Wadden Sea region, such as dunes and beaches, had a positive effect on the number of photographs taken in a given area. This suggests that these types of landscapes generate value for the Wadden Sea region.

We also conclude that there are clear differences in what draws visitors to the different Wadden Islands. Certain islands seemed to be more attractive due to their cultural heritage, where others are primarily visited for beach recreational opportunities. Furthermore, differences were found in the percentage of pictures taken between seasons when comparing the islands. When considering tourism strategies, identifying and comparing such patterns can help determine the niche in which the islands operate. Additionally, the descriptive results also highlighted where visitors to the islands originate from, and as such can be used to identify target groups for potential tourism marketing campaigns.

The aim of this study was to identify how landscape characteristics affect cultural ecosystem service provisioning in the trilateral Wadden Sea region. The results of this study indicate that there are region-wide patterns in the distribution of landscape appreciation as a proxy for cultural ecosystem service provisioning. These results contribute to the growing body of work emphasizing the need for integrated management of landscapes where natural and cultural values meet. Spatial management and planning could benefit from the use of novel methodologies for studying recreational use of the landscape through the use of social media data. The findings of this study support previous research into what draws people to the unique Wadden Sea region. To ensure that the cultural ecosystem services provided by the region are maintained and available for appreciation, it is vital that its characteristic coastal landscape are conserved, and that recreational infrastructure is in place that allows visitors to experience these landscapes.

The results of this study highlight how the unique characteristics of the Wadden Sea region contribute to the provisioning of cultural ecosystem services. Furthermore, they emphasize the need to maintain the landscapes that constitute them. These findings can be utilized in spatial management and planning to identify high value areas for cultural ecosystem services and to inform recreational infrastructure investment decisions. The importance of integrating analyses on the effect of landscape characteristics (Ridding et al., 2018) and cultural heritage values (Tengberg et al., 2012) for cultural ecosystem services has been noted by other researchers, and the results of this study further reinforce this notion. Social media data, as a revealed preference method, might also offer a way of complementing and strengthening stated preference methods (Li et al., 2018).

Although the analysis provides strong indications for patterns in the trilateral Wadden Sea region regarding landscape appreciation, it does not capture patterns on a more local level (see the second report of this bundle for an analysis on a more local level). In the trilateral Wadden Sea region there might be differences in regional cultural perspectives on preferred landscape characteristics (Walsh, 2018). Thus, it would be interesting to study whether the effects found in the present study would differ if compared between regions. Additionally, analysis of data from other social media platforms such as Strava could provide further insights into the use of the landscape and recreational infrastructure (Munira & Sener, 2020; Venter et al., 2021). This could also alleviate some of the biases that are often present in social media data (Mashhadi et al., 2021), by providing information on a wider range of users.

Lastly, patterns found in the present study could be compared with patterns found in the trilateral visitor survey developed by New Insights for Tourism (NIT) under the PROWAD Link program. An early screening of the origin of respondents in the trilateral visitor survey (NIT, unpublished data) indicates that there are noticeable differences between the survey and the origin of present study. This trilateral visitor survey provides insights into visitor motivations based on stated preferences and thus it might be interesting to compare these insights with the revealed preferences generated in the present social media study, to see if conflicting or supporting patterns are present between the two studies.

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Annex 1: Content analysis through Google Cloudvision

The content of photographs was classified using Google Cloudvision. This algorithm assigns 10 labels (words) that describe the content of photographs. All labels that occurred at least 50 times in our original dataset were then classified into nature and non-nature photographs. Nature photographs covers all photographs that had at least two labels associated with one of the following elements: animals, plants and/or natural landscape elements (i.e. dunes, beaches, sand). The table below provides the classification of labels with a count of more than 3000, to exemplify the way in which the content analysis worked. Please note that classifying these labels is subjective to an extent and for certain labels an argument could be made both for including it as a natural element or not including it. The classification of all labels can be provided by the authors upon request.

Label	Count	Nature label
Sky	44051	No
Cloud	27255	No
Plant	25377	Yes
Water	22583	No
Natural landscape	16070	Yes
Tree	15446	Yes
Grass	12249	Yes
Vehicle	12116	No
Building	10773	No
Landscape	10108	Yes
Wood	9442	Yes
Horizon	8652	Yes
Window	8154	No
Lake	7382	Yes
Boat	6552	No
Watercraft	6444	No
Atmosphere	5264	No
Land lot	5045	Yes
Ecoregion	4742	Yes
Beach	4736	Yes
Grassland	4725	Yes
Coastal and oceanic landforms	4615	Yes
Wheel	4358	No
Road surface	4302	No
Fluid	4261	No
Dusk	3897	No
Water resources	3813	Yes
Asphalt	3769	No
House	3705	No
Tire	3636	No
Naval architecture	3535	No
Rectangle	3474	No
Afterglow	3332	No
Body of water	3293	Yes
Bird	3284	Yes
Sunlight	3127	No
Motor vehicle	3065	No
Natural environment	3015	Yes

Annex 2: Correlation matrix of spatial predictors

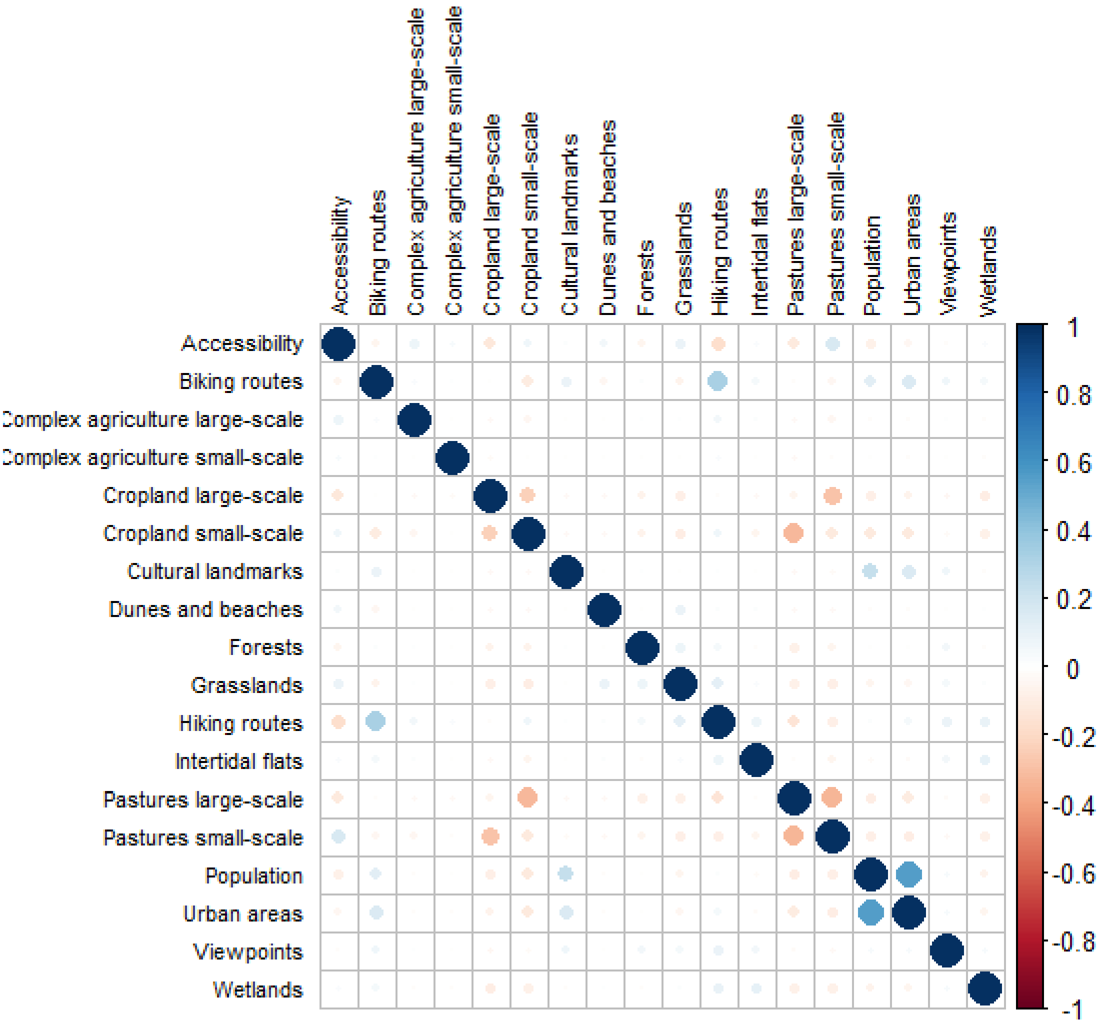

Figure 8 Correlation matrix of spatial predictors.


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