

SPATIAL HETEROGENEITY OF TOURIST ACCOMMODATION IN THE BALTIC SEA REGION: GEOSTATISTICAL APPROACH

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ABSTRACT

Motives: Open POI data from OpenStreetMap and GIS software enable comparative international analyses where access to national databases is limited.

Aim: Identify and interpret the spatial heterogeneity of accommodation (hotels, hostels, guesthouses, and campsites) across the Baltic Sea Region (seven countries) using geostatistical methods.

Approach: Kernel density estimation (KDE) was used to estimate the overall density for each accommodation type. Afterwards, the density values from four KDE rasters were processed with Raster calculator, to determine the dominant type of tourist accommodation, resulting in a raster dominance map.

Results: The study confirms spatial heterogeneity in tourist accommodation across all the analysed countries, both overall and within individual types of accommodation infrastructure. The raster dominance map shows the spatial dominance of hotels in Poland and southern Finland, while campsites dominate vast areas of Sweden and Denmark. Local clusters of guesthouses and hostels are mainly found in coastal areas and large cities. Open data enables repeatable and comparative international analyses of tourist accommodation.

Keywords: accommodation, tourism geography, points-of-interest, GIS

INTRODUCTION

Tourism is an integral part of everyone's life (Brouder & Eriksson, 2013; Hall & Page, 2009), which means changing one's current neighbourhood for another to seek out natural or anthropological attractions (Holden, 2004; Seaton, 1994). Tourism, therefore, requires moving from one's permanent place of residence to another temporary place of residence. This process of mobility therefore requires accommodation infrastructure, without which tourism could not take place.

This type of accommodation infrastructure is highly multifunctional; on the one hand, it provides a safe piece of greenery where you can pitch a tent, while on the other hand, it encompasses a group of buildings that serve as holiday resorts. Accommodation infrastructure is therefore extremely diverse (hotels, hostels, guesthouses, private accommodation, apartments, shelters and campsites), and its type and density can correlate strongly with the type and intensity of tourist activity in a given region. The existence of a well-functioning accommodation base in a given country influences:

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- type of tourism – the type of tourist accommodation determines the type of tourism (Constantin & Reveiu, 2018);
- heterogeneity of tourist destination – there is considerable variability in the location of specific types of accommodation infrastructure, and its density corresponds to the number of visitors (Belej, 2021; Nunna & Banerjee, 2022);
- extension of the tourist season – high availability of accommodation allows the season to be extended beyond the traditional summer period (Rudihartmann, 1986);
- regional economic development – tourism generates jobs and taxes related to tourist activities (Kulawiak et al., 2018; Napierała et al., 2022);
- local spatial changes – intensification of accommodation facilities in a traditional environmental area may permanently alter its characteristics towards urbanisation (Tofan et al., 2016).

The tourism sector, along with accommodation infrastructure, can be viewed as a spatial phenomenon that necessitates the collection and processing of spatial data (Boers & Cottrell, 2007). This means that any analyses related to the spatial heterogeneity of accommodation facilities for tourism purposes require access to data on the location of these facilities. The main source of data is usually official national databases, but their scope, level of detail and classification of accommodation establishments in official databases often vary considerably across countries, limiting their comparability in international studies. At the same time, part of the accommodation market remains outside official statistics and many formal databases (e.g. Airbnb). When a person from a given country uses such data, they are usually familiar with the procedure for accessing it. However, suppose a person from another country (and sometimes continent) undertakes to analyse the spatial heterogeneity of the distribution of accommodation facilities in foreign countries. In that case, they may encounter serious problems in obtaining such data. In addition, there is the problem of analysing multiple countries simultaneously. According to Kozłowska (2016) and Vartašová and Červená (2025) differences

in local nomenclature and accommodation typologies may substantially affect data comparability and interpretation. These may vary from country to country and may not provide clear solutions. In such a case, an interesting solution would be to utilise free, open data that is uniform across the entire area under study. This type of data serves as a valuable resource due to its accessibility and cost-effectiveness, particularly for analyses involving multiple countries or conducted by individuals in different regions.

The advantages include:

- cost-free data acquisition;
- continuous updates to the dataset;
- simple access to geographic information, which removes the need for complex coordinate collection processes such as geocoding;
- global applicability of survey methods, ensuring consistency across diverse regions;
- uniformity in the concepts and scope of datasets across various countries, facilitating comparative studies and comprehensive analyses.

Apart from its considerable advantages, open data has significant quality limitations that hinder its effective use and reuse. Data quality issues include inconsistency, inaccuracy, incompleteness and obsolescence, which should always be emphasised in scientific work (Rula et al., 2016; Tritt & Piotrowski, 2025; Vetrò et al., 2016).

The research question of this study may be as follows: based on open data and GIS modelling, is it possible to determine the distribution structure and spatial heterogeneity of the dominance of different types of accommodation infrastructure across national borders? The aim of the research, thus defined, is to analyse the spatial homogeneity of tourist accommodation facilities in the Baltic Sea Region, encompassing Denmark, Estonia, Finland, Latvia, Lithuania, Poland, and Sweden, and to attempt a general synthesis of its spatial structure. The study will use GIS-based spatial analysis using ArcGis Pro. For better clarity the paper's comprehensibility, the research procedure is presented in a visual format (Fig. 1).

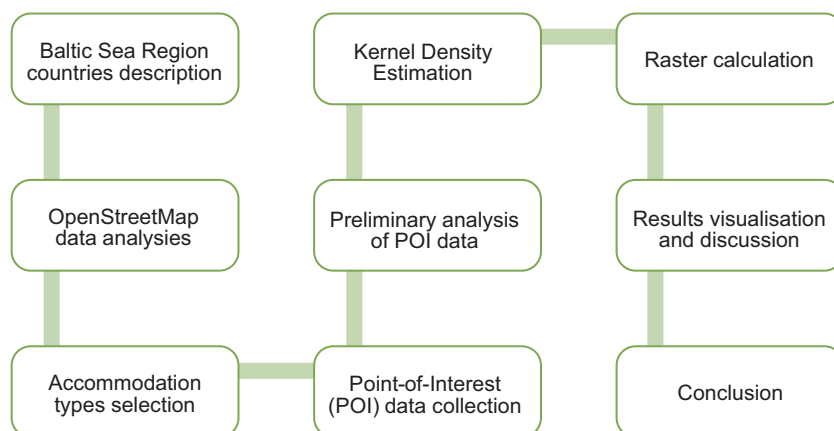


Fig. 1. Research procedure
Source: own elaboration.

The paper is structured as follows. In this section, a brief introduction to the main objective of this study is provided, along with a description of the research procedure. Section 2 presents a classic review of the literature related to the study’s topic. In Section 3, the authors provide an overview of the study area, a description of the methods used, a description of the data, and a preliminary study. This chapter presents the results of initial analyses examining tourism infrastructure in the countries under study. Additionally, this section provides a brief description of the research methods employed. In the results chapter (Section 4), the estimation findings are presented, their visualisation is shown, and a proposal of interpretation is made. The final chapter (Section 5) presents a scientific discussion of the results and conclusions.

LITERATURE REVIEW

In recent years, there has been a clear trend in scientific research toward utilising so-called Open Data, which can be downloaded for free and used, modified, and shared in virtually unlimited ways. Working group of so-called “Open Government Advocates” gathered in 2007 to develop the eight principles of open government data (OpenGovData, 2025): complete, primary, timely, accessible, machine processable, non-discriminatory, non-proprietary, license-free. The international public understood the

need for standardisation, unification and repeatability of the data made available to a large number of users. OpenStreetMap allows downloading data in the form of so-called POI points. Points of interest (POIs) are specific locations or features that are cartographically mapped in geographical space and are uniquely associated with different aspects of human life (Cellmer, 2023; Wu et al., 2021). This type of data applies to several objects that are precisely located in geographical space (cartographic representation), such as hotels, schools, kindergartens, parking lots, restaurants, cinemas, landmarks, green spaces, and others. This type of data is used, among other things, in the analysis of:

- demographics and society (Niu & Silva, 2023);
- transportation and mobility of the population (Jia et al., 2018);
- environment and ecological infrastructures (Dong et al., 2018);
- accessibility of public services (H. Wei et al., 2025);
- urban development trends, urbanisation, suburbanisation (Dudás et al., 2017);
- history and culture (Chang, 2024);
- spatial policy (Ganter et al., 2022);
- services and tourist traffic (Taylor et al., 2018).

In recent years there has been a dynamic increase in interest in the use of POI (Point-of-Interest) data in geographical analysis. Using points of interest (POI) data and GIS software, it is possible to analyse

the spatial differentiation of different types of accommodation quickly. POI database has been typically used for identifying urban polycentric spatial structures, analysing residents' daily activity characteristics, and personalised tourism route recommendations (Zhao & Liu, 2021). Some studies have used the same open-source data and drawn important conclusions, recommending personalised tours based on POI popularity and user interest preferences (Lim et al., 2018).

Previous literature on OSM in tourism research has analysed the quality, precision, and accuracy of the data contained therein (Mondzech & Sester, 2011) concluded that OSM data is quite accurate, achieving excellent spatial data quality. Regarding land use/usage, (Arsanjani et al., 2015) noted that OSM is also an alternative and supplementary source of information. Almendros-Jiménez and Becerra-Terón (2018) studied the quality of the tagging of the Spanish OSM, presenting a framework for analysing the quality of the tagging process.

Following this study, the distribution and characteristics of restaurants in Romania were analysed based on POI data, revealing a strong correlation between the availability of infrastructure and the volume of tourist traffic. According to the authors, this correlation has a direct impact on the economic development of the region (Constantin & Reveiu, 2018). Another study examined the potential of the attractions, including tourists' interests and travel patterns (Leung et al., 2017). The analysis of spatial changes associated with the development of tourist infrastructure and environmental pressure (Nunna & Banerjee, 2022) demonstrated both positive economic effects and adverse environmental effects of such pressure from developing accommodation infrastructure. Another article (Santamaria-Granados et al., 2020) examines the use of POI points in the context of recommending places for tourist traffic, analysing individual user experiences and considering their primary location. The authors of this study are analysing the system/way of matching routes or attractions to the individual needs of tourists using machine learning algorithms that implement recommendation systems.

The analysis of the literature indicates that in recent years there has been an increased interest in the use of POI data in spatial analysis, especially in the context of researching tourist services in spatial terms. The results of the research indicate that OSM data are mostly reliable and may serve as not only a supplementary, but also a primary source of information about tourist attractions, playing a key role in the analysis of tourist infrastructure.

MATERIALS AND METHODS

Study area

The spatial scope covers Poland, Sweden, Lithuania, Latvia, Finland, Estonia and Denmark, that is, the countries bordering the Baltic Sea in Europe. Germany and Russia were excluded from this study due to limited access to reliable data for these countries. A visualisation of the countries included in the study is presented in Fig. 2, while Table 1 presents basic statistical data for these countries.

Table 1. Baltic Sea Region countries included in the study: fundamental statistic

No.	Country	Population (mln)	Land area (thousand km ²)	Density (per./km ²)
I	Poland	38.14	306.23	125
II	Sweden	10.66	410.34	26
III	Lithuania	2.83	62.67	45
IV	Latvia	1.85	62.20	30
V	Finland	5.62	303.89	19
IV	Estonia	1.34	42.39	32
VII	Denmark	6.00	42.43	141

Source: Eurostat.

A significant decision criterion for selecting the seven countries for the study was their shared border with the Baltic Sea, which creates a natural area known as the Baltic Sea Region. It is an area of approximately 2.9 million km² inhabited by 80 million people (IBSR, 2025). The Baltic Sea Region (BSR) is traditionally regarded as a region of international cooperation, with development occurring at all levels—international, interregional, and intermunicipal (Fedorov et al.,

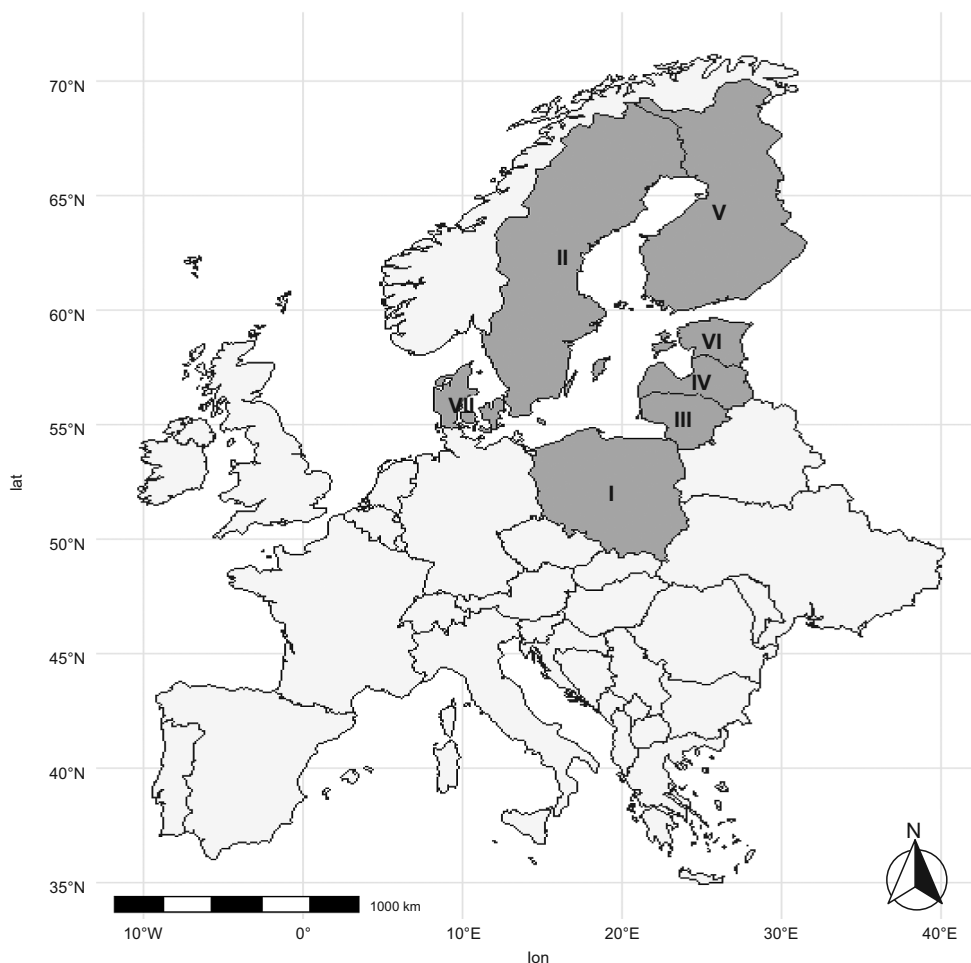


Fig. 2. Baltic Sea Region countries included in the study
Source: own elaboration.

2020). The efforts of countries and societies to create this region were based on several dozen international institutions, treaties, initiatives, and programs that aimed to shape the Baltic sea regional community (Palmowski, 2021). These efforts in 2009 resulted in the approval of the EU Strategy for the Baltic Sea Region (EUSBSR), based on:

- „Save the Sea” (several initiatives striving towards the conservation of the ecological richness of sea flora and fauna and ensuring safe navigation);
- „Connect the Region” (improvements in transport and energy integration);
- „Increase Prosperity” (concentration on economic development of the countries in the region) (Gänzle

& Kern, 2016; Joenniemi, 2010; Kosov & Gribanova, 2016).

The starting point for a brief assessment of this area is, of course, the Baltic Sea, which is a classic inland sea, with an area of approximately 400,000 km² and a 8000 km coastline. Among the countries selected for the study, Sweden possesses the longest coastline (3200 km), followed by Finland (1250 km), with Poland in third place, with a coastline of approximately 770 km. The coastline in Poland is fairly regular, whereas in Sweden and Finland it is quite fragmented, with numerous islands and archipelagos. According to data presented in Table 1, Sweden, Poland, and Finland form a group of the

largest countries in terms of area (ranging from 410,000 km² to 304,000 km²). In comparison, Estonia and Denmark can be counted among the smallest (around 42,000 km²). The geographical size of the countries does not correspond to their population size, as Poland ranks first in this category (approximately 38 million inhabitants), and Estonia ranks last (around 1 million inhabitants). The highest population density was observed in Denmark (141 people per square kilometre), followed by Poland (125 people per square kilometre). In Finland, there are only 19 people per square kilometre. A comprehensive description of the specific characteristics of this region can be found in several scientific publications (Kebza et al., 2019; Mezhevich et al., 2016; Żitkus, 2013), which confirm the high heterogeneity of the countries that comprise the Baltic Sea Region.

Data Description

A global community project, OpenStreetMap (Overpass Turbo, 2025) was the primary source of data about the accommodation facilities in the Baltic Sea Region, while the Overpass Turbo service (Overpass Turbo, 2025) was a platform for downloading Points-Of-Interest (POI) through a general query to Overpass API, with the z tag `tourism=*use` for Poland, Sweden, Finland, Lithuania, Denmark, Latvia and Estonia.

OpenStreetMap is part of an international community which, through many years of collaboration, has developed its own uniform standards for classifying accommodation objects. This system is not based

on official national guidelines, so the classification reflects the functional division of objects according to the international OSM user community rather than the formal legal classification in a given country. From the Overpass API, four categories of objects were selected using the global key ‘tourism=accommodation’: hotels, hostels, guesthouses, and campsites (we used query in Overpass Turbo; “tourism”~”hotel|hostel|guest_house|camp_site”, out center). Over 30,000 data points features were downloaded (in April 2025) in GeoJSON format, limited to objects mapped as points by OpenStreetMap users. This data set has been analysed, cleaned and prepared for further work with GIS software. The downloaded data refers only to the number of accommodation objects, as OpenStreetMap data on the number of beds is not sufficiently consistent and could affect the results and their interpretation. Table 2 presents the selected categories of accommodations, along with a standardised definition adopted by OpenStreetMap (OSM).

Fig. 3 illustrates the number of data regarding accommodation facilities in the Baltic Sea Region area, along with their categorisation into selected categories (see Table 2), as well as the spatial density of the total number of accommodations in each country.

It is interesting to note that the Baltic Sea Region countries surveyed (Fig. 3a) appear to be dominated by guest houses (11,327) and hotels (10,568), and next camping (6422) and hostels (2597). Generally speaking, the larger the country, the greater the number of hotels. However, this type of assessment may be inadequate. Sometimes a better approach to

Table 2. Accommodation POIs from OpenStreetMap description

Accommodation	POI names	POIs Description
Hotel	hotel	Buildings with at least 10 rooms (single or double rooms). A range of facilities available to customers during their stay
Hostel	hostel	A cheap place of temporary accommodation of a standard differing from a hotel mainly in the number of beds in rooms, bunk beds and sharing some equipment and rooms (e.g., kitchens, bathroom)
Guest House	guest_house	Rooms in dwellings and houses (excluding collective accommodation facilities) and adapted farm buildings owned by farmers, rented out for overnight stays for a fee
Camping Site	camp_site	Guarded sites, providing accommodation in tents, camper vans and caravans, preparing meals, parking cars, as well as providing services related to the stay of clients; these sites may additionally provide accommodation in tourist cabins or other permanent facilities

Source: Overpass Turbo (2025).

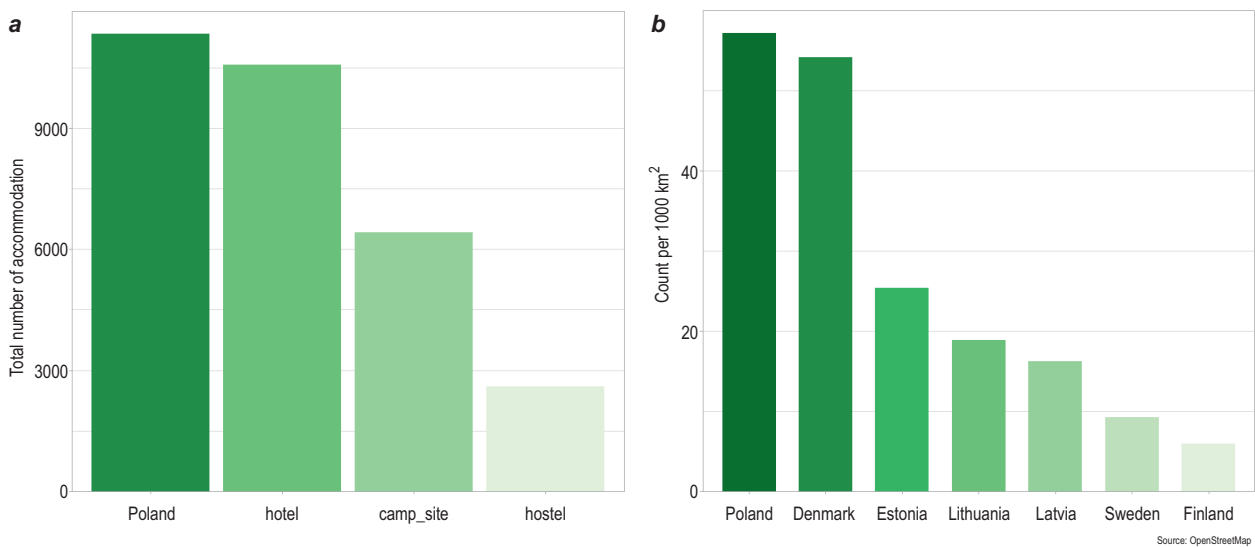


Fig. 3. The number of accommodations in Poland, Sweden, Finland, Denmark, Lithuania, Latvia and Estonia: a) total by type and b) density per 1000 km².

Source: own elaboration based on OpenStreetMap data.

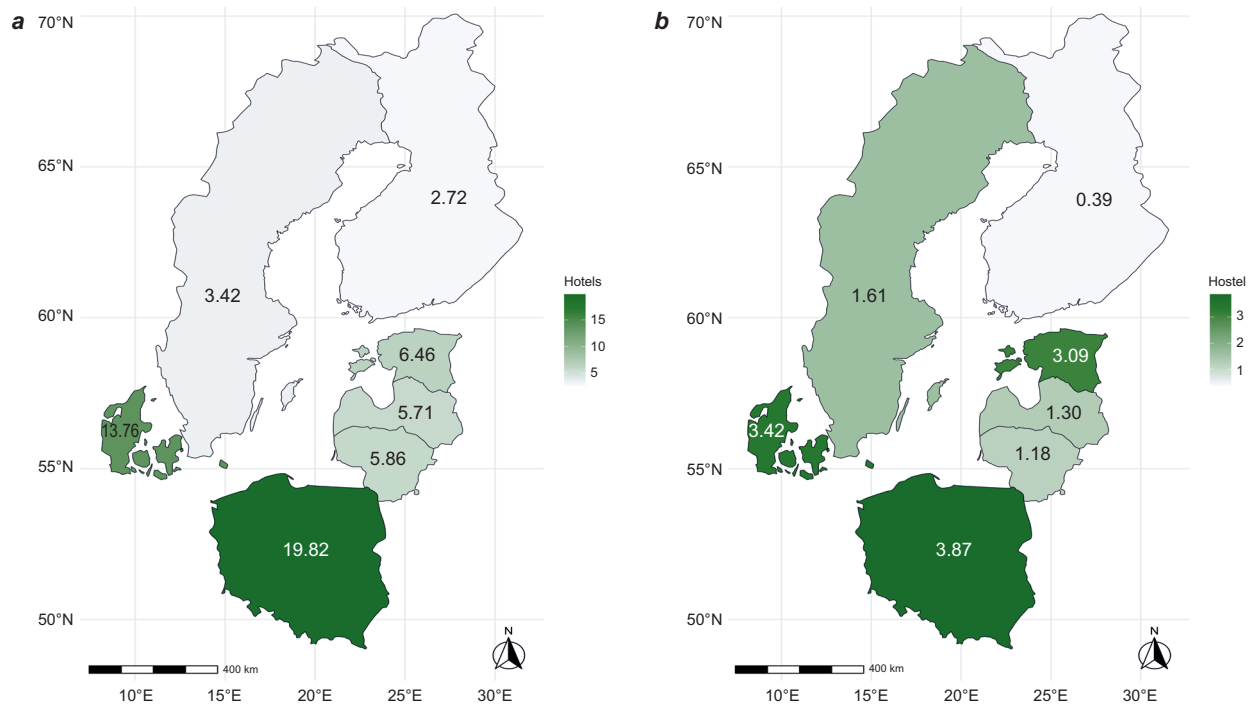


Fig. 4. Number of accommodations per country area per 1000 km² in the Baltic Sea Region: a) hotels, b) hostels

Source: own elaboration based on OpenStreetMap data.

assess the number of hotels is to transform it into the density of the hotels per thousand square kilometre in a given country (Fig. 3b). The most excellent density has been recorded in Poland (over a 35/1000 sq km) and in Denmark (33/1000 sq km), even though it is one of the smallest countries by area in BSR. The next were Estonia, Lithuania, and Latvia, with Sweden (9/1000 sq km) and Finland (6/1000 sq km) placing last. This simple analysis reveals a fundamental heterogeneity in the spatial distribution of hotel facilities in these countries. For a more detailed analysis of the data, cartograms were prepared, as shown in Figs. 4 and 5.

Fig. 4 illustrates the number of hotels and hostels per 1000 square kilometres in the Baltic Sea Area. Poland dominates both of these types of tourist accommodation (respectively 13.76 and 3.43). This reflects the well-developed accommodation base throughout the country. Interestingly, Denmark (the smallest country) places second in this ranking (respectively 13.76 and 3.43), with highly developed urban and coastal tourism. Lithuania (5.86), Latvia

(5.71) and Estonia (6.46) twice exceed the index number of hotels in relation to far larger countries, i.e. Sweden and Finland. In the case of hostels, it can be said that three countries take the lead (Poland – 3.87, Denmark – 3.42, Estonia – 3.09), while the rest do not have a significant number of this type of accommodation. The presented results clearly show that the number of accommodation facilities does not depend on the country's area, but rather on its character, i.e., the proportion of the natural regions, urbanisation, and road accessibility.

Fig. 5 shows the number of guest houses and campsites per 1000 km² in the Baltic Sea Area. In the case of guest houses, Poland dominates (28.12 facilities per 1000 km²), while Denmark leads in terms of campsites (28.66 facilities per 1000 km²). Polish accommodation base is largely based on individual economic initiatives, which support the large number of guesthouses as suitable places for family tourism and agritourism. Sweden (1.05) and Finland (0.96) show a very low number of guesthouses. For the

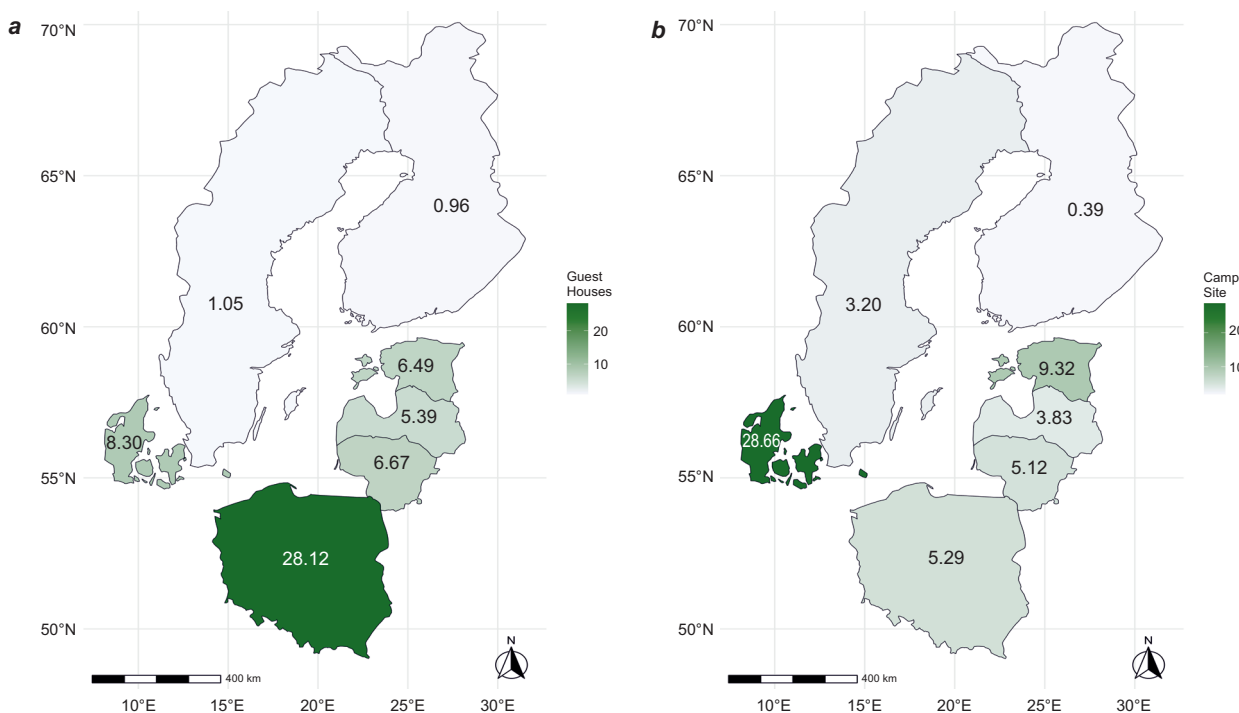


Fig. 5. Number of accommodations per country area per 1000 km² in the Baltic Sea Region: a) guesthouses, b) campsites
Source: own elaboration based on OpenStreetMap data.

campsites (excluding Denmark), the leading countries are Estonia, Poland, and Lithuania. Admittedly, Sweden has only 3.20 campsites per 1000 km²; however, in nominal values, it has as many as 1312 accommodations of this kind. This is due to the character of the natural appeal of the Scandinavian countries, as well as their cultural and legal traditions, i.e. the tradition of free access to nature (Ervola et al., 2024), the culture of outdoor activities (Allison et al., 2008; Bergsgard et al., 2019) or natural conditions (Ahtikoski et al., 2011). It appears that the dominant type of accommodation in a given country may reflect a dominant type of tourism. For example, the number of campsites in Denmark and Estonia indicates a dominant style of recreation that is in harmony with nature. This simple analysis confirms the conclusions resulting from earlier scientific works (Cerić, 2023; Kropinova, 2021; Łonyszyn & Terefenko, 2014).

Methods

The open character of the publicly available base of OpenStreetMap, its global reach, and its actuality constitute a significant advantage, especially in research that covers multiple countries, different spatial units, and classification systems simultaneously. The taxonomy, based on the uniform structure of the OSM data, enables comparability between countries and can be fully utilised in spatial analyses of tourism infrastructure. A key feature of this data is its spatial continuity, which is essential for studying the density, intensity, and severity of phenomena in space. To examine the spatial intensity of occurrence of each type of accommodation analysed, kernel density estimation (KDE) was used. It is a non-parametric technique that transforms points into a continuous raster surface by estimating the spatial density around each point (Silverman, 1986; Spencer & Angeles, 2007). The kernel density estimation, for the set of points x_1, x_2, \dots, x_n , is defined by the following formula:

$$\hat{f}(x) = \frac{1}{nh^n} \sum_{i=1}^n K\left(\frac{\|x - x_i\|}{h}\right) \quad (1)$$

Where m denotes the cardinality of the analysed set, h is a bandwidth parameter, while the expression $\|x - x_i\|$ represents the Euclidean distance between point x and observation x_i . The kernel function K must be symmetric about zero, and at the same time, should have a global maximum at this point. To approximate this function, the so-called quartic kernel of the form proposed by Silverman (1986) was adopted:

$$\hat{f}(x) = \frac{1}{mh^2} \sum_{i=1}^m 3\pi^{-1} \left(1 - \left(\frac{x}{h}\right)^2\right)^2 \quad (2)$$

In this way individual analyses were carried out for each of the four types of accommodation: hotels, hostels, guesthouses and campsites, which allowed for the creation of four spatial raster layers mapping the intensity of occurrence of objects of a given type in space. The benefits of using KDE in tourist analyses were repeatedly confirmed in the literature, which indicates that this method enables fast and precise mapping of the spatial concentration of phenomena on various scales (Belej, 2021; Vestal et al., 2021; Yu & Ai, 2014).

To determine the dominant type of tourist infrastructure in each location, density values from four KDE rasters were compared for each pixel in the analysed space. This resulted in a categorical raster dominance map, clearly showing which type of accommodation service dominates in a given area. This can be written down as:

$$D(x) = \arg \max_{c \in \{H,O,G,C\}} \hat{f}_c(x) \quad (3)$$

Where $D(x)$ denotes the dominant type of accommodation in point x , c is the analysed categories (hotel, hostel, guesthouse, camp site), whereas $\hat{f}_c(x)$ is the estimated KDE value for category c . The synthetic approach employed in this manner enables the spatial identification of the dominant tourist infrastructure at the regional level, indicating areas with a predominance of urban tourism (characterised by hotels and hostels) or recreational tourism (characterised by guesthouses and campsites)

(Constantin & Reveiu, 2018; Kropinova, 2021). The research was conducted using ArcGIS software and the R software [ggplot2 (Wickham, 2016), tidyverse (Wickham et al., 2019), dplyr (Wickham et al., 2023), raster (Hijmans, 2024), rnatuarearth (Massicotte & South, 2023), sf (Pebesma, 2018)].

RESULTS

The research on analysing spatial heterogeneity in the distribution of accommodation places in the countries of the Baltic Sea Region, using Points of Interest from OpenStreetMap, is conducted in several stages. The first part of the study will present the spatial distribution using the kernel density analysis (KDE) method separately for each analysed object, i.e., hotel, hostel, guest house, or campsite. In the second part of the study, an attempt will be made to visualise these objects on a single map using overlaying and raster value calculations. In both parts

of the study, 30,000 POI points were used, which were discussed in more detail earlier.

In the chapter concerning the description of collected data, Fig. 3 and Fig. 4 presented the number of different types of accommodation in the countries surveyed, i.e. Poland, Sweden, Finland, Denmark, Lithuania, Latvia, and Estonia. This type of analysis does not accurately represent the nationwide spatial distribution of these accommodations, which may lead to incorrect conclusions. Only by determining the spatial density of individual types of accommodation can the specific characteristics of a given country be properly analysed in the context of providing accommodation for tourism. In part of the study, ArcGIS Pro was used for GIS modelling, employing kernel density estimation (KDE), a model often applied in similar studies (Vestal et al., 2021; Yu & Ai, 2014; Zhu et al., 2017). Fig. 6 presents the spatial variation of the accommodations in the Baltic Sea Region for the hotels and hostels.

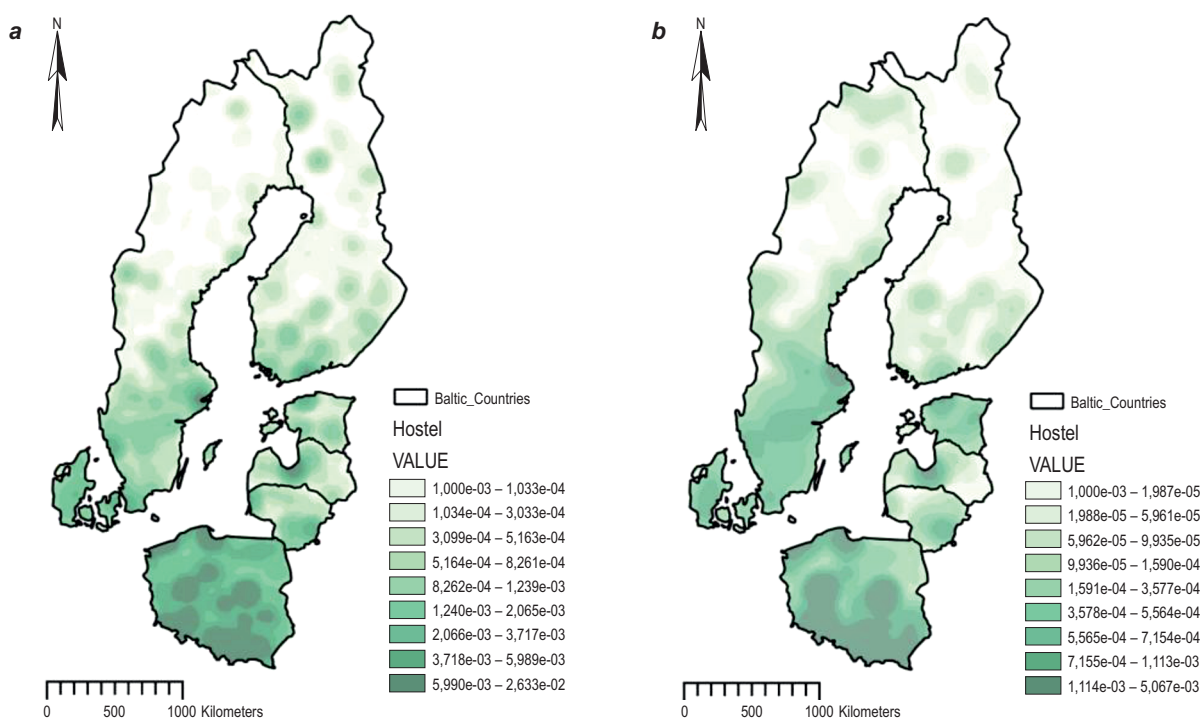


Fig. 6. Spatial diversity of accommodation in Baltic Sea Region, a) hotels, b) hostels
Source: own elaboration based on OpenStreetMap data.

Fig. 6a shows/indicates apparent differences in the spatial distribution of the hotels in the countries of the Baltic Sea Region when using the kernel density function. The highest density of POI points (hotels) in Poland was observed, especially in the centre (Warsaw, the capital city), in the western region between Poznań and Bydgoszcz, and in the southern part of the country. In other countries in this region, the largest concentration of hotels is typically located near large cities, which are often the country's capital. The intensification of hotel density is obvious near cities such as Copenhagen, Stockholm, and Helsinki. The specific nature of environmental conditions clearly correlates with lower hotel saturation in northern Sweden and Finland, reflecting the reduced availability of these services in these areas. Fig. 6b focuses on the spatial analysis of hostels, where their spatial distribution is quite similar to that of hotels. These two types of accommodation cater to a significant range of tourist needs for people visiting urban areas, where

demand is greatest. The basic difference between these facilities usually concerns the quality of services, number of amenities, level of privacy, or room size, but they fulfil a similar role. Fig. 7 demonstrates the spatial variation of accommodation in the Baltic Sea Region for guest houses and campsites.

Fig. 7a illustrates the complete dominance of guesthouses in Poland. Such a distribution reveals a certain duality between clusters in the north and south of the country. These are the areas dominated by leisure tourism linked to access to the sea (in the north) and to the mountain range (in the south). This type of accommodation is usually run by private businesses, which generally operate a single facility. These facilities typically play a significant role in seasonal tourism, which, due to Poland's weather conditions, primarily occurs in the summer, except facilities located near ski trails in the mountains, where winter is the dominant season. Guest houses are also observed to a significant extent in the Baltic states such as Lithuania, Latvia, and Estonia, which

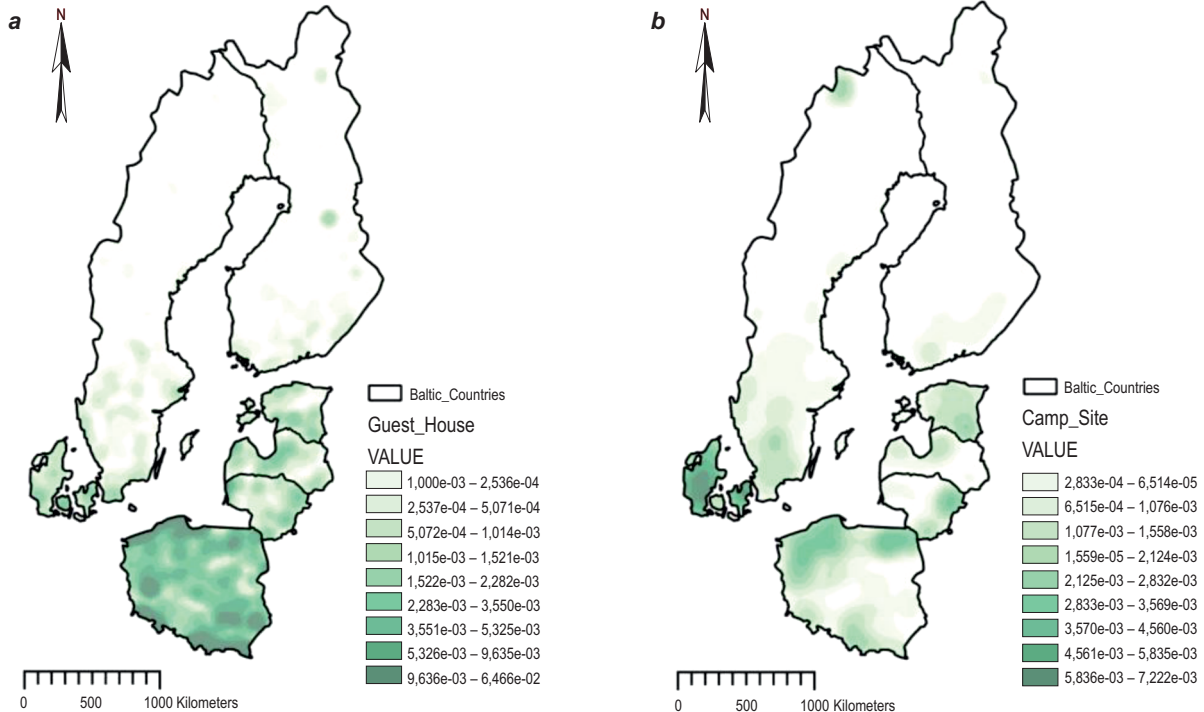


Fig. 7. Spatial diversity of accommodation in Baltic Sea Region, a) guest house, b) campsite
 Source: own elaboration based on OpenStreetMap data.

share a common history as post-socialist countries with Poland. In Nordic countries, such as Sweden and Finland, facilities of this kind are relatively scarce, and a different type of tourism model prevails. As can be seen particularly clearly in Fig. 7b, a high density of nature-based leisure tourism is observed in Denmark, Sweden, and Finland. The data for these countries reflects obvious structural differences in the tourist accommodation base between the north and the south of the countries, which results from the environmental and climatic conditions.

The following analysis attempted to integrate the individual results (Figs. 6–7) obtained to create a single, integrated map showing the spatial dominance of the selected category of accommodation facility. The essence of this research concept is to illustrate areas where one of the four types of hotel facilities clearly dominates in the Baltic Sea Region. The dominant type of tourist infrastructure was identified based on density maps. To ensure full comparability, a condition of identity of kernel functions in kernel estimation must be fulfilled. This applies not only to the functional form but especially to the smoothing parameter h (formulas (1) and (2)). The value of the smoothing parameter has a significant impact on the quality of the kernel estimator. A value that is too small results in the appearance of a significant number of local extremes, which may be inconsistent with the actual properties of real populations. On the other hand, excessively high values of the h parameter result in excessive smoothing of the estimator, masking the specific features of the distribution under study. The bandwidth parameter in the kernel density estimation was set to 100 km, as the study focuses on identifying the dominant forms of tourism rather than local accessibility or the micro-scale concentration of accommodation objects. The adopted bandwidth corresponds to the typical functional areas of influence of tourist destinations, covering not only accommodation objects, but also wider areas related to transport accessibility, labour markets, support services and short-term mobility patterns. The selected bandwidth is a compromise between spatial detail and regional interpretability.

In the next step, the values obtained from the rasters representing the density of tourist infrastructure were compared at each point in the analysed area. The dominant function corresponds to the highest value among the analysed raster layers, which represent the density of hotels, hostels, guesthouses, and campsites, as determined by formula (3). As a result, a synthetic image of the spatial distribution of the dominant accommodation categories was obtained (Fig. 8).

Fig. 8 shows the spatial dominance of accommodation services related to the tourist traffic in the area of the Baltic Sea Region in typological terms (hotels, hostels, guest houses and camp sites). A map constructed in this way allows for a quick and unambiguous graphical assessment of the spatial diversity of the analysed accommodation services. As a result, it is possible to clearly observe countries or regions of those countries where a given type of accommodation facility dominates, which, through its specific characteristics, can define areas with increased kind of tourist traffic, e.g., in the direction of environmental, ecological tourism that is more accepting of natural values (e.g., the dominance of campsites). By displaying many countries on a single map, it is possible to observe the secondary nature of administrative boundaries in relation to the spatial distribution of specific types of accommodation facilities. Areas of hotel or campsite domination do not take such boundaries into account, and only environmental conditions are relevant. This is clearly visible at the border between Sweden and Finland. Simultaneously, there is a clearly visible dominance of hotels in the areas of political, administrative, and economic centres of given countries, i.e., Warsaw (Poland), Stockholm (Sweden), Copenhagen (Denmark), Vilnius (Lithuania), Riga (Latvia), and Tallinn (Estonia). All the areas surrounding these major cities in the countries in question clearly indicate the dominance of hotels, as it is quite obvious that the concentration of this type of accommodation facility is best suited for implementing various administrative, legal, economic, or business tourism processes. The map shown in Fig. 8 can be an essential tool for commercial real

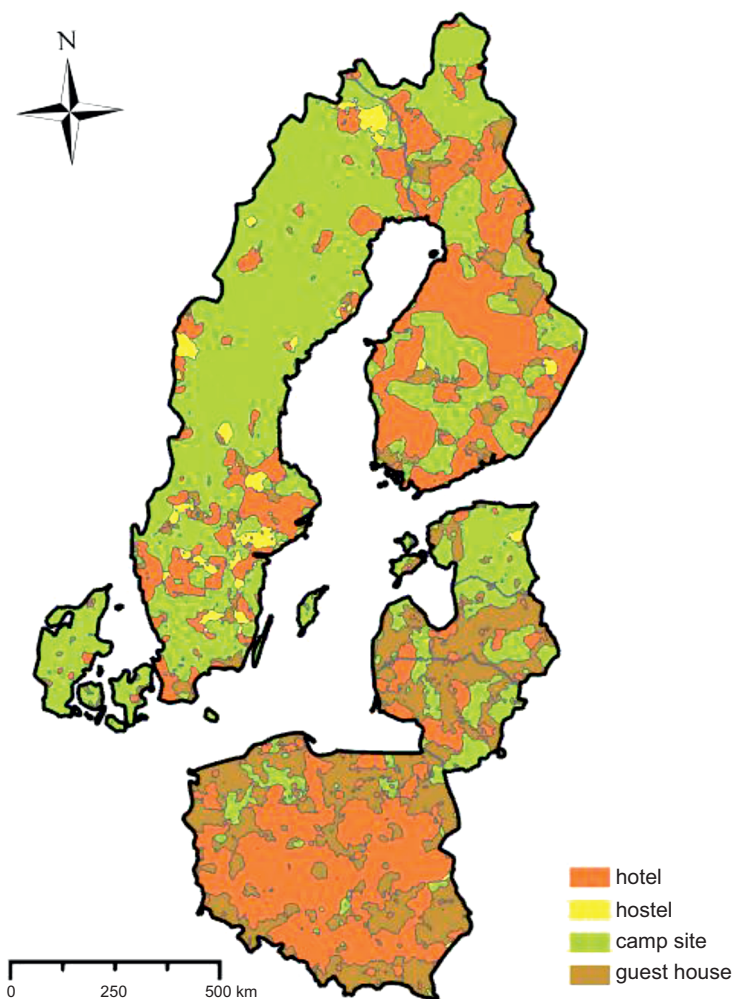


Fig. 8. Dominant accommodation type in the Baltic Sea Region
Source: own elaboration based on OpenStreetMap data.

estate investors, as identifying areas with specific types of accommodation facilities can significantly assist in making investment decisions regarding a given type of commercial real estate, according to the rule that there is less risk in locating a hotel near other hotels, due to the fact that their existence alone indicates the existing potential from tourist traffic focused on this type of accommodation.

CONCLUSIONS

Tourist mobility reflects the relationship between individual decisions and the social, environmental, economic, and cultural impacts on a given tourist region. An essential element for this type of tourist mobility is the provision of a place to rest, i.e., temporary accommodation. An analysis of the spatial distribution of such facilities may be a crucial factor in understanding the spatial patterns of tourist concentration and activity in the studied area. This type of research, combining open data, GIS modelling

and tourism, is increasingly becoming the subject of scientific work (Boers & Cottrell, 2007; Feng & Morrison, 2002). For example, Encalada et al. (2017) combined open data and tourist locations to create patterns of space utilisation in cities. POIs from OpenStreetMap can, according to Wei et al. (2022) provide an invaluable source of information on the spatial distribution and function of geographical objects related to tourism.

The main conclusion from this research is the confirmation of spatial heterogeneity in tourist accommodation across all the analysed countries, both as a whole and in individual types of accommodation infrastructure. Similar results were obtained in studies conducted in EU countries and in tourist accommodation (Roman et al., 2020), where countries were grouped using cluster analysis with GIS tools. In another study (Rodríguez Rangel & Sánchez Rivero, 2020), substantial spatial inequalities were revealed, and clusters of high and low values were identified in the availability of tourist accommodation (using Moran's I and the Getis–Ord G^* statistic).

In detail, three conclusions can be drawn from this research. First, a strong concentration of hotels and hostels was observed near large cities such as Warsaw, Copenhagen, Stockholm, Helsinki, Vilnius, Riga, and Tallinn. The spatial matrix created in this way reflects the intensification of cultural and business tourism around the main metropolitan hubs of the Baltic Sea Area. Secondly, there is a noticeable dominance of guesthouses in Poland, Lithuania and Latvia. This may correspond to generally lower income levels and a supply response to demand for accommodation that is not classified as hotels and is more family-friendly. In Poland, there is a strong concentration of guesthouses on the outskirts of the country, where the most environmentally attractive areas for recreational tourism are located – the sea, mountains and national parks. Thirdly, it has been shown that the pattern of tourism related to outdoor activities and traditions of free access to nature is mainly evident in Denmark and Sweden.

The first general conclusion from the presented research indicates a lack of correlation between the administrative boundaries of individual countries in

the Baltic Sea Area and the dominance of particular types of accommodation infrastructure. The same results are reported in another work (Parra et al., 2022), which suggests that geographical, natural, and infrastructural patterns have a greater influence than administrative boundaries on the spatial distribution of accommodation objects in Colombia. In our study, there are very clear gradients of dominance, for example, of campsites and guesthouses, which are more conditioned by local conditions of human access to the area than by the borders of individual countries. Therefore, the area of state jurisdiction does not affect the clusters of uniform dominance of a given accommodation facility; environmental conditions determine the course of continuous fields of dominance. The second general conclusion points to the good applicability of the open data used in the study. POIs from OpenStreetMap are free, accessible, and spatially mapped data on the main types of nighttime objects, defined uniformly for the entire world. This type of data enables cross-border analysis when official records from individual countries are unavailable. Of course, the quality of this data differs significantly from that of official data, partly due to the way it is created by active participants in the OpenStreetMap project, but its universality can compensate for this disadvantage.

The developed raster dominance map of individual types of accommodation facilities appears to be a quick and accessible tool for analysing spatial patterns in individual countries. It allows for the identification of uniform spatial clusters, which can be used as a tool for assessing the location of investments in tourist infrastructure in individual regions.

We recognise that a limitation of the approach adopted is its focus on dominant types of accommodation, which simplifies the internal structure of tourism supply. Future research could expand this framework by analysing combinations of accommodation types within areas to capture more complex and mixed patterns of tourism. The use of open data also poses a scientific challenge for comparing these results with official data from individual countries, which may constitute the next stage in implementing this research.

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