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ORIGINAL PAPER
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ANALYSIS OF SPATIAL DISTRIBUTION OF TOURISTIC ACCOMMODATION IN POLAND WITH THE KERNEL DENSITY ESTIMATION OF POI$_S$

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ABSTRACT

Motives: Using Points-of-Interest (POIs) data and GIS software, the spatial heterogeneity of different types of accommodation could cheap, easily and quick be analyzed.
Aim: The use of kernel density estimation (KDE) of Points-of-Interest data to shown spatial distribution of different types of accommodation in Poland.
Results: There is a close relationship between the type of accommodation and the type of tourist attraction.

Keywords: Accommodation, Tourism geography, Points-of-Interest, KDE.

INTRODUCTION

Tourism geography, as an element of socio-economic geography, approves the dualism of geographical space and economic space. According to Domański [2012], Lewandowska-Gwarda [2013], Włodarczyk [2014] the geographical space is split into anekumene (part of space not used economically and not inhabited by humans due to unfavorable natural conditions), subekumene (a part of space temporarily used economically and inhabited by human beings due to difficult natural conditions) and ekumene (a part of space continuously used economically and inhabited by humans due to favorable natural conditions). Perroux [1950] defined an economic space as an abstract space determined by the economic relationships that exist between economic elements. Tourism strongly connects geographical space with economic space, because this area of human activity is most dependent on natural conditions. According to Liszewski [1995], tourism space is a part of a geographical space understood as a space consisting of natural elements of the Earth's shell (natural environment), permanent effects of human activity in this environment (economic environment), as well as the human environment in the social sense. This kind of definition provides a detailed anthropocentric division of the geographical environment into natural, economic, and social [Zajadacz, 2014]. Thus, on the one hand the tourist space is based on the wealth of the natural environment (forests, rivers, lakes, mountains) and on the other hand tourist mobility requires economic activity in the field of tourist infrastructure and social acceptability for this type of purposes

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of human habitation. According to Włodarczyk [2014], tourism space is a part of the geographical space in which the phenomenon of tourism occurs. A necessary and sufficient condition to classify a part of the geographical space as a tourist space is tourist activity, regardless of its size and nature. The existence of tourism infrastructure (quality, quantity, specificity) is an additional condition that makes its delimitation possible. Comparison of geographical and touristic space are shown in Table 1.

The basic prerequisite for human tourist activity is adequate accommodation, which corresponds to the concentration of tourist attractions both typically natural and related to the history and culture of societies. According to Wojdacki [2014], accommodation is the foundation of tourism, allowing tourists to increase the length of their stay outside their place of residence (more than 1 day).

Different types of accommodation in Poland (hotels, hostels, motels, pensions, holiday resorts, and camping sites, more on this topic in the chapter Data Description) will be the subject of spatial analysis, in this work Gathering information on all establishments providing accommodation throughout the country, is a difficult and time-consuming task. There are no structured accommodation databases that show geographical coordinates along with facility information, in Poland. Based on the growing interest in the application of POIs (Point-of-Interest) data in geographical research [Yu & Ai, 2014, Jia, Khadka & Kim, 2018, Lu et al., 2020], we also believe that POIs points, as an accessible and simple additional spatial data source, have got an potential. Using POIs data and GIS software, the spatial heterogeneity of different types of accommodation could quick be analyzed. The aim of this paper is to verify the assumption that POIs can be a simple and easy-to-use source of spatial data to diagnose the spatial distribution of accommodation in a given region, country or continent. Additional aim, is to find is there a close relationship between the dominant type of accommodation and the dominant type of region's tourist attraction (anthropological or environmental). The research used the Kernel Density Estimation (KDE) through ArcGIS Pro.

Table 1. Comparison of geographical and tourism space

Sphere	Space in general terms – geographical space	Tourism space
Geosphere	Includes concentric layers of the earth, of diversified chemical composition and state, e.g. lithosphere, hydrosphere, atmosphere. A part of it is the biosphere, understood as space inhabited by living organism, including humans	Natural tourism assets and attractions which are the basis for the development of many tourism activities
Anthroposphere		
Technosphere	The sphere of human interference with nature, involving the introduction of technical means into the natural environment. A part of it is the infosphere, i.e. the whole of registered, processed and stored information	At base, it is formed due to tourism development and accessibility by transport. The elements of tourism infosphere are distribution and reservation systems, which may enter non-sociological relations with the elements of development or accessibility by transport
Sociosphere	The sphere of interpersonal relations, human psycho-social environment. These relations may be variously characterised (e.g. economic, political, cultural, etc.)	Describes the relational approach to tourism space and landscape. Similar to space in general, these relations may be variously characterised, but in most cases they concern the relations of people with other components of tourism space
Noosphere	The sphere of thought, human mental activity, usually without formal limits	Includes perceptual-mental and metaphorical approaches to tourism space (virtual space, spiritual space, etc.)

Source: Włodarczyk [2014].

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LITERATURE REVIEW

In geography, basic research aims to develop new theories and methods that help explain the processes through which the spatial dimensions of physical and human environments evolve. Applied research, on the other hand, uses existing geographical theory or techniques to understand and solve specific empirical problems [Hall & Page, 2009]. This paper presents the second dimension of geography, because the spatial heterogeneity of different types of accommodation by using POIs data and GIS, is analysed as an element of tourism geography.

Tourism contributes to the growth of regional economies, providing a source of income for both resident households and local firms [Carrascal Incera & Fernández, 2015]. Tourism sector is a spatial phenomenon that requires spatial data collection and processing [Boers & Cottrell, 2007], namely to identify features relationships and to analyse those relationships in a spatial context [Basu & Thibodeau, 1998]. Tourism is the mobility of society in geographical space, which is conditioned by the search for tourist attractions, both natural and anthropological. Tourism is the mobility of society in geographical space, which is conditioned by the search for tourist attractions, both natural and anthropological. The close relationship between tourism and the natural, social and economic conditions of an individual place (as a resting area) has brought these two research areas together in a single science discipline. According to Williams and Shaw [Williams & Shaw, 2015] tourism geography is a broad research area that studies the interactions between the space, place, and environmental dimensions of geography. According to Hall [2013] if tourism is subject to scientific research taking into account concepts from geography, it can be treated as a separate discipline, i.e. tourism geography. According to Wei [2012] tourism has strong geographical attributes and GIS (geographical information system) itself is information system offering services to geographical research and decision-making, which can play a role in tourism management. Research in the field of tourism geography can use a number of tools available in GIS software: GWR model [Jin, Xu & Huang, 2019, Lee, Jang & Kim, 2020, Tasyurek & Celik, 2020], Bayesian model [Wong, Song & Chon, 2006, Assaf, 2012, Assaf, Tsionas & Oh, 2018, Kulshrestha, Krishnaswamy & Sharma, 2020], K-means clustering [Arimond & Elfessi, 2001, Gao, Janowicz & Couclelis, 2017, Renjith, Sreekumar & Jathavedan, 2018], GIS based 3-D landscape visualization [Woolard & Colby, 2002, Cowell & Zeng, 2003, Yang, 2016] and KDE (kernel density estimation) [Yu & Ai, 2014, Zhu et al., 2017, Lee, Jang & Kim, 2020].

This research proposes a KDE model to investigate the spatial density of accommodation in Poland, with the use of Points-of-Interest. POIs can be obtained from many online sources, in which they are an integral part for example Twitter and Instagram (geo-positioned social media), OpenStreetMap and Google Maps (map applications), Airbnb, and Tripadvisor (applications for booking accommodation and positioning tourist attractions) [Milias & Psyllidis, 2021].

According to Lu et al. [2020] the Points-of-Interest are cartographically mapped in a geographical space and are uniquely associated with different aspects of human life. POIs in geographical information systems can greatly enhance the ability to describe the physical location of shopping facilities or even bus stops, for example [Gao, Janowicz & Couclelis, 2017]. There is currently a lot of interest in using points-of-interest in various studies [Gao, Janowicz & Couclelis, 2017, Lu et al., 2020, Milias & Psyllidis, 2021, Wu et al., 2021].

In this work, the spatial diversity of hotels, hostels, motels, pensions, holiday resorts, private, and camping sites were identified using the kernel density analysis method (KDE). The research results in a spatial visualization of the density for each of the accommodation types listed above. There are not many studies in the available literature that combine the use of spatial studies on accommodation types using points-of-interest as a spatial data source. Jeffrey [1985] conducted the research concerned with the identification and interpretation of spatial-temporal patterns of demand for hotel accommodation. The spatial-temporal patterns identified in that study would help with

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formulating an marketing and development policy for the hotel industry. In the research of Wall et al. [1985] the changing number and types of accommodation has been described and the spatial distribution of accommodation is analyzed using three methods of point pattern analysis and draw an attention to the significance of large cities as tourist destinations and to the importance of accommodation establishments as a component of the urban fabric. Voltes-Dort and Sanchez-Median [2020] presented a study about the drivers of Airbnb prices in Bristol using ordinary least squares (OLS) and geographically weighted regression (GWR) methods. The results also uncover statistically significant differences between the price determinants of apartments and house listings and reveal spatial patterns in the price effects. Similar studies were carried out by Suarez-Vega and Hernandez [2020] in terms of selecting prices determinants and including spatial effects in peer-to-peer accommodation. Spatial analysis of intensity in tourism accommodation has been conducted by Rodríguez Rangel et al. [2020] by using three different methods: quadrant counting, K-function, and kernel smoothing. The impact of various characteristics of geographical space on the location of tourist accommodation facilities has been assessed in the work of Navrátil et al. [2012] spatial indicators, nearest-neighbour analysis, kernel estimation of the probability density of occurrence, analyses of distances and location in selected environments were used. Applying the contour tree and location quotient index methods, based on the points of interest (POIs) data of the accommodation and catering industry in Beijing and on the identification of the spatial structure and cluster centre of the accommodation and catering industry, Han and Song [2020] investigated the distribution and agglomeration characteristics of the urban accommodation and catering industry from the perspective of industrial spatial differentiation.

MATERIALS AND METHODS

Study area

The spatial coverage of the research is limited to the borders of Poland, which is located in Eastern Europe. Poland has joined the European Union in 2004 and acceded to the Schengen Agreement in 2007. These two important events gave a positive impulse to the economic development of Poland and give a place to the increasing tourist movement. The area of Poland is about 313 thousand km² with about 38 million of inhabitants. The shape of the Polish territory is quite regular, in the north there is the Baltic Sea

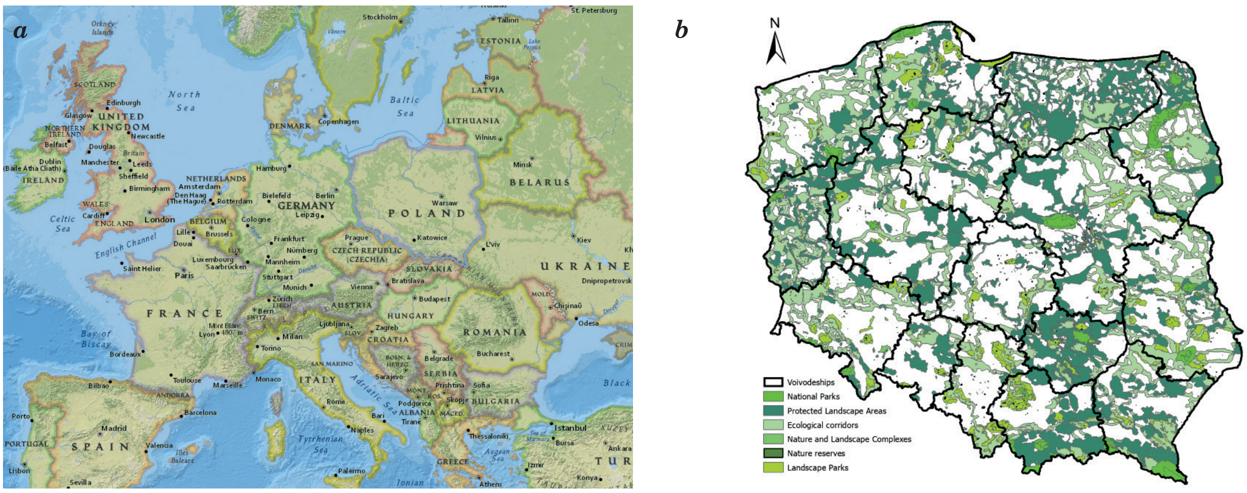

Fig. 1. Poland: (a) Location in Europe; (b) National and Landscape Parks, Protected Landscape areas, Nature reserves, Nature and Landscape Complexes, Ecological corridors
Source: own preparation.

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and in the south the mountains – the Sudetes and the Carpathians. The highest point is the Tatra peak Rysy 2499 m.a.s.l. The lowest point is located in Żuławy Wiślane – Raczki Elbląskie -1,8 m.a.s.l. Poland is a lowland country, descending in north-western direction. The area of forest land is almost 9.5 million hectares, in Poland. Figure 1 shows Poland's location in Europe and areas of National and Landscape Parks, Protected Landscape areas, Nature reserves, Nature and Landscape Complexes, Ecological corridors.

Data Description

The main idea of this research is to use simple and quickly available data from POIs (Points-of-Interest) databases. The source of data used in this paper is POIs

Table 2. Description of variables

POIs Types	POIs Description
Hotel	Buildings with at least 10 rooms (single or double rooms). A range of facilities available to customers during their stay
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)
Motel	Buildings with at least 10 rooms (single and double rooms) located by roads with parking lot
Pension	Rooms in dwellings and houses (excluding collective accommodation facilities) and adapted farm buildings owned by farmers, rented out for overnight stays for a fee
Holiday Resort	Buildings with at least 30 beds, suitable for customer self-service and providing a minimum range of services related to the stay of customers
Private	Furnished rooms and premises in apartments, houses and other dwellings or converted farm buildings belonging to natural or legal persons (excluding farmers) which are rented out to tourists for the night against payment, excluding collective accommodation facilities such as hotels, holiday and leisure centres, guest houses, hostels, and camping grounds
Camping Sites	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: Act [1997].

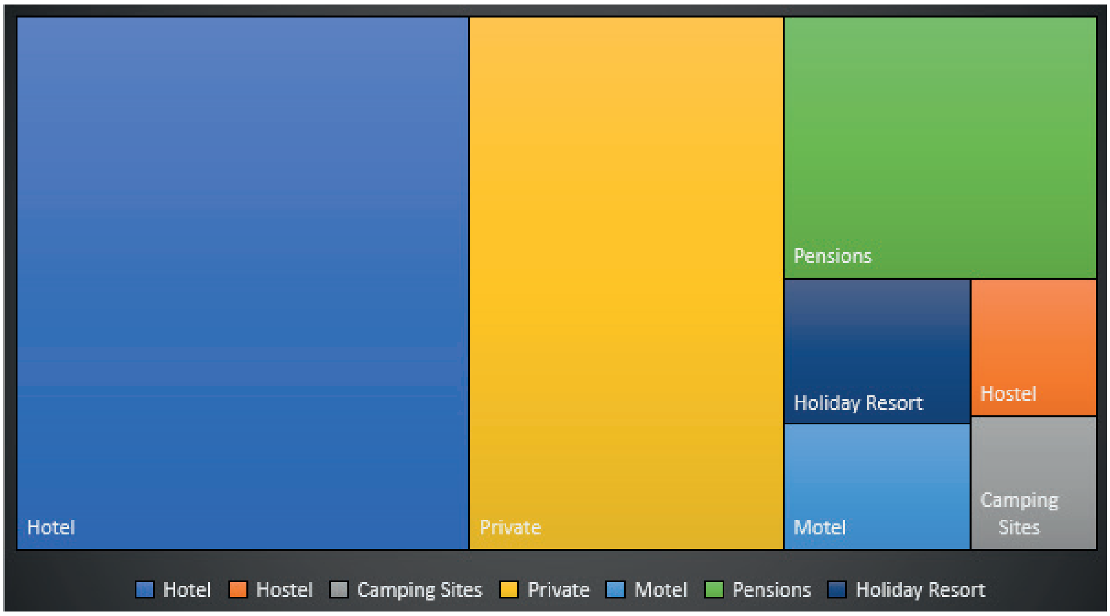

Fig. 2. The quantity of accommodation facility used in the study
Source: own preparation.

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database (www.poipoint.pl). Data was downloaded in February 2021. Data on 5743 accommodation facilities was collected. The scope of data is quite limited: type of accommodation and geographical coordinates. Table 2 shows the types of accommodation facilities with their description. Figure 2 shows the quantity of each accommodation facility.

Methods

The Kernel Density Estimation (KDE) through ArcGis Pro was used to analyze the spatial density of accommodation facilities in Poland. According to the *First Law of Geography* [Tobler, 1970], everything is related to everything else, but those which are near to each other are more related when compared to those that are further away. Thus, one can conclude that this method is based on this law, as explained in detail below.

The purpose of KDE is to generate a smooth density surface of point events over space by computing the event intensity as density estimation, and further to discover the spatial heterogeneity or inconsistency of the geographical process [Yu and Ai, 2014]. The density level is estimated using the so-called simple and kernel method. In the simple approach of the kernel density method, an area division into cells is created. Then, using the circular neighbourhood method, the density level is determined around each of the cells created. This is estimated by ratio of features number in relation to the size of the area. A smoother density surface is estimated by increasing the radius of the circular neighbourhood. This is the result of the circular neighbourhood covering more points [Läuter, 1988].

In the kernel approach of the kernel density method, during division, the area under examination has a number of cells defined by the investigator. In this method, a circular neighbourhood is estimated around each feature point and then a mathematical equation is applied that goes from 1 at the location of the feature point to 0 at the neighbourhood boundary [Anderson, 2009]. By using the kernel density method, an arbitrary spatial facility of analysis can be defined that is homogenous for the entire area, which makes the comparison and ultimately classification possible. According to Jia et al. [2018] by using the KDE method, any spatial object of analysis can be identified that is homogeneous for the whole area, which enables comparison and classification possible. Kernel Density Estimation (KDE) can be calculated using the formula at an (x,y) location to predict the density (ArcGis, 2021):

$$Density = \frac{1}{(radius)^2} \sum_{i=1}^{n} \left[\frac{3}{\pi} \cdot pop_i \left(1 - \left(\frac{dist_i}{radius} \right)^2 \right)^2 \right] \quad (1)$$

where:

- $i = 1, \ldots, n$ are the input points. Only include points in the sum if they are within the radius distance of the (x, y) location;
- pop_i is the population field value of point i, which is an optional parameter;
- $dist_i$ is the distance between point i and the (x, y) location.

The calculated density in the next step is multiplied by the number of points or the sum of the population area, if such an area is given. This correction procedure makes the spatial integral equal to the number of points (or sum or population field) rather than always being equal to 1 [ArcGis, 2021]. An important part of the Kernel Density procedure is the choice of bandwidth, as this significantly affects the final results. The selection of the optimal bandwidth is influenced by the type of data and the specifics of the area under study. A large bandwidth leads to a smooth density pattern which makes it difficult to separate local hotspots, whereas, a small bandwidth leads to a sharp density pattern highlighting only individual hotspot locations [Shariat-Mohaymany et al., 2013, Jia, Khadka & Kim, 2018]. According to Anderson [2009] the KDE method, compared to clustering (K-means) or statistical hotspot methods, is more advantageous to use.

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RESULTS

In this research, using the kernel density analysis method (KDE) of POIs (hotel, hostel, motel, pension, holiday resorts, private and camping sites) was visualized, and its spatial density was determined. Points-of-interest of all types of accommodation in Poland are shown in Figure 3.

Figure 3 shows all accommodation types used in the study based on available POIs data. Based on 5743 accommodation facilities gathered from POIs point data bases (with ArcGisPro), you can observe the spatial distribution of all types of accommodation. Already this stage of work it confirms that POIs database can be an alterative source of quick, cheap, and simple spatial data. However, such a simple and

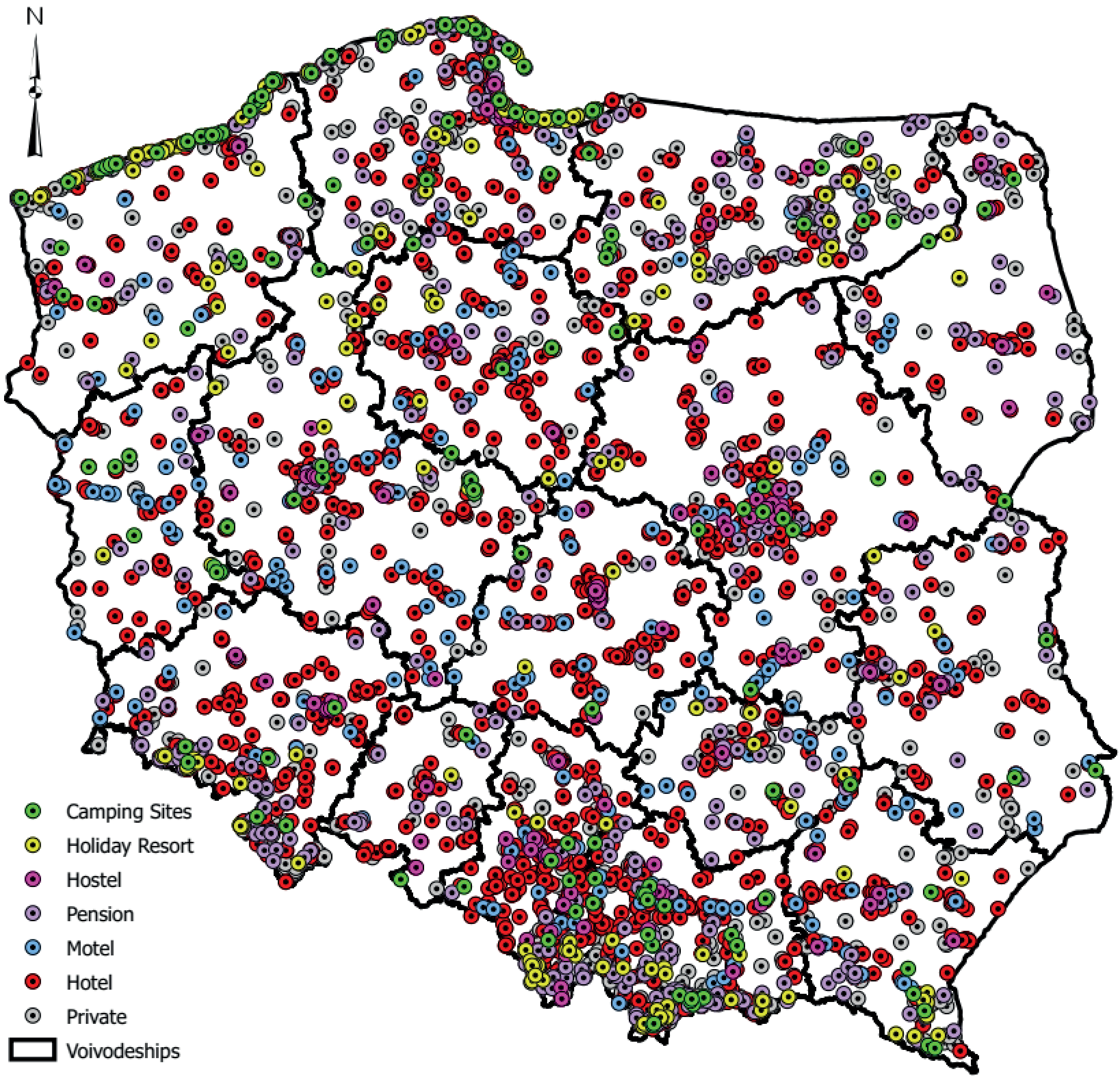

Fig. 3. Spatial diversity of all types of accommodation, based on point-of-interest, in Poland
Source: own preparation.

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effective (Fig. 3) type of spatial visualization of accommodation location has a large range of information in it. The highest density of accommodation facilities (all types) is in northern Poland (sea) and in southern Poland (mountains). Such a saturation of accommodation facilities is quite obvious and indicates tourism related to communing with nature. Further research using KDE will provide a more detailed explanation of this, for each type of accommodation individually. There is also a large concentration of accommodation facilities in the central part of Poland, near the capital Warsaw. Business and cultural tourism may be suspected here. The next stage of the research is the analysis of the spatial diversity of individual types of accommodation based on kernel density estimation (KDE), to model more accurate and smooth density all over the study area. Figure 4 shows the division of Poland into regions (a) and the KDE analysis for hotels. Figure 5 shows the kernel density estimations for hostels and models.

Figure 4a shows the area of Poland with administrative division of the country into voivodeships, to better organize the description of KDE results for various infrastructure accommodations. In the first stage, the kernel density estimation was carried out for hotels as the most numerous objects in the POIs database. The results of the kernel density analysis (Fig. 4a) show that the distribution of hotels in Poland is relatively uniform (in relation to other accommodation types). As a rule, overnight stays in hotels are related to business tourism or socio-cultural tourism (human culture). Therefore, in each of the voivodeships in Poland, we have a good hotel infrastructure. The highest kernel density of hotels has been estimated for Kraków (Małopolska – see Fig. 4a), Katowice (Śląskie), Warsaw (Mazowieckie) and the so-called Tricity (Pomorskie). This result is quite obvious because Warsaw, as the capital of Poland, is the first business tourism destination. Kraków in recent years has been a very attractive place for cultural and weekend tourism (entertainment). Katowice, as the capital of Silesia, (the energy center of Poland), is a business tourism destination. However, in the last decade the city has been changing its image towards a city of culture and art, which strengthens this area of tourism. Smaller density clusters are found near of Bydgoszcz (Kujawsko-Pomorskie) and Poznań (Wielkopolskie), it may be related to highway hubs in these voivodships.

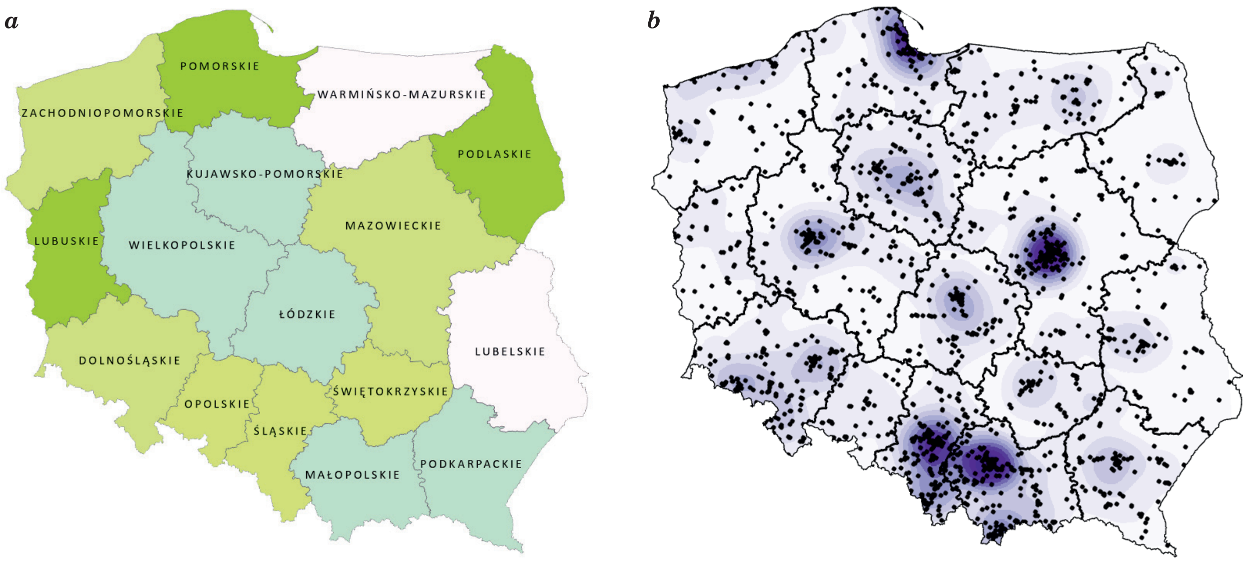

Fig. 4. Poland: (a) Administrative division of the country into provinces (voivodeships); (b) Kernel density analysis of POIs data: Hotel
Source: own preparation.

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The most impoverished eastern regions of Poland (Podlaskie, Lubelskie, Podkarpackie) have the lowest density of hotels, which is quite typical.

The spatial distribution of hostels and motels is quite similar to that of hotels in Poland (Fig. 5). Hostels are a cheap alternative to hotels (especially for foreign tourists), as they are usually well located in city centers. This feature, along with the low accommodation costs, provides an incentive for culture and entertainment tourism for youth. These assumptions are fulfilled in Warsaw, Kraków and Tricity, that's why KDE shows the highest density in these cities. In other parts of Poland you can see single hostels (Fig. 5b). Motels are usually located on the side of major highways, interstates, and ring roads and this kind of accommodation offers a convenient place to rest for travel. As you can clearly see, the kernel density of models, is less locationally clustered than hostels. KDE creates clustered states along the nation's major road infrastructure. An interesting result of the research is the large concentration of models in the Lubuskie voivodeship. This density is along the A2 highway, which leads to Berlin and all of Western Europe. The highest density is near the border with Germany and its cause is the lower cost of accommodation in Poland as a part of Eastern Europe. Figure 6 shows the kernel density estimations for private and pension accommodation.

Private accommodation (Fig. 6a) is a form of individual activity of apartment or house owners. The specificity of this market has a historical background from the time when Poland was a socialist country and its economy was centrally controlled (before 1989). Private accommodation was an acceptable form of additional income, during periods of seasonal tourist demand. Pension accommodation also have similar conditions (Fig. 6b). This has resulted in the high densities seen in Figures 6a and 6b at typical nature-based recreational tourism sites, namely the seaside and mountains. The whole part of northern Poland bordering the Baltic Sea shows a high level of concentrations, especially within 2–3 km from the sea. In the south of Poland, the typical tourist town of Zakopane is clearly visible. It is a base for mountain hiking and skiing in the winter. Another density is seen in the south-western part of Poland (Dolnośląskie) near the Sudety Mountains. The last high density is seen in the Warmińsko-Mazurskie province, which accumulates yachting tourism.

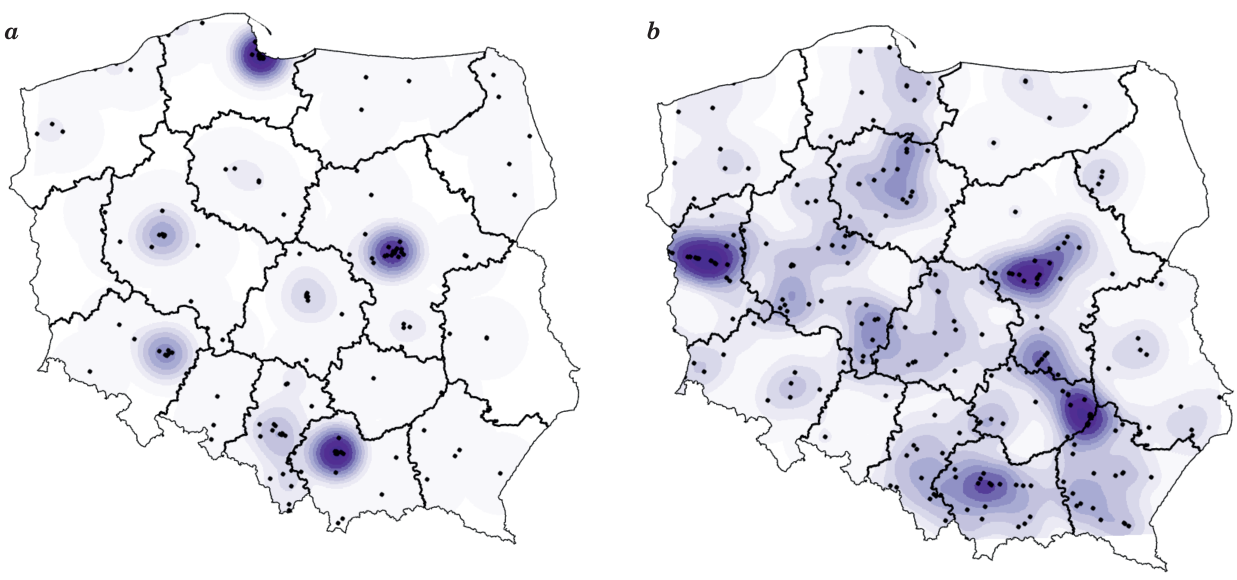

Fig. 5. Kernel density analysis of POIs data: (a) Hostel; (b) Motel
Source: own preparation.

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The colloquial name of this province, the Land of a Thousand Lakes, explains it. KDE results are significantly similar for both types of accommodation analyzed, namely, guesthouse and private. Figure 7 shows the kernel density estimations for holiday, resort, and camping sites.

The research visualized in Figure 7 shows that holiday resorts and camping sites have a very irregular spatial distribution. Due to its specific nature, this type of accommodation infrastructure is seasonal, focused on summer (in Poland from June to September). The highest concentrations of prices are therefore located in the entire coastal belt.

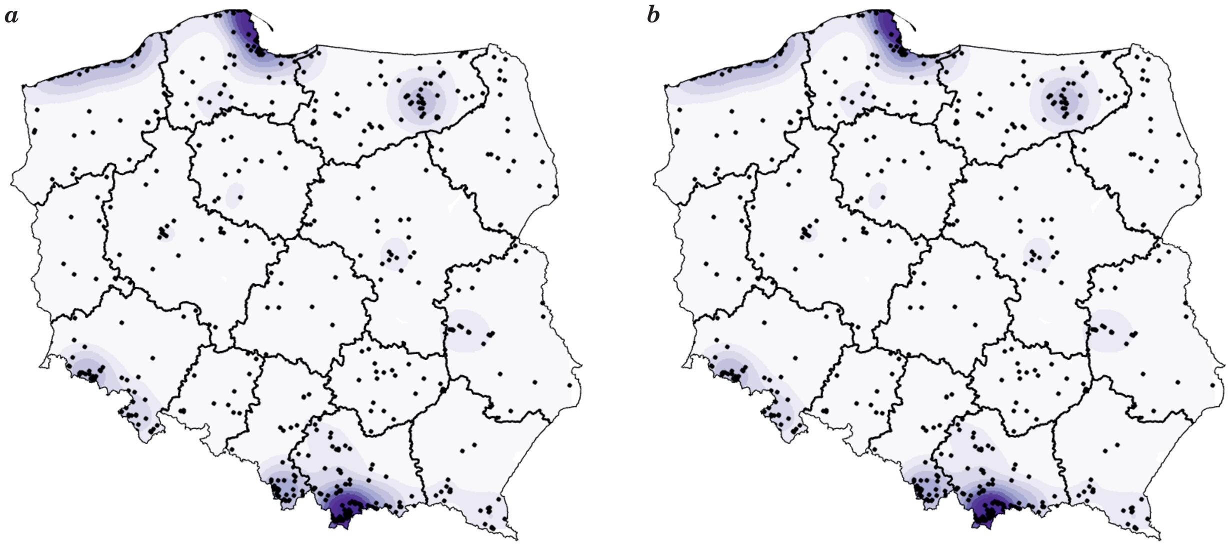

Fig. 6. Kernel density analysis of POIs data: (a) Private; (b) Pension
Source: own preparation.

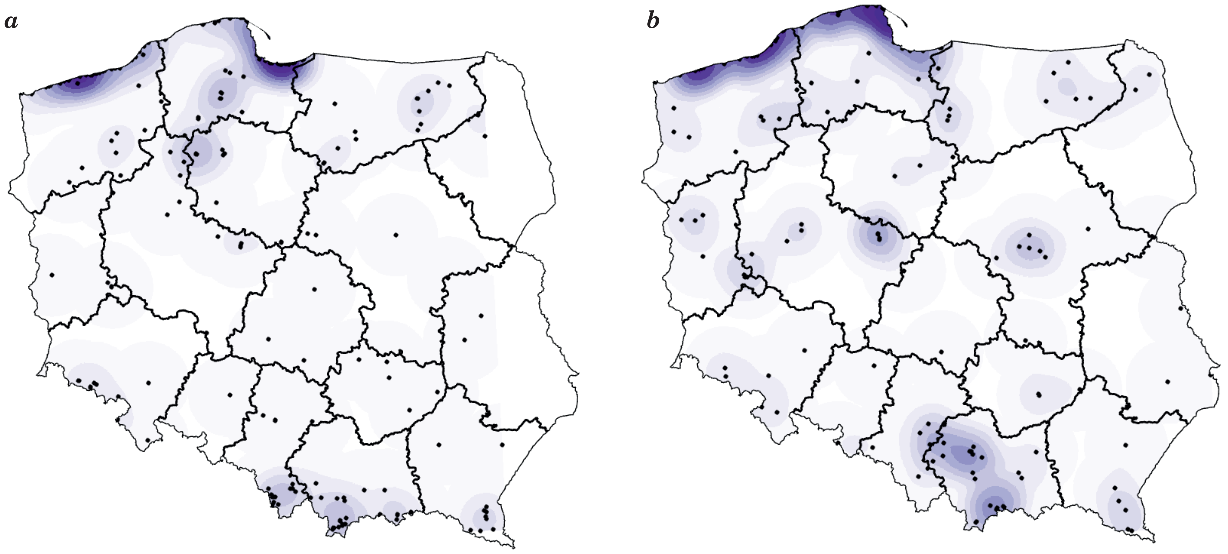

Fig. 7. Kernel density analysis of POIs data: (a) Holiday Resort; (b) Camping Site
Source: own preparation.

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CONCLUSIONS

Tourism, as an element of socio-economic geography, cannot exist without accommodation infrastructure. The intensification of accommodation in particular country areas is directly proportional to the tourist attractiveness of that place. Based on this research, it could be concluded that there is a close relationship between the type of accommodation and the type of tourist attraction. The research clearly shows that tourism focused on environmental attractions creates clusters of holiday resorts, guesthouses, private accommodation, and camping sites. Tourism focused on cultural and entertainment attractions, on the other hand, creates clusters of hotels and hostels. Motels, on the other hand, indicate places of car transit intensity in the road infrastructure.

The use of kernel density estimation (KDE) of points of interest data, allows us to quickly answer questions about the spatial distribution of different types of accommodation. This type of research procedure allows for clear and quick analyses whether you are researching a region, a country, a continent or the world. As a result, only on the basis of POIs and types of accommodation can we make conclusions about the type of dominant tourist attraction (natural environment or human cultural heritage). A great advantage of this procedure is the possibility of obtaining data from various sources, e.g., car navigation, which allow for the creation of spatial distribution of nights even without knowledge of the specificity of a given country.

Author contributions: author have given approval to the final version of the article. Authors contributed to this work as follows: M.B. developed the concept and designed the study, M.B. collected the data, M.B. analysed and interpreted the data, M.B. prepared draft of article, M.B. revised the article critically for important intellectual content.

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