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THE SPATIAL HETEROGENEITY OF THE DIFFERENT TYPES OF ACCOMMODATION WITH THE USE OF POI DATA

Abstract: This study investigates the geographical dimension of tourist accommodation in Slovenia, Croatia, and Bosnia and Herzegovina and attempts to synthesize its spatial structure. The countries were chosen for the study due to their undoubted tourism qualities, their proximity in terms of location and, at the same time, the fundamental diversity of country size, population and access to the sea. The basis of this research was the use of point of interest (POIs), an open-source data, to analyse the spatial heterogeneity of the different types of accommodation. Kernel Density Estimation and Empirical Bayesian Kriging were used in the research.

Keywords: tourism, accommodation, points-of-interest, spatial heterogeneity

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Introduction

Geography focuses on place, space, and environment as its central concerns. A recent area of proper development for applied geographical research has been GIS, which enables geographers to play a problem-solving role in tourism (Hall & Page, 2009). According to Williams and Shaw (Williams & Shaw, 2015), tourism geography is a broad research area that studies the interactions between geography's space, place, and environmental dimensions. 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 is the mobility of society in geographical space, conditioned by the search for natural and anthropological tourist attractions (Bełej, 2021; Lengyel, 2016; Silviu-Florin, 2014). Tourism means moving from one point (home) to another, which is a place intended to give a feeling of relaxation. As a result, tourism combines spatial, environmental, infrastructural (forms of transport), economic, cultural, religious, or health aspects. Tourism is performed in the tourist space, which is the area of tourist services provision. Tourist services include, among others:

- transport services – transport by air, rail, coach, ship, or individual vehicle traffic,
- leisure and sports services – infrastructure for active recreation,
- tour guiding services – allows, under the guidance of a guide, to acquire knowledge related to cultural or environmental tourism,
- organisation and agency services – facilitate purchasing processes for, e.g. catering, leisure, insurance, accommodation services,
- commercial services – providing the opportunity to purchase local products, tourist equipment or souvenirs,
- cultural and entertainment services – providing access to cultural events such as museums, theatres, philharmonics, or cinemas,
- catering services – providing catering during tourist stays,
- accommodation services – providing temporary accommodation away from the usual place of residence.

In a brief analysis of the services presented above, we know their high complementarity. Each of these services strengthens tourist traffic and ensures the demand for other services. One of the basic human needs is a sense of security, provided by a roof over one's head. In the place of permanent residence, a person fulfils this need in his/her dwelling or house, while the tourist must have access to temporary rental accommodation. From the catalogue of services presented above, this is an essential service, which may be a reason for choosing or abandoning specific tourist destinations due to its high economic dimension. Generally, establishments are divided into (Han & Song, 2020; Lee et al., 2020; Navrátil et al., 2012; Rodríguez Rangel et al., 2020; Suárez-Vega & Hernández, 2020): hotels, motels, hostels, boutique hotels, guest houses, tour houses, hostels, youth hostels, bungalows, campsites and agritourism.

This study investigates the geographical dimension of tourist accommodation in Slovenia, Croatia, and Bosnia and Herzegovina and attempts a general synthesis of its spatial structure. This study assumes that the spatial distribution of the accommodation

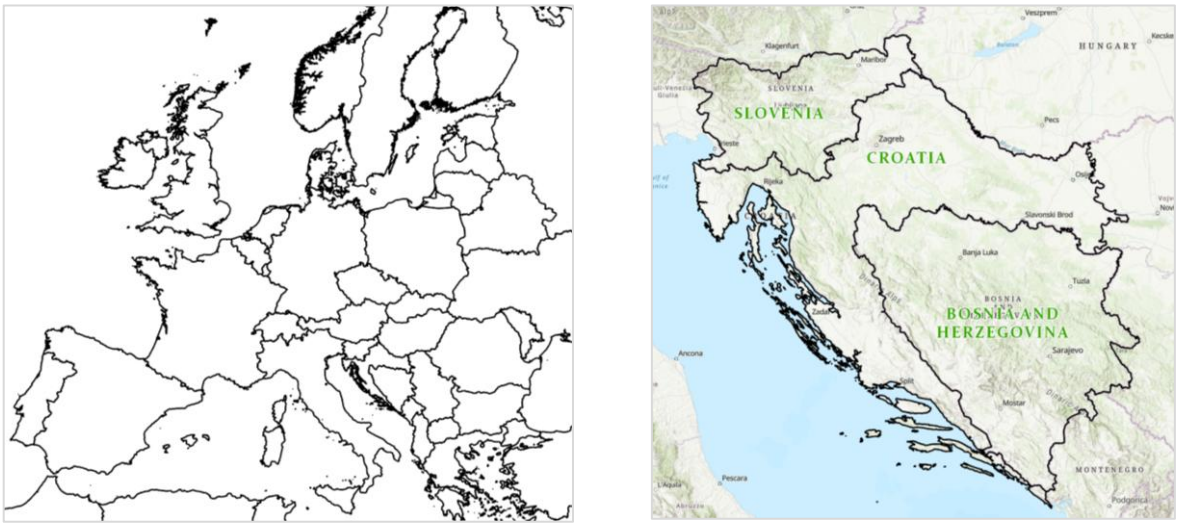
facilities allows evaluation of the potential popularity of different areas in each country. When a country is not well identified in terms of tourist attractiveness, the number of different accommodation establishments accumulated in specific destinations may suggest the high tourist value of these destinations. The analysis of the spatial distribution of accommodation facilities requires geolocalisation data on these facilities. The acquisition of such data is not always quick and free of charge. Often, data on the location of accommodation facilities are based solely on administrative address data. As a result, geographical coordinates are missing, and a sometimes cumbersome procedure for obtaining such coordinates is necessary. This research proposes to use open-type data provided by OpenStreetMap. These data are the so-called Point-of-Interest (POI), which contain information on geographic coordinates and the type of, e.g. fire station, post office, library, prison, courthouse, university, school, kindergarten, hospital, theatre, night club, cinema, park, swimming pool, tennis court, restaurant, pub, bakery, shop, bank, castle, tourist information and of course many types of accommodations. In conclusion, the research is based on the use of POI points concerning tourist accommodation facilities in Slovenia, Croatia, Bosnia and Herzegovina using a GIS tool: Kernel Density Estimation and Empirical Bayesian Kriging.

Points-of-Interest is cartographically mapped in geographical space and is uniquely associated with different aspects of human life (Liu et al., 2020; Wu et al., 2021). According to (Milias & Psyllidis, 2021), Points of Interest are available from several internet sources, 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). There is a broad literature available on the geographic application of GIS tools and POI points (Cai et al., 2021; Jia et al., 2018; Liu et al., 2020; Lu et al., 2020; Milias & Psyllidis, 2021; Vestal et al., 2021; Wu et al., 2021; Yu and Ai, 2014).

Materials and methods

Study area. The spatial coverage of the presented study is limited to the borders of three countries; Slovenia, Croatia, Bosnia, and Herzegovina, which are located in South Europe. These countries were part of Yugoslavia (before 1991), so they have a shared history, but today they are developing independently, with Slovenia and Croatia being members of the European Union and Bosnia and Herzegovina not being. The reasons for choosing these countries were, on the one hand, territorial proximity (these countries border each other) and access to the Adriatic Sea (as a fundamental factor for the development of tourism services). On the other hand, these countries are fundamentally different in terms of surface area, population, and, above all, unequal access to the sea. Both Slovenia and Bosnia and Herzegovina have very little access to the Adriatic Sea, which for the most part forms Croatia's southern border; hence, the country relies heavily on tourism. In the context of the spatial distribution of accommodation analysis, such a definite difference between countries may give interesting and fundamentally

different results. It seems natural that it will be substantially different for Bosnia and Herzegovina and Slovenia, which have limited access to the sea (Fig. 1.)



a) b)

Fig. 1. Study area: (a) Location in Europe; (b) Slovenia, Croatia, Bosnia, and Herzegovina
Source: Own study

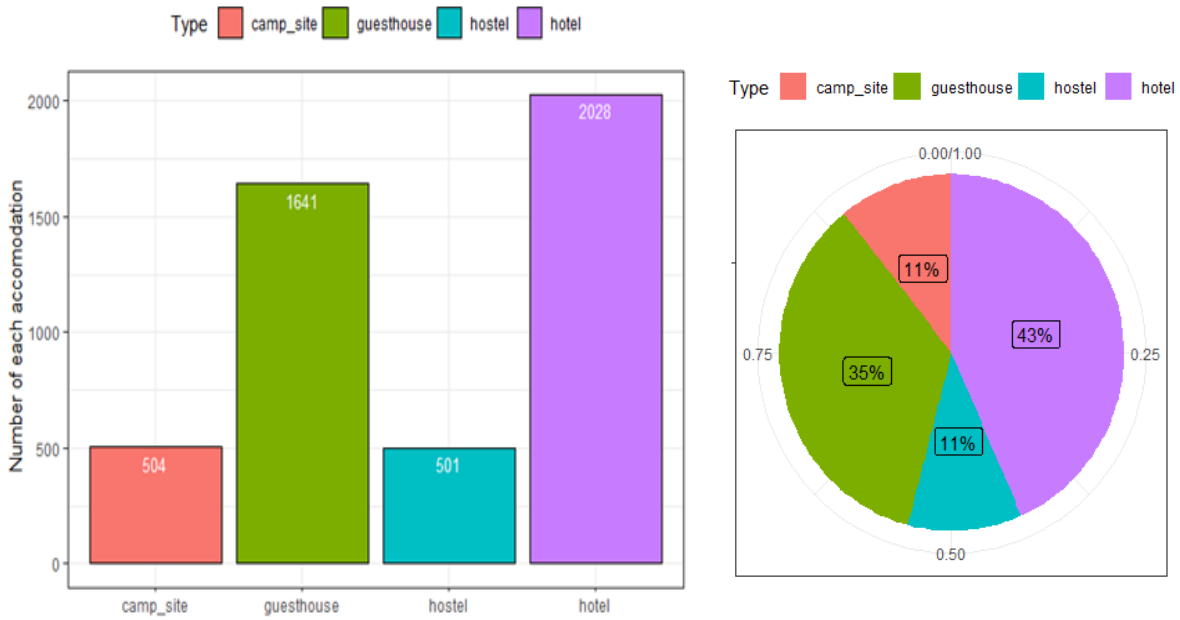
Data description and preliminary analysis. One of the study's primary objectives is to demonstrate that Point-of-Interest (POI) is a cheap (in principle free), fast, and reliable data source on the spatial heterogeneity of accommodation facilities in different countries. POI data were collected from OpenStreetMap (OSM) through the Geofabrik portal. According to Geofabrik (Geofabrik, 2022), free data encourage creativity and innovation and allow many people to contribute their ideas. However, for daily use, free data has tangible and pragmatic benefits: where data, format specifications, and software are open to everyone, where worldwide communities work with the same data, many problems that one encounters have already been solved by someone else, and the solution can be found. The data was downloaded on 31 March 2022. OpenStreetMap divides POIs, relating tourist accommodation into hotels, motels, bed and breakfast, guesthouses, hostels, chalets, hostels, camping, mountain hut, and camping site. Table 1 shows the accommodation facilities used in this study and their description.

4674 POIs related to tourist accommodation were downloaded from OpenStreetMap for Slovenia, Croatia, and Bosnia and Herzegovina. The details of the data collected, together with its visualisation, are shown in Figure 2. Most are hotels (2028), followed by guesthouses (1641) and a similar number of hostels (501) and campsites (504) (see Fig.2.a). Hotels were found to be 43%, guest houses 35%, and hostels and campsites 11% each. The level of diversification of different accommodation facilities in each surveyed country is shown in Figure 3.

Table 1. Description of variables

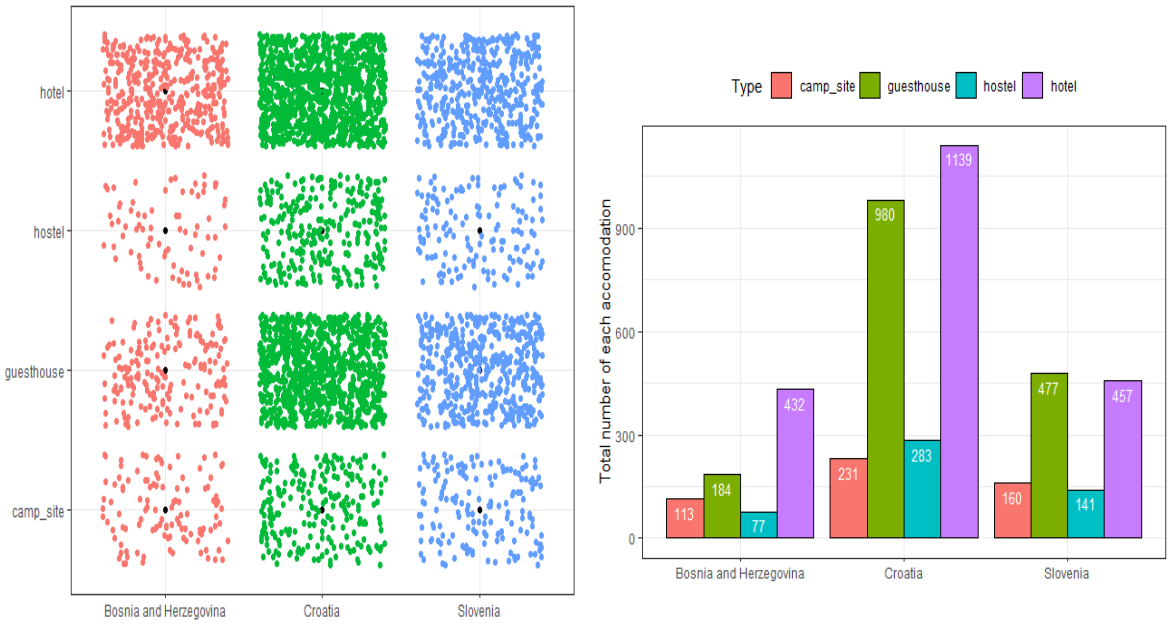
POI Types	POI Description
Hotel	Buildings with at least ten rooms, with most places in single and double rooms, provide a wide range of services related to customers' stay.
Hostel	It is cheaper than a hotel and differs in the number of beds in rooms, bunk beds and sharing (e.g. kitchen, bathroom).
Guesthouse	Rooms in dwellings and houses (excluding collective accommodation facilities) and adapted farm buildings owned by farmers, rented out for overnight stays for a fee.
Campsite	Guarded sites provide accommodation in tents, camper vans and caravans, preparing meals, parking cars, and providing services related to clients' stay; these sites may also provide accommodation in tourist cabins or other permanent facilities.

Source: Own study



(a) (b)

Fig. 2. Touristic accommodation in Croatia, Slovenia, and Bosnia and Herzegovina:
(a) Total number of each accommodation type;
(b) Percentage of each accommodation type
Source: Own study



(a) (b)

Fig. 3. Touristic accommodation in Slovenia, Croatia and Bosnia and Herzegovina: (a) Visualization of the volume of different types of accommodation in each country; (b) Total number of each type of accommodation type in each country
Source: Own study

Figura 2 (a) shows the volume visualisation of different types of touristic accommodation in Slovenia, Croatia and Bosnia and Herzegovina. This type of graph provides a good visual representation of the differences in numbers for each country and each type of accommodation establishment (without specifying their numbers). Bosnia and Herzegovina bases the vast majority of its accommodation services on hotels; the number of others is low. The structure of hotel facilities in this country is probably due to the limited access to the sea. Therefore, there are no distinctive seaside hotels, which are very different from typical business hotels. Croatia and Slovenia are dominated by seaside hotels and guesthouses, while the number of hostels and camping sites is much smaller. According to Figura 2 (b), Croatia has the highest number of hotels (1139) and guesthouses (980). Although the number of hostels and campsites is almost twice as high as in Slovenia and Bosnia and Herzegovina, they represent a small proportion of accommodation. Surprisingly, in Slovenia, we have more guesthouses than hotels. Bosnia and Herzegovina has only 77 hostels, although it is almost twice as large as Slovenia.

The data analysis (POI point) verified the assumption of the random spatial distribution of accommodation facilities in each country analysed. The Average Nearest-Neighbor method (Table 2) and Spatial Autocorrelation with Moran's Global Statistic I (Table 3) were applied.

Table 2. Average Nearest-Neighbor

	Slovenia	Croatia	Bosnia and Herzegovina
Observed Mean Distance (metres)	2221,1989	951,9488	1766,1387
Expected Mean Distance (metres)	9149,2042	5425,9938	6941,7250
Nearest Neighbor Ratio	0,242775	0,175442	0,254424
z-score	-50,908377	-80,942641	-40,493989
p-value	0,000	0,000000	0,000000

Source: Own study

Table 3. Spatial autocorrelation with Moran's I global statistic

	Slovenia	Croatia	Bosnia and Herzegovina
Moran's Index	0,118536	0,132821	0,153844
Expected Index	-0,000810	-0,000380	-0,001242
Variance	0,000127	0,000043	0,000222
z-score	10,599161	20,387262	10,397824
p-value	0,000000	0,000000	0,000000

Source: Own study

Given the z-score (Table 2), it is a less than 1% likelihood that this cluster pattern accommodation in chosen countries could result from random chance. The results of spatial autocorrelation presented in Table 3 allow us to check the dispersion of facilities in individual countries and verify the hypothesis of clusters of attribute values. Obtained from OpenStreetMap, the dataset does not value the different types of accommodation. In order to apply Moran's global statistic I, the code value of a particular type of accommodation facility from OpenStreetMaps was used. It was also confirmed that the z-score value means there is a less than 1% likelihood that this clustered pattern accommodation in chosen countries could result from random chance.

Methods

The Kernel Density Estimation (KDE) and Empirical Bayesian Kriging (EBK) were used to visualise spatial heterogeneity of accommodation in Slovenia, Croatia, Bosnia, and Herzegovina.

KDE aims to generate a smooth density surface of point events over space by computing the event intensity as density estimation and further discovering the spatial heterogeneity or inconsistency of the geographical process (Yu and Ai, 2014). Using the kernel density method, an arbitrary spatial unit of analysis can be defined that is homogeneous for the entire area, making comparison and classification possible. KDE involves placing a symmetrical surface over each point, evaluating the distance from the point to a reference location based on a mathematical function, and then summing the

value for all surface points for that reference location (Jia et al., 2018). The density estimate (KDE) can be calculated using the formula at an (x, y) location to predict the density (ArcGis, 2021):

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

$$\text{For } dist_i < radius$$

where:

- i = 1,…,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 location (x, y)

Empirical Bayesian Kriging, is one of the kriging techniques which assumes that at least some of the spatial variability observed in natural, social or economic phenomena can be modelled by random processes with spatial autocorrelation, and requires explicit modelling of spatial autocorrelation. The basic assumptions of kriging: spatial continuity, spatial autocorrelation, stationarity, normal distribution, no global trends, spatial clustering.

Kriging uses a semivariogram, a function of the distance and direction that separate two locations, to quantify the spatial dependence in the data. A semivariogram is constructed by calculating half the average squared difference of the values of all pairs of measurements at locations separated by a given distance h. The semi-variogram is plotted on the y axis against the separation distance h (Krivoruchko, 2012). EBK differs from classical kriging methods by accounting for the error introduced by estimating the semivariogram model. This is done by estimating and then using many semivariogram models rather than a single semivariogram. This process entails the following steps (Krivoruchko, 2012):

- A semivariogram model is estimated from the data.
- Using this semivariogram, a new value is simulated at each input data location.
- A new semivariogram model is estimated from the simulated data.

The weight for this semivariogram is then calculated using the Bayes rule, which shows how likely the observed data can be generated from the semivariogram. For a given distance h, empirical Bayesian kriging supports the following semivariograms:

- Power $\gamma(h) = \text{Nugget} + b|h|^{\alpha}$ (2)
- Linear $\gamma(h) = \text{Nugget} + b|h|$ (3)
- Thin Plate Spline $\gamma(h) = \text{Nugget} + b|h^2|*ln(|h|)$ (4)

Empirical Bayesian Kriging (EBK) models do not require specification of the prior distributions for the model parameters; allow moderate local and large global data non-stationarity; locally transform data to Gaussian distribution, if needed; allow for varying measurement error; use covariates, and work reasonably fast and produce reliable outputs with default parameters (Krivoruchko & Gribov, 2019). Empirical Bayesian Kriging is a conglomerate of two geostatistical models: the intrinsic

random function kriging and the linear mixed model (Gupta et al., 2017; Oliver & Webster, 1990).

Results and Discussion

Figure 4 shows collected POIs from OpenStreetMap to visualise the spatial heterogeneity of their distribution across countries. At this stage, individual types of accommodation facilities have not yet been analysed. Figure 4 shows the most homogeneously distributed accommodation facilities in Slovenia. Of course, some clusters are visible; however, the number of areas where none of the selected 4 types of accommodation is identified is low. On the other hand, Croatia is characterised by a linear distribution of accommodation facilities accumulated along the coastline. It is clear that the further away from the sea, the density of accommodation facilities decreases significantly. We have a much lower density of analyzed POIs than Slovenia in the rest of the country. Bosnia and Herzegovina is characterised by a small number of accommodation facilities concentrated in a few essential locations.

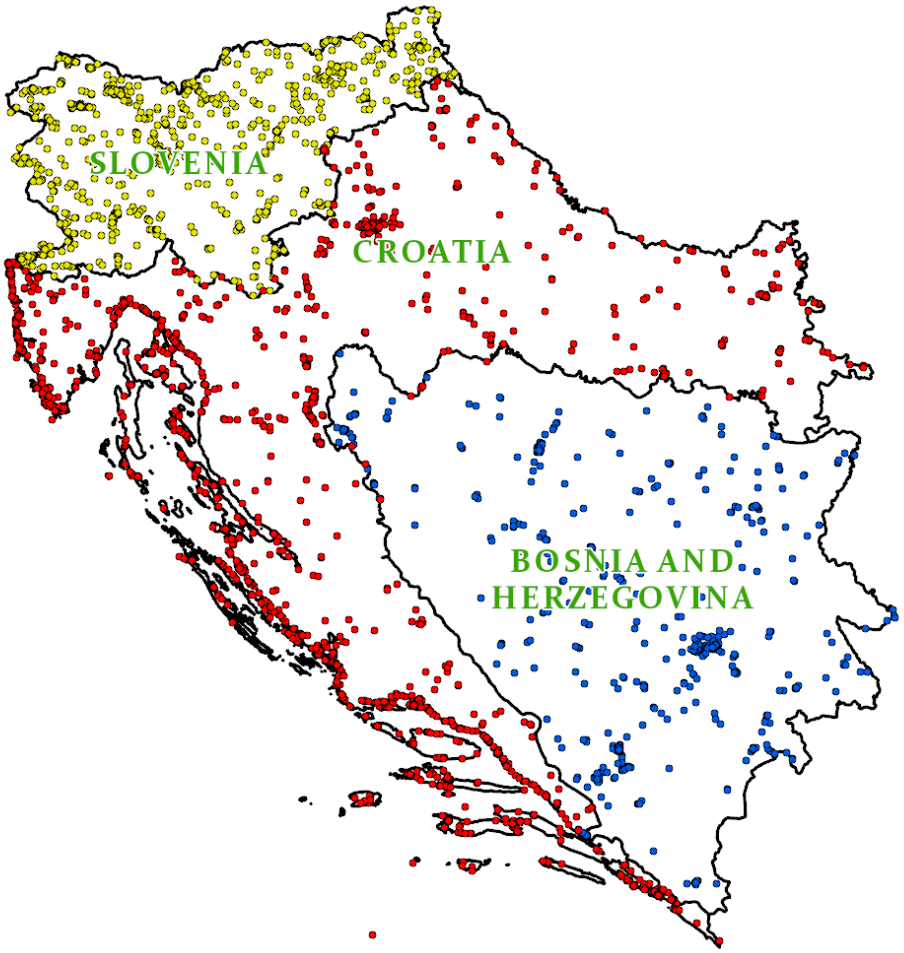


Fig. 4. Spatial heterogeneity of all POIs (all types of accommodation)
Source: Own study

This study assumes that the spatial distribution of POIs, which identify different types of accommodation, informs us about the potential tourist popularity of different areas in a country. In this sense, Croatia and Bosnia and Herzegovina have highly concentrated tourist attraction sites, with a significant part of their area providing practically little in the way of accommodation services. As a result, it is possible to focus on such underinvested accommodation facilities to determine whether the reasons are anthropogenic or environmental (terrain) in nature. This article does not address this issue. Slovenia, having the most even spatial distribution of POIs, shows that its tourism potential is not only based on leisure tourism associated with proximity to the sea.

Further modelling of tourist accommodation facilities was using ArcGIS Pro. In this next stage of the study, the kernel density analysis method (KDE) was applied to all points. This stage aims to explain in more detail the spatial confinement of accommodation facilities (without categorising them). Figure 5 shows the kernel density estimation for all analysed accommodation facilities in Slovenia, Croatia and Bosnia and Herzegovina.

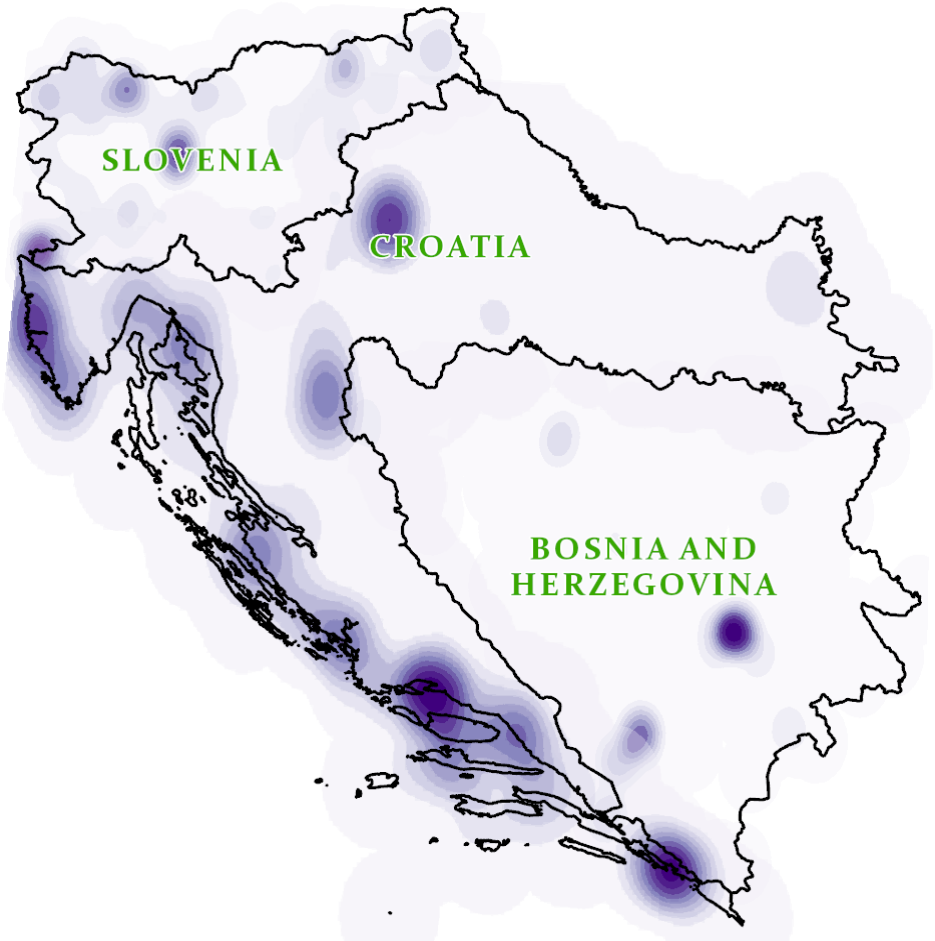


Fig. 5. Estimation of kernel density for all analysed accommodation facilities in Slovenia, Croatia and Bosnia and Herzegovina
Source: Own Study

In Croatia, areas of density of tourist accommodation are visible from the west of the coast, from the town of Poreč, through Rovinj to the southern edge of the Istrian peninsula and the town of Pula. A medium-density tourist accommodation can be seen around Rijeka, Zadar, and Sibenik. In Croatia, the highest density of tourist accommodation is in two places. The first of these can be found around Split (the heart of Dalmatia) and on the surrounding islands of Brač, Korčula and Hvar. The second is the Dubrovnik area. In Bosnia and Herzegovina, only two clusters of tourist accommodation density are visible: the capital Sarajevo and the capital of the Herzegovinian-Nereto canton, the city of Mostar. There are several areas of density in Slovenia, e.g. the area around Maribor, Radovijica, Tolmin, Postojna or the capital Ljubljana. The largest concentration of accommodation facilities is located in the coastal area of Slovenia, which is quite obvious.

So far the analysis has been based on all types of accommodation facilities. Further research considers differences in the spatial distribution of different accommodation facilities. Four types were selected: hotel, hostel, guesthouse and camp site (Data description chapter). The research was carried out using Empirical Bayesian Kriging modelling. The model used required the adoption of different weights for different accommodation establishments. To minimise subjective selection of weights, weights were set based on the percentage abundance of all types of accommodation establishments in all countries. The results of the analysis are presented in Table 2.

Table 4. Determination of weights for various touristic accommodation types

	Total numbers	Percentage	Weights
Hotel	2028	43%	43
Guesthouse	1641	35%	35
Hostel	501	11%	11
Camp site	504	11%	11

Source: Own study

The procedure of Empirical Bayesian Kriging was carried out for Slovenia (Fig. 6), Croatia (Fig. 7) and Bosnia and Herzegovina (Fig. 8).

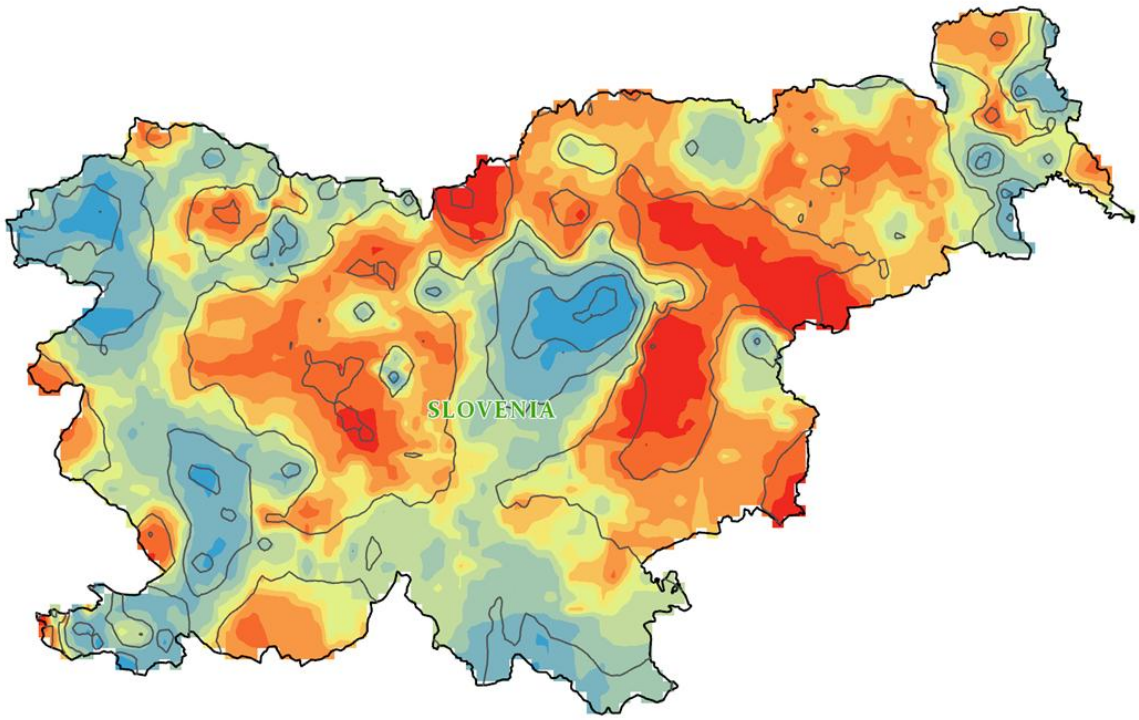


Fig. 6. Empirical Bayesian Kriging of accommodation in Slovenia
Source: Own Study

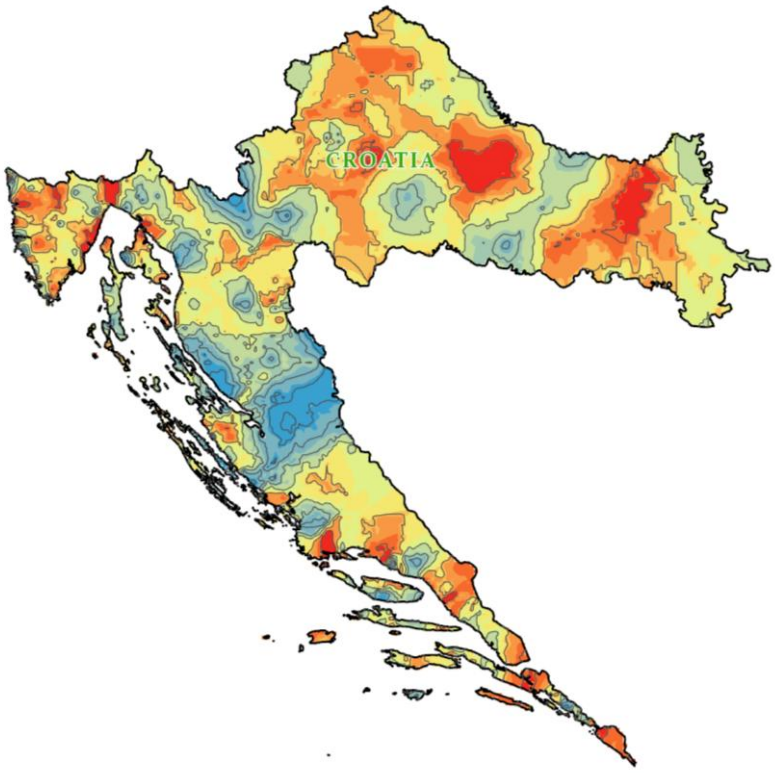


Fig. 7. Empirical Bayesian Kriging of accommodation in Croatia
Source: Own Study

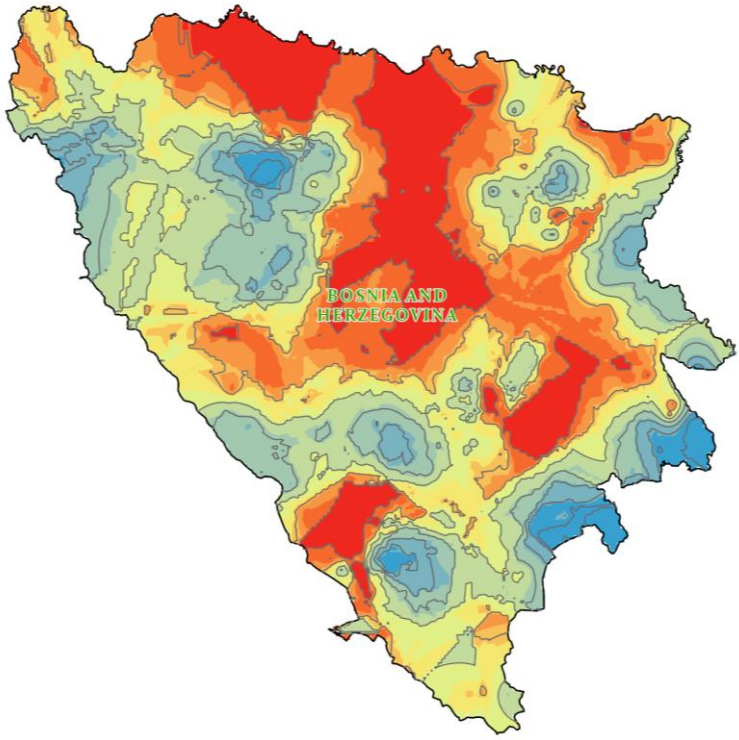


Fig. 8. Empirical Bayesian Kriging of accommodation in Bosnia and Herzegovina
Source: Own Study

Graphical interpretation of the obtained results in Fig. 6, Fig. 7 and Fig. 8 results from the adopted weighting system (Table 4). In each of the analysed countries, red and orange colours symbolise hotels and guesthouses respectively, while light green and blue indicate areas of the dominance of hostels and campsites. Modelling using different accommodation facilities and Empirical Bayesian Kriging is a more accurate method than Kernel Density Estimation. The use of POI as a fast and accessible source of data on accommodation facilities allows a simplified spatial analysis of the heterogeneity of accommodation facilities in a fast and cost-effective way. A detailed analysis taking into account the type of tourist attractions (cultural, natural, or business) is not the purpose of this study.

Conclusions

Tourism is an important bridge between economics and the environment in socio-economic geography. In general, tourism is associated with the possibility of contact with nature and the culture and history of a given society. It seems that an increase in the intensity of accommodation in particular areas of the studied region or country is closely correlated with the tourist attractiveness of that place. If the research is conducted by someone familiar with the region's specifics, the spatial distribution of accommodation facilities and the differences in this distribution are obvious. On the other hand, if the research is conducted in an environment that has not been autopsied, there are limited possibilities for accurate and quick analysis. The proposed

combination of points of interest (POI point) with basic GIS analysis models (Kernel Density Estimation and Empirical Bayesian Kriging) provides a fast and cheap procedure. The presented research represents the initial phase of the analysis of tourist accommodation services in Slovenia, Croatia, and Bosnia and Herzegovina. The analysis constructed in this way may be the beginning of more detailed studies taking into account the historical, political, cultural, and environmental specificities of the selected countries.

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