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SPATIAL DIFFERENTIATION OF TOURIST INFRASTRUCTURE IN THE RIPARIAN ZONE OF THE BIAŁE LAKE (MIDDLE-EAST POLAND)

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K e y w o r d s: tourist infrastructure, land use, cartographic modelling.

A b s t r a c t

The aim of this study is to analyze the degree of impact of different forms of tourist infrastructure on the natural environment of the riparian zone of Białe Lake. The spatial variation of the index of impact on environment was calculated (MIKA 2004, FURGAŁA et al. 2010) depending on the distance from the shoreline. The analysis was carried out in fixed minimal mapping units and in the buffer zones with segmentation based on shoreline type criterion and distance from the lake.

ZRÓŻNICOWANIE PRZESTRZENNE ZAGOSPODAROWANIA TURYSTYCZNEGO STREFY BRZEGOWEJ JEZIORA BIAŁEGO (POLSKA ŚRODKOWO-WSCHODNIA)

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S ł o w a k l u c z o w e: infrastruktura turystyczna, użytkowanie ziemi, modelowanie kartograficzne.

A b s t r a k t

Celem pracy jest analiza stopnia oddziaływania różnych form zagospodarowania turystycznego na środowisko przyrodnicze strefy brzegowej Jeziora Białego. Określono przestrzenne zróżnicowanie wskaźnika obciążenia środowiska przyrodniczego (MIKA 2004, FURGAŁA i in. 2010) w zależności od odległości od linii brzegowej. Analizę przeprowadzono w polach podstawowych jednakowej wielkości oraz w strefach buforowych posegmentowanych według kryterium typu użytkowania linii brzegowej i odległości od jeziora.

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Introduction

Waters and their shore zones are attractive element and play an important role in recreation and holidays. They are one of the most valuable tourism attractions because of their vivid natural landscape and high quality environment (HALL and HÄRKÖNEN 2006, BAHAR and KOZAK 2008). Besides coastal tourism, a large number of lake and wetland destinations can be found worldwide. Most of those lakes destinations are very different in terms of morphology, climate and so on. However, they show also various similarities concerning their characteristics, development potentials and the threats they are exposed to, including those caused by tourism (GATTENLÖHNER 2006).

One of the major causes of the degeneration of environment is unplanned and unchecked developmental activities in the tourist destinations. Tourism also results in disorderly and scattered tourist facilities which generally are not eco-friendly and that leads to aesthetic degradation of the landscape (SHRUTI 2010). Successful tourism development depends on a proper balance of the use of environmental resources and the negative environmental effects tourism might cause to the environment and nature (GATTENLÖHNER 2006).

The Łęczyńsko-Włodawskie Lake District is the only group of lakes in Poland located beyond the extent of the ice sheet in the last glacial period. The Lake District is one of the most important tourist areas in mid-eastern Poland. An analysis of tourist attractiveness of the Łęczyńsko-Włodawskie Lake District shows that area of Białe Lake is classified in the highest attractiveness degree (KRUKOWSKA and KRUKOWSKI 2009).

Białe Lake covers an area of over 106 ha (it is 1616 m long and 806 m wide), and its maximum depth is 33.6 m. With the highest average depth (14.1 m) Białe Lake is the most capacious reservoir of the area. Its waters are classified as first class of water quality – "water for human consumption". The Lake's basin is formed on the chalk. Development of riparian vegetation in the Białe Lake is minimal; grater agglomerations of reed beds which primarily consist of Lesser Bulrush (*Typha angustifolia*) and Common reed (*Phragmites australis*) are formed only in the north-western and western parts of the lake. In other parts there are only small parts of reed beds. In lacustrine zone there are mainly beaches and meadows. From the south, to surrounding road, is adjacent forest complex of the Sobiborski Landscape Park.

Main aim of this study is to analyse the degree of impact of different forms of tourist infrastructure (facilities) on the natural environment of the riparian zone of Białe Lake. The spatial variation of environmental impact (MIKA 2004, FURGAŁA-SELEZNIOW et al. 2011) was determined depending on the distance from the shoreline. The analysis was carried out in buffer zones segmented by type of use the criterion of the shoreline and in hexagon mapping units.

Materials and Methods

The previously conducted research on landscape changes in the recreation area of Białe Lake (KRUKOWSKA et al. 2010) have shown a correlation between the changes the landscape of the analysed area, and an increasing tourist function. Transforming the landscape was characterized by a very dynamic growth of tourism development area, especially in the immediate vicinity of the lakes. In the years of 1980–2005 the built-up area occupied by accommodation increased by about 90%, and the area of recreational plots (summer houses) by about almost 1360%.

At present, the area around the lake is almost entirely developed for tourism and recreation. There are 101 accommodation facilities offering 7200 beds and about 1200 recreational plots with reception capacity for 5300 people. On the northern shore of the lake, a shopping centre with numerous catering and entertainment facilities and shops has developed (KRUKOWSKA et al. 2010)

In connection with such a large tourist pressure studies were undertaken on the differentiation of forms of tourist infrastructure of the Białe Lake and its use by selected forms of tourism and recreational activities. The basis for its determination was to separate areas with different forms of tourist use: tourist settlement, active recreation areas and other recreational areas. In order to determine the extent of their impact on the environment three different values of valuation were assigned (Table 1). The index of tourism infrastructure impact on lake' shoreline environment was used as proposed by MIKA (2004) and modified by FURGAŁA-SELEZNIOW et al. (2011). The index was calculated using the formula (MIKA 2004):

$$K = \frac{\Sigma P_i \cdot B_i}{P_o},$$

where:
K – index of tourism infrastructure impact on lake' shoreline environment;
P_i – area under different types of tourist use;
B_i – valuation score;
P_o – reference unit area.

In adopted method, the numerical ratio allows to classify the degree of environmental impact in the three-scale (Table 2).

Analyses were carried out in two types of mapping units:

1. Buffer zones designated every 100 meters from the shoreline to a distance of 1 km. In addition, every buffer zone area is divided into sectors, which are determined by criteria type of land use of the shoreline (beach, grassy area with access to water, grassy area with no access to water (reeds), grassy wetland area).

2. Fixed hexagon shaped units of 50 acres, covering area about 1 km around the lake. Geometric fields of the same size allow for comparability of results in terms of spatial analysis.

In all fields designated this way areas occupied by the different forms of tourist infrastructure were identified. Analyses were carried out in an ArcGIS 10 (ESRI) on the base of aerial photographs (available on the website www.geoportal.gov.pl), cadastral maps and stocktaking.

Table 1

Form of tourist use of shoreline zone and valuation of its impact on natural environment

Form of tourist use	Symbol (P_i) and type of area	Kind of impact	Valuation symbol (B_i) and score
Tourist settlement	P_1 – technogenic areas under permanent tourist use	permanent transformation of land use, denaturalization of environment, noise, litter, vehicles pollutions, wastewater and sewage	$B_2 = 5$
Active recreation areas	P_2 – beaches, marinas, water equipment rentals, piers, sports grounds, playgrounds, ground car parks, catering facilities	trampling and mechanical damage of plants, erosion of shores, litter, pollution of lakeshores, water turbidity and pollution, noise	$B_2 = 4$
	P_3 – tent fields, camp sites, bicycle trails	destruction of plants and soil cover, noise, litter, vehicles pollutions, wastewater and sewage	$B_3 = 3$
	P_4 – hiking trails, angling piers and sites	trampling and mechanical damage of plants, pollution, soil erosion, water turbidity and pollution	$B_4 = 2$
Other recreational areas	P_5 – recreational plots, green areas around tourist facilities, green areas around villages	Change to the type of use of green areas, noise, litter, wastewater and sewage	$B_5 = 1$

Source: according to FURGAŁA-SELEZNIOW et al. (2011), MIKA (2004)

Table 2

The ranges of index of tourism infrastructure impact on lake' shoreline environment

Class	Impact	Range of K value
I	significant	> 0.1
II	moderate	0.1–0.01
III	small	<0.01

Source: MIKA (2004)

Results and Discussion

The study led to the designation of 7 sectors (1S-7S) associated with a different type of the shoreline. Among these there were identified: three sectors of dominance beaches and occasional occurrence of grassy banks and aquatic vegetation (1S, 2S, 7S), two grassland areas with access to water and an occasional occurrence of rushes (3S, 6S), one sector of grassy banks with difficult access to water and beach (4S), and one sector of wetlands and grasslands rushes (5S) – Figure 1).

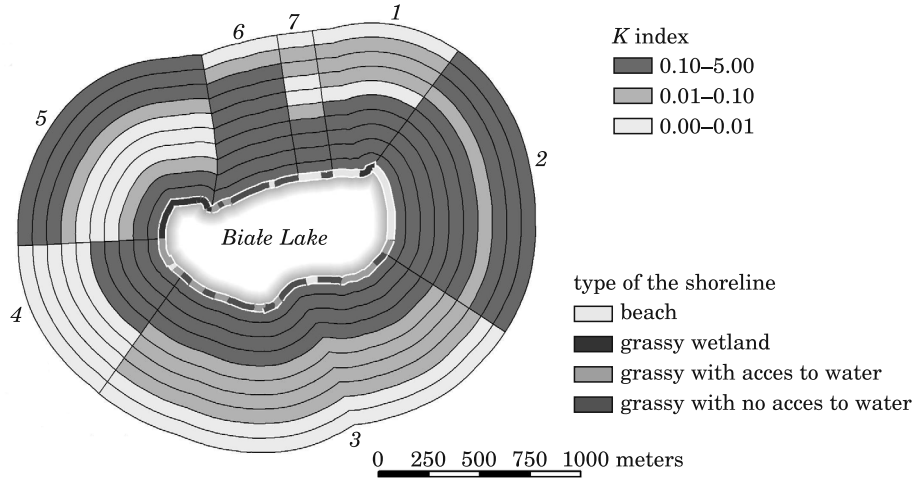

Fig. 1. Index of tourism infrastructure impact on lake' shoreline environment in sectors and buffer zones

The value of K index for the area around the lake (buffer zone 1 km) is 0.803 – that means that the impact on lake' shoreline environment is in the highest level – "significant". The lowest rate of $K = 0.082$ determined for S5 (difficult access to water), which corresponds to the "moderate" impact of tourist infrastructure. This zone covers an area of wet meadows adjacent to the lake from the NW (Table 3).

Other sectors have a "significant" level of the impact on the lake's shoreline environment and achieve values from 0.774 (S4) to 1.237 (S2). It can be seen that the values of K index are related to the type of shoreline. The highest values are associated with designated sectors of shoreline with beaches domination (S1 – 0.939, S2 – 1.237, S7 – 0.915), followed by grassland area with good access to water (S3 – 0.781, S6 – 0.891) and area of grasslands with difficult access to water (S4 – 0.774).

Table 3

K index values calculated for sectors and buffer zones

Buffer zone	*K* indeks							
	zone	sector 1	sector 2	sector 3	sector 4	sector 5	sector 6	sector 7
100	3.401	4.171	4.720	3.894	2.428	0.004	4.582	4.006
200	2.465	3.307	3.752	2.904	3.283	0.002	1.331	2.673
300	0.985	1.338	1.741	0.666	1.249	0.001	0.651	1.246
400	0.502	0.312	1.093	0.153	0.448	0.000	0.363	1.144
500	0.187	0.118	0.455	0.062	0.329	0.000	0.306	0.041
600	0.069	0.004	0.166	0.052	0.003	0.000	0.256	0.000
700	0.123	0.054	0.087	0.060	0.000	0.013	0.646	0.000
800	0.180	0.060	0.120	0.018	0.000	0.353	0.690	0.015
900	0.077	0.020	0.107	0.000	0.000	0.303	0.085	0.024
1000	0.039	0.000	0.131	0.001	0.000	0.138	0.000	0.001
Average	0.803	0.938	1.237	0.781	0.774	0.081	0.891	0.915

An important element of the studies is an analysis of the degree of tourist infrastructure impact on the environment in 100 m wide buffer zones. In this case, only the area covered by 900 and 1000 meters buffer zones (which reached *K* values, respectively 0.077 and 0.039), are classified in the second class degree of environmental impact ("moderate"). The highest level of environmental impact is associated with zones located in the nearest 100 and 200 m from the shoreline. *K* index in 100 m buffer distance was 3.401, and in the zone 200 m – 2.465 (Table 3).

As shown in Figure 1 the degree of environmental impact of tourist infrastructure decreases with the distance from the shoreline of the lake. K index reached the highest value in the zone 100 m in the sector S2 (4.720). Very high levels are also associated with sectors: S6 (4.582), S1 (4.170), S7 (4.005), S3 (3.893). The lowest value of *K* index in 100 m zone was observed in S5 (0.005) – Table 3.

By analyzing the spatial distribution of the index *K* calculated for each sector and distance zones it can be seen that the rate of environmental impact of tourist infrastructure is fitting-radial distribution (centric), with its value decreasing with the distance from the shoreline.

A steady decline of *K* index value is especially marked for a distance of 500 m from the lake (Figure 2). Apart from this buffer distance the environmental impact of tourist infrastructure remains at the same level of slightly declining trend. On this background, two extreme cases can be described. First, for the shoreline with difficult access to the shore (S5) – the rate is relatively low (as for the study area) to a distance of 700 m, where it can be marked by slight

growth, resulting from the existence of the buildings of Okuninka village. On the other hand, we have cases of S6 and S2 sectors, with high availability and a favorable shoreline relaxation – here there are the intensive development of 800 meters and beyond.

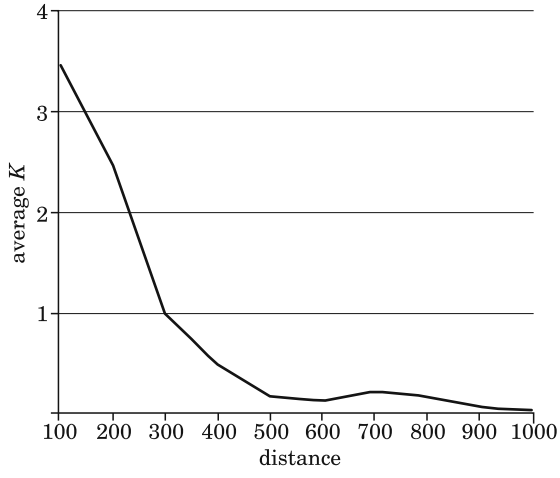

Fig. 2. Relations between average *K* index and distance from lake shoreline

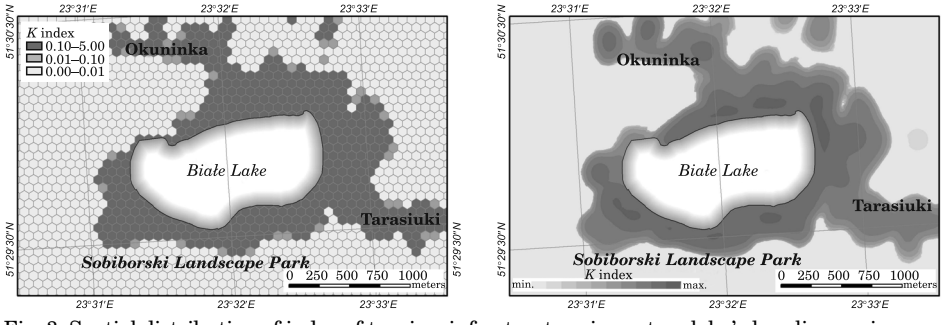

Fig. 3. Spatial distribution of index of tourism infrastructure impact on lake' shoreline environment in minimal mapping units (hexagons) – left; Local trends in the spatial distribution of Index *K* (isopleth map) – right

Such an arrangement of tourist infrastructure is the result of the existence of the village Okuninka built at some distance from the lake, and above all, build the road surrounding the lake. This road strongly determines the radial spread of the tourist infrastructure. The only one limitation (barrier) is the area of the Sobiborski Landscape Park, which covers the area of wetland forests, located south of the lake.

The above analysis were also carried out in other mapping units – 50 acres hexagons. On that base the map of detailed spatial variation of index

of tourism infrastructure impact on lake' shoreline environment was prepared (Figure 3). The area of the highest values of *K* index can be designated – it extends along the build-up area of Okuninka and Tarasiuki villages. As a result of further analysis an isopleth map was obtained (Figure 3) that shows the spatial distribution of the local tendency of tourist infrastructure impact.

Conclusions

One of the major causes of the degeneration of environment in areas near lakes is unplanned and unchecked development of tourist facilities. These infrastructure is often created near or on the banks of a lakes.

The example of Białe Lake gives an overview of the effects of uncontrolled land development. Intensive infrastructure development near the shoreline on the one side has a negative effect on landscape aesthetics, on the other hand – it decreases the availability of this zone for other tourists. This leads to the overpopulation of certain areas. The negative situation was additionally intensified by existing of the road encompassing the lake near the shoreline, which resulted in development of tide ring of infrastructure.

In conclusion it should be noted that the nature of the Białe Lake and its shoreline has caused (not often found) intensity of tourist infrastructure development. That's why we can talk about almost extreme anthropogenic influence of the lake and the resulting environmental hazards. It should be kept in mind that agglomerations of tourism infrastructure are a threat to the local ecological systems. It's mainly because of waste, sewage waters, emission of CFC, CO2 and other greenhouse gases, which are often a serious problem in most of the tourist destinations all over the world.

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