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TOURISM IMPACT ON THE SHORE ZONE OF LAKES: A CASE STUDY OF FOUR LAKES OF MRĄGOWO LAKELAND*

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Abstract

Lakes are an essential element of human well-being and lake tourism is becoming an increasingly important branch of the tourism industry worldwide. Numerous investments in tourism infrastructure, located in the shore zone of lakes, attract more and more tourists. This phenomenon has a negative impact on the natural environment of the lakes. Their shore zone, which is an ecotone zone, is particularly vulnerable to human pressure. Four lakes were selected for the study. They differed substantially in their use and land cover in the shore zone. GIS datasets were used for the analysis. A set of indices was proposed to monitoring the lake shore zone tourism load. The shore zone of the lakes with a high share of the residential buildings and the forest was the most affected by tourism. The shore zone of reservoirs with a high share of agricultural land and non-forest semi-natural areas was less loaded.

Introduction

Tourism is a complex phenomenon and its new forms are still appearing. Many of them are based on the tourist resources of the water environment and its nearest surroundings. These include sea, river and lake tourism (JENNINGS 2003, *Tourism and global…* 2006, *Lake tourism…* 2006, VENOHR et al. 2018). In the mid-twentieth and early 2000s there was a significant increase in interest in water tourism, leisure, recreation and sport (JENNINGS 2007). Water tourism is developing in two directions. The

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first one is the so-called nature-based tourism. It is defined as tourism "associated primarily with the direct use of an almost untouched natural environment" (KUENZI and MCNEELY 2008, WOLF et al. 2019). Tourists undertake activities such as bird watching, canoeing and nature hiking (JENNINGS 2007, ROCHELLE et al. 2015). Nature-based tourism often supports the development of rural areas (LANFRANCHI et al. 2014, LIU et al. 2018). In Canada, lake tourism is often seen as a synonym for rural tourism as a result of its numerous lakeside cottages (SMITH 2003, TUOHINO 2015). The second direction is tourism related to destinations (especially cities) located by water bodies, based on the infrastructure offered by them. Tourism is one of the important functions of cities (BIAGI et al. 2019). The importance of this function is growing, which results from the fact that they are more and more frequently chosen for tourist destinations (ŁAPKO and PANASIUK 2019). Although lakes have long been an important area of recreational and tourism activity, they were not the subject of international tourism research until the beginning of the 21st century (HADWEN et al. 2005, *Lake tourism*… 2006, TUOHINO 2015).

In recent decades, demand for tourism and leisure services has steadily increased worldwide. The development of tourism, in addition to its contribution to the national economy is a major force affecting negatively basic environmental resources (air, water, biodiversity, soil and land) both in tourist destinations (locally) (DORNIER and MAURI 2018, TRANCOSO GONZÁLEZ 2018, among others) and globally (BUCKLEY 2011). The increase in some areas of tourism (e.g. cruise tourism) and the increased frequency and seasonality of holiday trips have a severe impact on the environment at regional and local level (BRIDA and ZAPATA 2009, CARIC and MACKELWORTH 2014, BARNETT et al. 2018, MACNEILL and WOZNIAK 2018). Major tourist destinations face challenges in terms of water supply, waste management and waste water treatment. In addition, changes in land use/land cover (LU/LC), air and noise pollution from the means of transport and landscape disturbances caused by the constantly increasing surface area of built-up land are also quite common consequences of tourism development (ASHA 2013, ATZORI et al. 2018, TRANCOSO GONZÁLEZ 2018). According to GÖSSLING (2002), there are five main aspects of environmental change related to tourism: change in land use and land cover, excessive energy consumption, reduction of biodiversity and introduction of invasive species, spread of diseases and changes in the perception and understanding of the natural environment.

The shore zone is an ecologically and economically important component of lake ecosystems. The natural shores are a habitat for aquatic and terrestrial organisms, affect the cycling of nutrients and organic matter

between land and water and reduce soil erosion (SCHMIEDER 2004). The recreational and aesthetic potential of the lake shores makes them attractive for human settlement, hence the development of settlement is often concentrated around the lakes (SCHNAIBERG et al. 2002, WALSH et al. 2003). The problem, concerning protected areas, was described in relation to conflicts resulting from excessive pressure from the growing number of tourists (WHITELAW et al. 2014, SPENCELEY 2017).

Most forms of tourist activity are not environmentally friendly (BUCKLEY 2011, ASHA 2013). Research on lakes and other water landscapes in the context of tourism development was relatively rare at the beginning of the 21st century, especially in the field of tourism geography (TUOHINO 2015). Most previous studies in this field have focused on the direct impact of tourism on water bodies (BURGIN and HARDIMAN 2011, DOKULIL 2014, TANDYRAK et al. 2016). RAMAZANOVA et al. (2019) made a number of important observations on the indirect effects of lake tourism, with particular emphasis on the accommodation sector in the vicinity. The impact of tourism development on the shore zone of the lake is an important research topic, but publications in this field are scarce (FOLGADO-FERNÁNDEZ et al. 2019). The aim of our study was to assess the load of tourism on the shore zone of the selected lakes of the Mrągowo Lakeland. The lakes selected for the study differed in the type of land use/cover around the reservoir. Moreover, the aim of the study was to propose a complex method of assessing the impact of tourism on the shore zone of lakes on the basis of a set of indices, in connection with the LU/LC type around lakes.

Material and Methods

Study area

The study focused on four lakes located in the Mrągowo Lakeland (Masurian Lakeland, North-Eastern Poland, Central Europe), in the district of Mrągowo. Czos Lake (area 279.1 ha) is situated within the administrative boundaries of Mrągowo city (Figure 1). The western and northern part of its shore zone (more than two thirds) is a typical urban area. The southern edge of the lake is protected under the Natura 2000 network (PLB280008 Puszcza Piska). Probarskie Lake (201.4 ha) is separated from the southern edge of Lake Juksty by about 300 meters wide strip of land. The national road No. 16 and railway tracks run in this strip. The lake is located in the buffer zone of the Mazurian Landscape Park. It is a typical lake located in rural areas (more than 20% of the

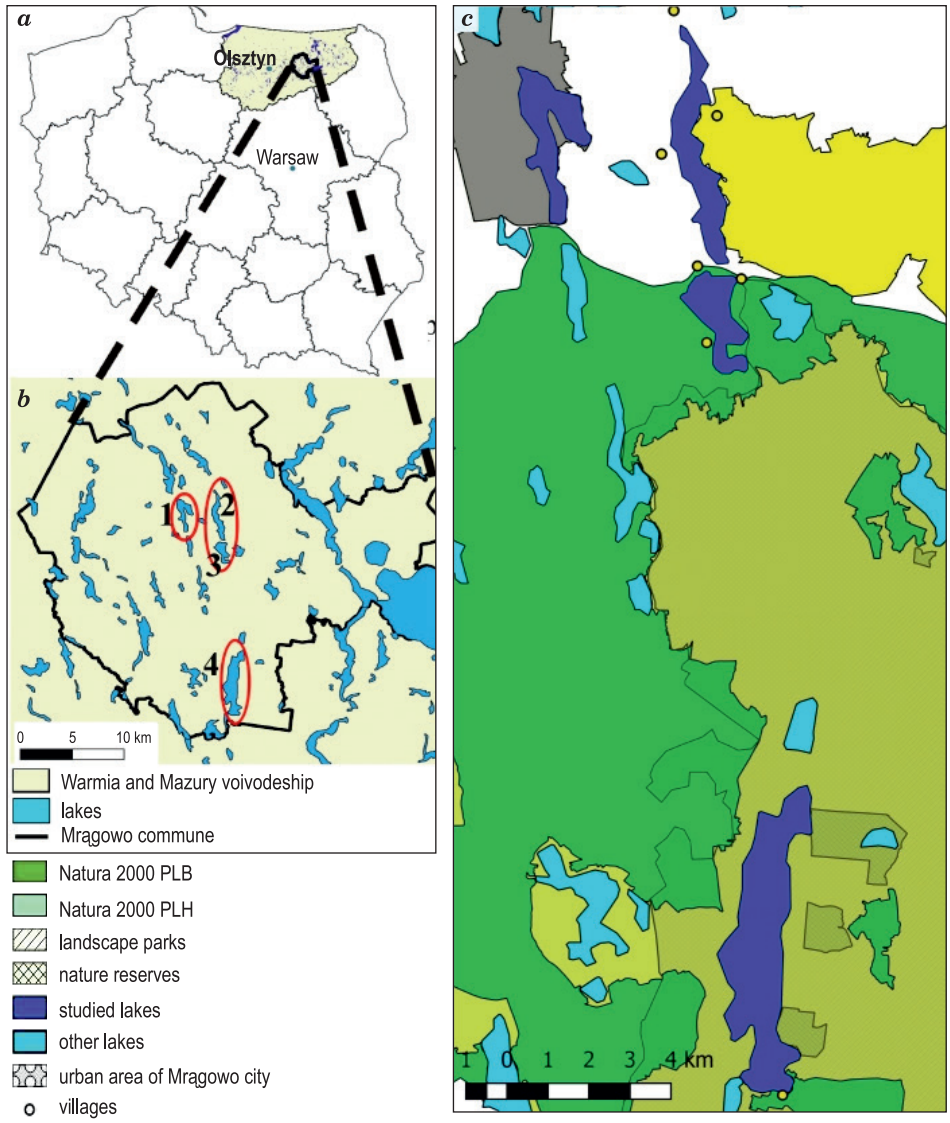

Fig. 1. Mrągowo District with studied lakes; *a* – warmińsko-mazurskie voivodship; *b* – Mrągowo District; *c* – study area

shore zone is covered by rural housing). In the close vicinity of the shoreline of the lake there are four villages: Kosewo, Probark, Nowy Probark and Jakubowo. Lake Juksty (330 ha), located about 3 km east of Lake Czos, is protected within the Protected Landscape Area of the Legińsko-Mrągowskie Lakes and its eastern edge belongs to Natura 2000 network (Masurian Tortoise Refuge Baranowo PLH 280055). Its shore zone is

mainly covered by semi-natural and agricultural land. The built-up areas cover less than 1.5% of the shore zone of the lake. The largest of the studied lakes, Mokre (814 ha), is located about 10 km south of Lake Probarskie and is situated entirely in the Mazurian Landscape Park. In addition, a fragment of the shore zone (along a 1.7 km long shoreline) in the south-eastern part of the lake is protected as a nature reserve (the Reserve Royal Pine). The north-east edge of the lake belongs to nature reserve Krutynia.

Fig. 2. The different landscape types of the lake shore zone: *a* – urban (Lake Czos); *b* – rural (Lake Probarskie), *c* – semi-natural (Lake Juksty), *d* – forest (Lake Mokre)

Mokre Lake is also protected under the Natura 2000 network (PLH280048 Ostoja Piska and PLB280008 Puszcza Piska). Approximately 85% of the shore zone is covered by forest and less than 5% is occupied by built-up areas (mainly belonged to the Zgon village). Figure 2 shows the different landscape types in the lakeshore zone.

Methodology

In the assessment of the tourist attractiveness of studied lakes, the scoring method was applied, which qualifies water reservoirs to appropriate classes of tourist and recreational attractiveness on the basis of the number of points awarded for the value of selected morphometric parameters (Deja 2001). Seven morphometric features of the lake were taken into account: surface area, mean depth, shoreline development index, elongation index, index of the shore zone cover by vegetation [%], index of the lake

surface area cover by water vegetation [%], index of the shore zone cover by forest [%]. The point values for the individual indices were in the range from 0 to 6. Table 1 illustrates the classification into attractiveness classes.

Table 1

Classes of lakes attractiveness depending on the evaluation score (DEJA 2001)

Attractiveness level (in points)	Class of attractiveness
Unattractive ≤ 10	IV
Moderately attractive 10.1–16	III
Attractive 16.1–22	II
Very attractive > 22	I

In order to assess the impact of tourism on the lake environment, an index defining the impact of tourism development on lake shores was created (MIKA 2004). While constructing this index, it was necessary to identify various types of areas used by tourism in the lake shore zone. In order to differentiate the character and directions of tourism impact on the shore zone of lakes, an evaluation system was created (Table 2).

Table 2

Forms of tourist use of the natural environment of lakes shore zone and evaluation of their effect (according to MIKA 2004, FURGAŁA-SELEZNIOW et al. 2010)

Forms of tourist use	Type of area	Area symbol (Pi)	Type of effect	Bi valuation score
Tourist settlement	technogenic areas under permanent tourist use	P1	permanent transformation of land use, denaturalization of environment, permanent changes of landscape, noise, litter, vehicles pollutions, wastewater and sewage	5
Active recreation areas	beaches, marinas, water equipment rentals, piers, sport grounds, playgrounds, car parks, catering facilities	P2	trampling and mechanical damage of plants, erosion of shores, litter, pollution of lakeshores, water turbidity and pollution, noise	4
	tent fields, camp sites, bicycle trails	P3	destruction of plants and soil cover, noise, litter, vehicles pollutions, wastewater and sewage	3
	hiking trails, angling piers and sites, paths	P4	trampling and mechanical damage of plants, pollution, soil erosion, water turbidity and pollution	2
Other recreational areas	recreational plots, green areas around tourist facilities, green areas around villages	P5	change to the type of use of green areas, noise, litter, wastewater and sewage	1

The index of the impact of tourism infrastructure on the environment of the lake shore zone was applied in accordance with the proposal of MIKA (2004) and modified by FURGAŁA-SELEZNIOW et al. (2010). The index was calculated according to the formula (MIKA 2004):

$$K = ((\sum Pi \cdot Bi))/Po$$

where:
K – index of the impact of tourism on the shore zone of lakes (tourism impact index)
Pi – type of area under tourist use [ha]
Po – reference unit area – total area of a delimitated field [ha]
Bi – valuation score

The K index ranged from 0 to 5. In order to group areas in the shore zone according to the degree of tourism load, appropriate classes were created depending on the value of the K index (Table 3).

Table 3

Classes due to the level of tourism impact on the environment according to the tourism impact index (K)

Class	Impacts on environment	Range of K value
I	very high	$K \geq 1.0$
II	high	$0.1 \leq K < 1.0$
III	moderate	$0.01 \leq K < 0.1$
IV	small	$0 < K < 0.01$
V	none	$K = 0$

The study was provided using current topographic maps scaled 1:10 000. All raster maps were obtained from Provincial Centre for Geodetic and Cartographic Documentation in Olsztyn. Vector polygons (territories and area objects) and lines (linear objects) were made over the raster topographic maps using QGIS 2.18 software. A 200 m wide strip of land was determined around the shoreline of the lakes. In the water part of shore zone the 100 m wide strip was determined. The designated area was divided into basic fields covering about 500-metre sections along the shoreline. In order to calculate the K index, data on the current use of the shore zone for tourism and recreation were collected. The total area of land under particular forms of tourism and recreation was determined according to the criteria given in Table 2. The total area of the basic fields was also calculated. A vector polygon layer was created to compare the LU/LC status of the shore zone of studied lakes. The status of land use and land cover at the studied area was additionally verified by direct observations in summer seasons of 2017–2018.

Morphometric data of the studied lakes were assumed according to JAŃCZAK (*Atlas jezior*… 1999) and CHOIŃSKI (2006). Topographic maps of the area were used as well as bathymetric plans of the lakes which were amended on the basis of data gathered during the field studies. Tourist information brochures and available literature were used for additional information.

An analysis of the density of accommodation and other tourist facilities was also carried out, as well as an index of the development of other tourist facilities in the shore zone of the studied lakes. In the analysis of the density of accommodation facilities, all the accommodation facilities located in the 200-metre strip around the lakes were taken into account. For the analysis of the other tourist facilities, water equipment and/or bicycle rentals, gastronomy facilities, car parks, beaches, access to reservoirs and other facilities used by tourists (e.g. sports fields, recreation areas, amphitheatre) were selected.

The index of density of accommodation facilities (P_A) was calculated according to the following formula:

$$P_A = N/S$$

In the formula, N is the number of beds, S is the area of the delimited strip [km^2].

The density index of the other tourist facilities (P_O) was calculated according to the following formula (FURGAŁA-SELEZNIOW et al. 2019):

$$P_O = (N_O \cdot 100)/S$$

In the formula, S is the area of the delimited strip [km^2], N_O is the number of other tourist facility items.

Calculation of the other tourist facilities development index (B_O) was performed according to the formula created for the present study:

$$B_O = N_O \cdot 100/N$$

In the formula, N is the number of beds, N_O is the number of other tourist facility items.

In addition, the dock density index (D_d) was calculated as a measure of the impact of docks and related activities on the water shore zone of the lake. The actual state of development was determined by manual identification of artificial water structures such as marinas, harbors, bathing sites with piers, large recreational platforms and small fishing piers on the orthophotograph maps. According to BECK et al. (2013) and DUSTIN and JACOBSON (2015), these structures are referred to in this study as "docks". Smaller docks (small angling piers) have been designated as single objects,

while large docks (with several branches) have been designated as complex objects. Each branch within a complex dock has been treated as a separate object so that the total number of docks better reflects the actual impact of the individual docks on the development status of the water shore zone of the lake. According to DUSTIN and JACOBSON (2015) lakes with D_d index over 5 has been defined as highly developed:

$$D_d = D/M$$

In the formula, D means the number of docks and M is the shoreline length [km].

Information on the number of accommodation facilities, the number of beds at these facilities and the number of other tourist facility items was obtained from the Tourist Information Office in Mrągowo, direct interviews with accommodation facility managers and a website with the function of browsing and searching for accommodation offers under the domain e-turysta.pl and Google Maps.

Results

Two lakes (Juksty and Czos) are classified as the first class of tourist attractiveness (Table 4). Both lakes were characterized by a low index of the lake surface area covered by water vegetation and the highest shoreline development index. The Probarskie and Mokre lakes were classified

Table 4

Assessment of the degree of tourist attractiveness of selected lakes in Mrągowo Lakeland

Parameter	Juksty		Czos		Probarskie		Mokre	
	value	score	value	score	value	score	value	score
Surface area [ha]	330	6	279.1	5	201.4	5	814	6
Mean depth [m]	8	2	11.1	2	9.2	2	12.7	2
Shoreline development index	3.11	5	2.53	4	1.88	2	2.52	4
Elongation index	5.95	2	5.31	2	1.7	2	2.08	2
Index of the shore zone cover by vegetation [%]	13	4	32	2	50	2	8	4
Index of the lake surface area cover by water vegetation (%)	5	4	9	4	15	2	10	2
Index of the shore zone cover by forest [%]	5	1	23	3	35	3	85	1
Total	24		22		18		21	
Class	I		I		II		II	

as the second class of tourist attractiveness. The shores of Mokre Lake were the most forested. Probarskie Lake had the lowest shoreline development index. Table 5 presents the number of accommodation facilities in

Table 5

Accommodation objects in studied localities

Lake	Type of accomodation object	Number of accomodation objects	Number of beds in tourists objects		Range of beds
			permanent	seasonal	
Juksty	guesthouse	6	98	0	6–30
	summer house	3	10	18	6–12
	guest rooms	2	16	12	12–16
	agritourism farm	1	15	0	15
	total	**12**	**139**	**30**	**6–30**
Czos	hotel	8	869	49	9–182
	guesthouse	2	132	0	32–100
	summer house	1	6	0	6
	guest rooms	9	145	0	5–40
	agritourism farm	1	8	0	8
	camping	1	0	300	300
	total	**22**	**1160**	**349**	**5–300**
Probarskie	hotel	1	50	0	50
	guesthouse	2	48	0	18–30
	resort	1	0	150	150
	guest rooms	8	82	34	4–30
	summer house	4	9	40	4–24
	agritourism farm	3	41	15	15–24
	camping	2	0	120	60
	total	**21**	**230**	**359**	**4-150**
Mokre	guesthouse	2	16	12	12–16
	resort	2	36	474	210-300
	camping	3	0	240	30-130
	total	**7**	**52**	**726**	**12-00**
Total number of objects and beds		**62**	**1581**	**1464**	**4-474**

the analyzed zone divided into particular types, the number of accommodation places and the range of the number of accommodation places in particular types of facilities. It was found that the most numerous group of objects were guest rooms (20). The largest number of beds was offered by hotels (968) and camping sites (420). More than half of all accommodation

places and more than one third of all accommodation facilities (including eight out of nine hotels) were located on Lake Czos (Table 5). More than half of the seasonal accommodation facilities and almost half of the seasonal beds were located on Lake Probarskie. Apart from accommodation facilities, there were other tourist facilities at the lakes under study (Table 6).

Table 6

A comparison of other tourist facilities in the shore zone of the studied lakes

Lake	Gastronomy facilities	Car parks	Access to reservoirs	Beaches	Water equipment and/or bicycle rentals	Remaining objects	Total
Juksty	4	0	0	0	0	0	4
Czos	10	12	2	2	4	9	39
Probarskie	4	1	2	4	1	1	13
Mokre	6	5	2	1	4	2	20
Total	**24**	**18**	**6**	**7**	**9**	**12**	**76**

The largest number of other tourist facilities was located on Lake Czos. Remaining objects included: a promenade, an eco-marina, an amphitheatre, a playground, an outdoor gym and five sports fields for Lake Czos, while for Lake Probarskie the bicycle trail and for Lake Mokre the sculpture gallery in Zgon and the bicycle trail around the lake. The most numerous group of objects were angling piers and walking platforms. The largest number of other tourist objects were located on Czos and Probarskie lakes.

The area of the distinguished shore zone of the examined lakes ranged from 237.7 ha for Probarskie Lake to 401.1 ha for Mokre Lake, and the water part of the shore zone area from 67.6 ha to 258 ha respectively. The number of distinguished basic fields ranged from 13 (Probarskie) to 38 (Juksty). The K index for the whole shore zone ranged from 0.140 (Juksty) to 1.892 (Czos) – Table 7. The value of the accommodation facility density index (P_A) and other tourist facility density index (P_O) was definitely the highest for Lake Czos and the lowest for Lake Juksty. The values of the other tourist facility development index (B_O) were very similar for all the lakes under study. Dock density index (D_d) reached values above 5 for Probarskie and Czos lakes, whose water part of the shore zone was defined as highly developed.

More than 50% of the shore zone of Lake Juksty and about 25% of the shore zone of Lake Czos were the areas without any tourist facilities. Basic fields without any tourist facilities did not occur in the shore zone of Probarskie and Mokre lakes (Figure 3). The most uniform pressure of

tourism on the shore zone was noted for Lake Probarskie (*K* ranged from 0.011 to 0.85). The maximum range in *K* index was noted for the lake Czos (0–4.97).

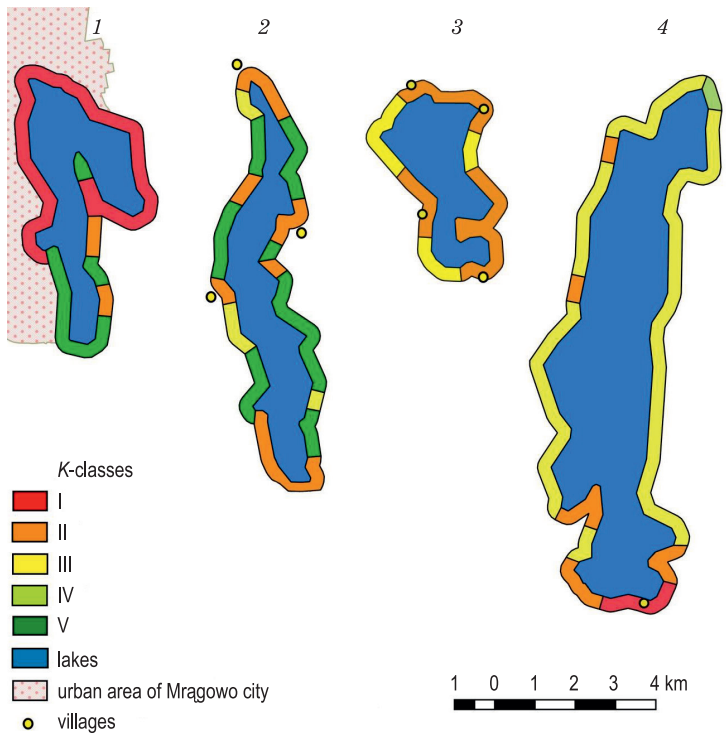

Fig. 3. Spatial pattern of tourism impact in shore zone of studied lakes: *1* – Czos; *2* – Juksty; *3* – Probarskie; *4* – Mokre

Discussion and conclusions

All lakes selected for the study were attractive or very attractive in terms of tourism. According to the authors of this study, the method of evaluation of the shore zone of lakes, taking into account their natural conditions (DEJA 2001), was inadequate in the case of the forest cover share. The lakes Juksty (5% of the forest) and Mokre (85% of the forest) received one point each. For this reason Mokre Lake was classified lower (attractiveness class II) than Juksty Lake (attractiveness class I), whereas P_A, P_O and *K* indices assumed higher values for Mokre Lake, which means that it was more often visited by tourists than Juksty Lake. According to the authors, the lake which shore zone is covered with forest in more than 40% should receive the maximum number of points (5). The authors believe

that reducing the number of points for the "excess" of forests in the shore zone of the lake is unjustified, if only because resting in forest areas positively affects the well-being of tourists (BIELINIS et al. 2018, 2019, TAKAYAMA et al. 2019).

The shore zone of the lakes, on which there are towns and villages, is the most loaded with tourism. The tourism load level is related to the share of residential buildings in the shore zone of the lake. The location of Czos Lake within the administrative borders of Mrągowo city makes the development level of the shore zone approximately 60%. This lake was characterized by the highest values of tourism load indices in the shore zone. The presence of four villages in the shore zone of Lake Probarskie caused that 20% of the zone was covered by residential buildings. Lake Probarskie was characterized by relatively high values of tourism load indices in the shore zone. Probarskie and Czos lakes were also characterized by the highest values of dock density index (D_d above 5). According to the criteria defined by DUSTIN and JACOBSON (2015), the water part of the shore zone of these lakes was highly developed. According to BURAK et al. (2004), small coastal settlements have become tourist destinations in Turkey as a result of legal and institutional incentives to invest in tourism. This has had a negative impact on landscape aesthetics and the loss of fertile land. However, the greatest pressure on coastal areas was exerted by urbanization. Masurian lakes are in a similar situation (FURGAŁA-SELEZNIOW et al. 2020). This results from the development strategy of the warmińsko-mazurskie voivodeship. One of the most important components of this strategy is the development of tourism as one of the main economic sectors in the region (*Strategia rozwoju…* 2013). Lake Mokre, whose shore zone is covered mainly by forest and which is located in the Mazurian Landscape Park, had a moderately developed water part of the shore zone. Its land shore zone was developed very unevenly, mainly by large seasonal resorts and campsites located on the south side of the lake, near the village of Zgon. Mokre Lake is located on the canoeing trail (116 km long) of the Krutynia River. These route is considered to be of international importance (LIJEWSKI et al. 1998). The eastern shore of the lake is undeveloped, there is only a bicycle path that runs around the whole lake.

The development of tourism can stimulate economic growth and play an important role in promoting the social development of backward regions. However, the development of lake tourism should also take into account the protection of lakes. Benefits for the natural environment should be transformed into economic and social benefits (DAVID et al. 2012). According to DAVID et al. (2012), the main principles of lake tourism development are environmental protection, reasonable use of resources,

coherent management and sustainable use. The planning of lake tourism development should be based on scientific principles and include monitoring of tourism development plans and prevention of damage resulting from inappropriate development. Despite very high tourist attractiveness (class I) and short distance (3 km) from Mrągowo city, Lake Juksty was characterised by significantly lower tourism load indices than other lakes. This was probably due to the particular type of land cover in the shore zone, in which the share of forest and residential buildings was negligible (ca. 5% and 1.5% respectively). The level of attractiveness plays an important role in the assessment of the place as a tourist resource. For planners and tourism managers it is of key importance. However, from the point of view of tourists, it is not enough to ensure sufficient investment in this area. Tourists expect the appropriate infrastructure to be in place before they visit the site (ALAEDDINOGLU and CAN 2011). Tourism in relation to places far away from settlements, in relatively natural places is defined as nature-based tourism (PRISKIN 2001).

Most of the year-round accommodation places were in the shore zone of lakes Czos and Probarskie. A clear correlation was observed between the level of residential development in the shore zone of the studied lakes and the number of all-year-round beds. The lowest number of all-year-round (and at the same time the highest number of seasonal) beds was recorded in the shore zone of Lake Mokre. The Probarskie Lake was the second lake in terms of the number of seasonal beds in the shore zone. The shore zone of the lake was covered by 35% forest and 20% by rural buildings. The development index of other tourist facilities (*Bo*) was very similar for all the studied lakes. This fact indicates that the development of the other tourist facilities is proportional to the accommodation base. At each lake there were more than two other tourist facilities (2.2–2.6) per 100 beds (no distinction was made between year-round and seasonal beds). The location of four villages around Probarskie Lake results in uniform spatial distribution of the shore zone tourism load. The presence of a bicycle path around Lake Mokre was the reason for the lack of completely undeveloped areas. However, the tourism impact on the shore zone of this lake was uneven. Tourist objects had been concentrated mainly on its southern edge in the vicinity of a typical tourist village Zgon (which in itself is a tourist attraction due to the nature of its architecture). Two thirds of the eastern shore of Lake Juksty was occupied by a turtle refuge. The highest level of tourism load was noted at both ends of this guttering lake, situated longitudinally. The southern, undeveloped edge of Lake Czos was outside the city border. The city border at this place run along the lake shoreline. In this part of the shore zone there were completely

undeveloped areas (V class of load). Such areas were also located in the south-western part of the shore zone of the lake, already within the boundaries of the municipality of Mrągowo. At the same time, the lake was the only one with areas in its shore zone that belong to the highest tourism load class (I).

The research showed the influence of the type of land use/cover (LU/LC) around the lakes on the level of tourism load on their shore zone. The proposed method makes it possible to study the tourism load on the shore zone of lakes in relation to the LU/LC type around the lakes. The set of indices enables a reliable assessment of the impact of tourism on the shore zone of lakes and monitoring its changes over time. The studies aimed at monitoring the impact of tourism on the natural environment, especially the lake shore zone, which is a vulnerable ecotone, are scarce. The paper fills a gap in the literature by presenting a useful tool for such analyses. The methodology used in this paper can be used in the study of most glacial lakes in Europe and other regions of the world to monitor the threats arising from the tourist development of the lake shore zone.

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