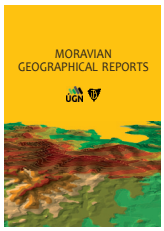

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Recreational use of the urban riverscape: What brings people to the river?

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Abstract

Visiting urban green and blue spaces improves the quality of life in cities as it helps to preserve human-nature bonds. In this context, the role of urban parks and forests has been well-recognised; however, much less is known about the landscapes of inland water bodies. To fill this gap, the study aimed to identify spatiotemporal patterns of recreational activities in the urban riverscape in relation to the visitors' residential proximity. Also, survey results were combined with spatial and remote sensing data to determine how the spatial characteristics of the riverscape affect its recreational use. The case of Warsaw, Poland, was used. The results indicated that the riverscape serves as a local park for the neighbouring communities, while it is rather a warm-weekend attraction for far-living ones. Visitors concentrate in the city centre, and spread out along the communication paths; however, spatial patterns of the magnitude of particular activities also show interbank differences. Spatial error models of drivers of riverscape recreation revealed (1) the multifaceted role of trees in densely visited areas and (2) the importance of physical availability for contact with the urban river. These findings expand knowledge on the recreational use of urban rivers by exploring its place-related motivations.

Keywords: *urban riverscape, recreation, PPGIS, spatiotemporal patterns, spatial drivers, Warsaw, Poland*

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1. Introduction

Urban green and blue spaces positively contribute to the quality of life in cities with multiple ecosystem services they provide. These spaces support air purification, heat reduction, water retention, and habitat/biodiversity maintenance (McPhearson et al., 2014). They are also significant providers of cultural ecosystem services (CES), namely non-material benefits to people's well-being arising from human-nature interactions (Chan et al., 2012). As a prominent reason for spending time outdoors, nature-related recreation is regarded as a key link between people and nature in urban areas (Bolund & Hunhammar, 1999). At the same time, urban growth leads to the increased demand for recreational use of urban nature (Chen et al., 2019). Therefore, the adequate provision of accessible, multifunctional, and inclusive green and blue spaces in cities should be of particular importance for urban planners as a part of the implementation of Sustainable Development Goals (United Nations, 2015). These spaces need to be created and managed in a way that balances their increased use intensity with the robustness of the recreational opportunities they provide. In this respect, it is essential to identify drivers of recreation, including which characteristics of green and blue spaces attract people depending on the purpose of their visits (Hegetschweiler et al., 2017).

This paper concerns the recreation within the urban riverscape, one of the key types of urban green and blue spaces. The results of a citywide participatory mapping survey were used to identify spatially explicit information about people's recreational activities along the river. Survey data were combined with spatial and remote sensing data to provide answers for the following questions:

1. To what extent the residential proximity to the urban riverscape influences the seasonal/intraweek patterns of recreational activities?;
2. What are the spatial patterns of urban riverscape activities?; and
3. How do urban riverscape characteristics influence its recreational use?

The problem was addressed by taking the example of the Vistula River in Warsaw, Poland. By linking spatiotemporal patterns of recreational activities with urban riverscape features, insights from the study can be applied in the context of spatial planning in riverine cities of the temperate zone in general, and management of recreation in particular.

2. Theoretical background

Previous studies have explored links between the recreational activities of city dwellers and the spatial characteristics of urban green and blue spaces. Changes in recreational preferences were identified along the urban-periurban gradient (Rall et al., 2017; Riechers et al., 2019). Differences were also found while comparing various settings, such as parks and brownfields (Palliwoda & Priess,

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2021), or parks and forests (Pinto et al., 2021). The size of the area (Bertram & Rehdanz, 2015), its shape (Brown et al., 2014), and connectivity to other green spaces (Wang et al., 2022) proved to be of particular importance for some users, such as cyclists or dog walkers. The relationship between actual or perceived distance from home and the visited places has been explored, with a general preference for regular visits to nearby green and blue spaces (Priess et al., 2021). Zhang and Zhou (2018) found an association between the accessibility of urban parks with public transport and visitation rates. Referring to the site characteristics, biodiversity level (Bertram & Rehdanz, 2015), land cover (Dade et al., 2020; Pinto et al., 2021), landscape diversity (Chang & Olafsson, 2022) and density of vegetation (Bjerke et al., 2006) were found to explain how people use these spaces. Recreation is also fostered by the presence of man-made amenities, such as paths, benches, gastronomy, and sports equipment (McCormack et al., 2010; Palliwoda & Priess, 2021), with the specific needs of visitors for different activities (Krellenberg et al., 2021).

The above findings are mostly related to urban parks and forests, as their recreational role has been studied most extensively (Hegetschweiler et al., 2017; Browning et al., 2022). Much less attention has been paid to urban blue spaces, however, including rivers and streams (Veerkamp et al., 2021). With adjacent areas, rivers in cities form urban riverscapes. The character and physiognomy of riverscapes have evolved as a mutual effect of natural processes and man-made transformations; as a result, they consist of a variety of formal and informal green spaces along with various types of man-made riverfronts (Duran-Vian et al., 2021). Due to this heterogeneity, urban riverscapes provide multiple recreational opportunities to city dwellers, related to the use of riverbanks and the corridor itself (Stepniewska & Sobczak, 2017). Flowing water supports relaxation and contemplation by attracting multiple senses (Völker & Kistemann, 2013). The suitability of the riverscape for physical activities is stimulated by its linear shape; walking, cycling, or jogging can be performed on more or less landscaped shores, while water-based activities (e.g. kayaking, cruising) along the river corridor (Stepniewska & Sobczak, 2017). Apart from recreation, the paths along urban streams are aesthetically pleasing and evoke a sense of place (Kicić et al., 2022). Rivers are also perceived as highly natural compared to other types of urban green and blue spaces, which may attract people trying to isolate themselves from the urban rush (Kaplan & Kaplan, 1989).

Studies on recreational use of urban blue spaces have focused so far on exploring the spectrum of activities (Stepniewska & Sobczak, 2017) and identifying user-related determinants of recreational preferences (Hossu et al., 2019). At the same time, they sparsely addressed the temporal variability of the use of blue spaces (Vierikko & Yli-Pelkonen, 2019), and rarely explored the spatial patterns and drivers of the activities (Scott Schafer et al., 2013).

3. Materials and methods

3.1 The study area

Warsaw, a 2-million Polish metropolis, is located in the central part of the country, on both banks of the Vistula River (Fig. 1). Comparable to Berlin (51%) and Vienna (44%), nearly half of the city area (47%) is covered with green and blue spaces (European Environment Agency, 2022). The Vistula is a key element of the ecological system of the city, serving as main aeration corridor, supporting urban heat reduction, and connecting urban and suburban green spaces. It is also protected under the Natura 2000 programme as a corridor for migratory birds. Riverbed regulation processes have not advanced, with the construction of groynes and regular river dredging as the main interventions of the river flow (Degórska & Degórski, 2017). Warsaw's riverscape was used as a case study as it represents multiple types of riverfronts that can be found in other riverine cities in the temperate zone. In the city centre, a sequence of concrete boulevards has formed on the western bank (Fig. 1, photo A). Similar constructions that join flood prevention and urban promenade functions have been built in numerous cities and studied in terms of benefits from experiencing the river (Völker & Kistemann, 2013), typical and nontypical use of recreational facilities (Miaux & Garneau, 2016), or the impact of infrastructural changes on people's perception and use of promenade (Vert et al., 2019). On the opposite shore, the quasi-natural riparian zone is covered with trees and grass (Fig. 1, photo B). Outside the city centre, the original shape of the middle-course valley was greatly preserved (Fig. 1, photo C); similar landscapes can be found in Bratislava, Slovakia, or Novi Sad, Serbia.

In 2018, 73% of Warsaw residents visited the river (Warsaw City Hall, 2019). Similar to other riverine cities, typical visitors are young or middle-aged, and spend time on the boulevards for leisure and taking walks (Warsaw City Hall, 2020; Bąkowska-Waldmann, 2022).

3.2 Survey participants and questionnaire design

Data on recreational activities was collected as a part of the broader participatory mapping survey on how urban residents use and perceive the riverscape. The online map-based questionnaire was designed using Maptionnaire (Mapita, www.maptionnaire.com). This way of data collection was chosen for several reasons. First, mapping in selected locations within the riverscape can narrow the scope of the research to the preferences of visitors only met in these places; the online distribution of the survey broadened the spatial extent of the obtained results. Also, online PPGIS surveys are relatively easy to conduct both in terms of survey distribution and filling them by the respondents (Brown & Kyttä, 2014). Ultimately, the online form was preferred due to the sanitary conditions as the number of cases of COVID-19 in Poland increased when the survey was conducted (autumn 2021).

The bottom-up approach was followed in this study as it was aimed at the members of all local communities across the city of Warsaw. To invite the participants, the questionnaire was sent to ca. 200 local communities (neighbourhoods, housing estates, housing cooperatives) using Facebook groups gathering members of these communities. It was additionally submitted to several district and sport-related groups (e.g. cyclists, kayakers, ice swimmers, fishers). As a result, 246 groups were addressed with the survey (Supplementary Material S1). The survey was active between 29 November and 22 December 2021. 7, 14, and 21 days after the first publication, the link to the questionnaire was republished in order to attract new participants.

Overall, the survey was comprised of six sections grouping 24 questions; the sections that were used in this paper can be found in Supplementary Material S2. The key part of the survey was questions related to the mapping results. Participants were asked to mark up to three places and three routes they preferred to visit within the study area. The city and district boundaries, as well as the extent of the study area, were presented on the background map. For each of the marks, the respondents indicated the frequency of visits, seasonal and weekly preferences, and preferred activities. Survey participants could choose up to three activities from the predefined list, including the option to provide their own answer using the open question. The answers from both sources were then grouped into nine bunches:

- Recreational walks (taking walks);
- Routine necessities (walking a dog; spending time with a child);
- Land sports (riding a bicycle; practising yoga; using open-air gym and workout zone; running);

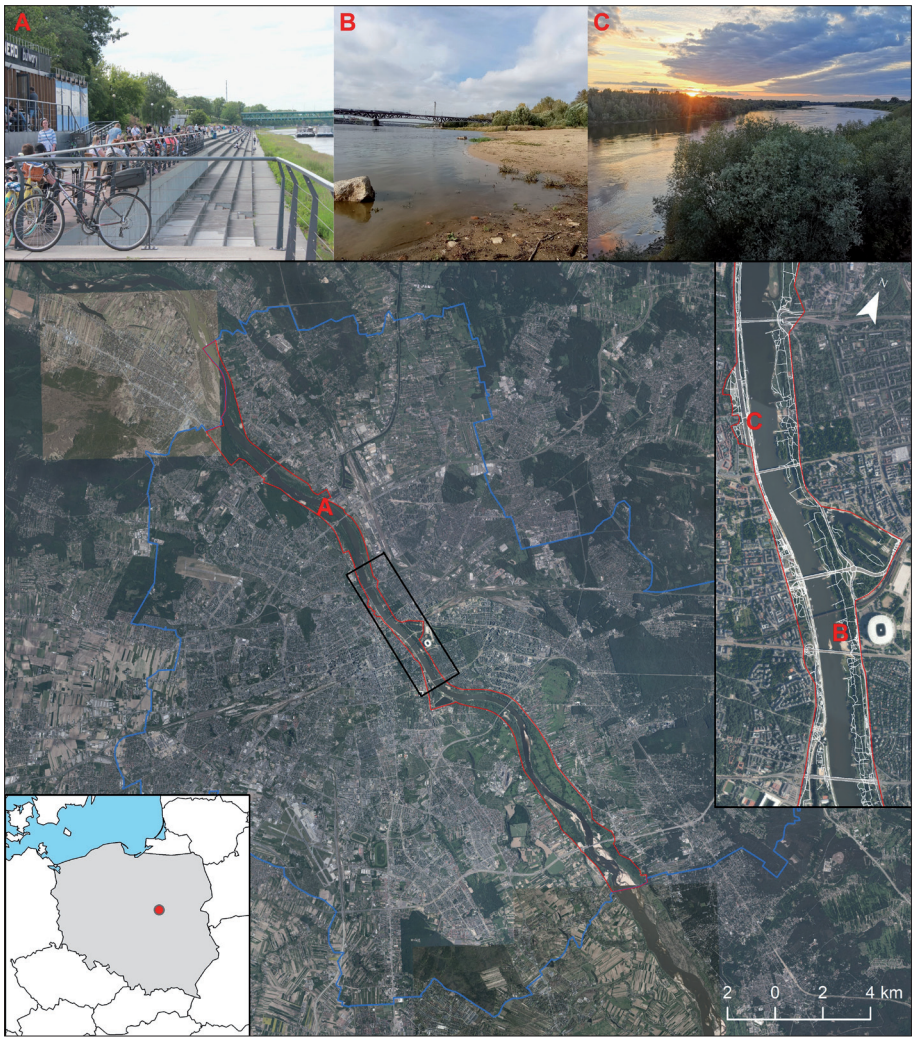

Fig. 1: The study area (red line)
Notes: The boundary of Warsaw is marked with the blue line. In the box, the path/trail network was marked with the white lines
Source: National Geoportal (2023), modified by the author; photographs by the author

- Contact with nature (observing nature; feeding animals);
- Water sports (kayaking, sailing; cruising; fishing; bathing);
- Social life and entertainment (spend time in bars, restaurants, cafes; take part in cultural events, e.g. outdoor cinema, festivals, fairs; drinking alcohol);
- Relax (relax/do nothing - sit on a blanket/grass, rest, sunbathe);
- Taking photographs; and
- Transit (moving through on the way to other places).

3.3 Data analysis

3.3.1 Temporal patterns of urban riverscape recreation

The associations between the temporal preferences of visitors and recreational activities were assessed in relation to their place of residence. The received questionnaires were grouped into two sets regarding residential proximity to the riverscape. Close-living visitors (inside the 1-km buffer around the study area) and far-living visitors (the remaining of the surveyed) were compared in terms of their seasonal and weekday-weekend recreational preferences. Seasonal patterns were identified using the percentages of users who declared they undertake the particular activity in a season in relation to all close-living or far-living survey participants visiting the riverscape in this season. For intraweek preferences, percentages of users were calculated separately for each activity in relation to the number of close-living or far-living respondents who declared they undertake this activity.

3.3.2 Spatial patterns of urban riverscape recreation

The marks were initially pre-processed by excluding points and routes drawn outside the study area. Additionally, all routes were checked for evident spatial biases arising from imprecise marking; if necessary, they were generally adjusted to the nearest possible route (e.g. to the nearest bridge). The spatial distribution of the riverscape activities was analysed using a fishnet with a cell side length of 100 meters. On a cell level, the magnitude of the recreational activity was measured in order to balance the absolute and relative importance of each activity across space. It was calculated using the following formula:

$$M_x = \frac{n_x}{n_{all}} \times \sqrt{n_x}$$

where n_x means the number of marks representing activity x in a cell, and n_{all} means the number of all marks in this cell. The results were then plotted as a series of maps in order to identify how the magnitude of the particular activity varies within the riverscape, and to compare spatial patterns of the activities.

3.3.3 Spatial drivers of riverscape recreation

The demand for riverscape recreation may vary spatially, as influenced by the landscape characteristics that attract visitors or amenities that enable them to undertake particular activities. To identify these links, eight variables were tested as potential spatial

drivers of riverscape recreation (Tab. 1). The catalogue of variables aimed to encompass multiple aspects of the functioning of the riverscape as a recreational space, including the spatial variation of its accessibility, land cover, management level, and spaciousness. To allow the replicability of the study, the variables were built using publicly available data. Using the rasterised network of pedestrian and cycling paths of the study area, Cost Distance tool from Spatial Analyst toolbox was applied to generate raster datasets of path distance to the nearest entrance/exit point, public transport stop, recreational amenity, or gastronomy object. The datasets were vectorised, and spatially joined to the fishnet to calculate the mean distance per cell. Path distance was preferred over Euclidean distance as it takes into account the actual accessibility of the riverscape; for example, the distance between locations situated on the opposite banks of the river was calculated assuming the use of the nearest bridge. Near tool from the Analysis toolbox was used to calculate the shortest Euclidean distance from the centroids of the fishnet's cells to the shoreline. Viewshed tool from the Spatial Analyst toolbox was used to generate viewsheds from the centroids of the cells. All spatial analyses were conducted using ArcMap 10.8 (Esri, 2020).

Spatial drivers of riverscape recreation were analysed on a cell level, with the same fishnet as used to identify spatial distribution of the activities undertaken along the river; only cells where the particular activity was reported were taken into analysis. The magnitude of activity (M_x) was set as a dependent variable. The explanatory variables were z-scored to facilitate the interpretation of the models. The collinearity of explanatory variables was checked using the Variation Inflation Index (VIF), with the criterion of variable exclusion of VIF > 4; as a result, the variable Distance to riverine gastronomy was excluded from all models. Next, for each activity, a 3-nearest neighbour queen contiguity spatial matrix was created. The distance of 300–400 meters from the cell centroid (up to 5 minutes walking distance) was used both to identify the spatial dependence of the variables and to overcome potential respondent mapping bias. The matrices were then applied to the OLS regression models of riverscape activities in order to diagnose spatial dependence with Global Moran's I of residuals and Lagrange Multiplier (lag and error tests). Spatial Error Models (SEM) were eventually performed for all activities as the results of Robust Lagrange Multiplier (*error*) for sports, relax, and contact with water were significant, and for the other activities the significant value of Robust Lagrange Multiplier (*error*) was higher than the significant value of Robust Lagrange Multiplier (*lag*). The results of the OLS and SEM models were reported with coefficients and significance levels. The goodness-of-fit of the models was reported with the AIC value and R-squared. Statistical analyses were conducted using GEODA software (v.1.20.0.36).

4. Results

4.1 Survey sample and general recreational preferences

462 completely-filled questionnaires were returned by Warsaw residents. The sample consisted of a majority of women (61.9%) over men (35.3%); 4.8% of the surveyed did not specify their gender or refused to answer. The participants were mostly middle-aged (75.3%), highly educated (83.4%), and had a full-time job (81.2%). The median age was 39 (Standard Deviation = 10.5).

193 out of 462 survey participants (41.8%) lived in a 1-km buffer around the study area; 269 of them lived further away (58.2%). Close-living respondents visited the riverscape far more often than the far-living ones; 49.2% of them appeared along the river at least once a week (vs. 22.3% of far-living), while only one of the nine close-living respondents preferred rare visits, i.e. less often than once a month (vs. 39.4% of far-living). Close-living respondents predominantly reached the riverscape by foot (89.6%) or by bike (35.8%); fewer of them used public transport (16.6%) or private cars (13%). Transport preferences of far-living visitors were more balanced, with the descending willingness for using public transport (49.4%), bikes (48.3%), private cars (41.6%) and walking (37.2%).

439 of 462 respondents contributed with 998 marks related to their visits to the riverscape that intersect the study area (597 points and 401 routes); close-living visitors provided 2.39 marks per capita, while far-living ones 2.12 per capita. Regarding the activities they undertook, more than half of the survey participants declared recreational walks along the river (64.9%), social life and entertainment (52.3%), contact with nature (50.9%), and land sports (50.9%). Four of ten visitors preferred routine necessities

Variable	Description	Spatial extent	Measure unit	Source of data	Reference
Distance to entrance/ exit points	Mean path distance from the cell to the nearest physical location where the border of the study area can be crossed: path/trail/stairs that enable to reach the path on the top of the embankments; crossings, tunnels, footbridges of the multilane roads; locations where pedestrian/bike paths cross the border	Study area	metres	Open Street Map (OSM), fieldwork	Sikorska et al., 2019
Distance to public transport stops	Mean path distance from the cell to the nearest public transport stop (bus, tram, train, metro)	Study area and 300 m buffer	metres	OSM, National Database of Topographic Objects (NDTO)	Zhang and Zhou, 2018
Distance to recreational amenities	Mean path distance from the cell to the nearest bench, picnic site, playground, bonfire place, dog park or outdoor gym	Study area and 50 m buffer	metres	OSM	McCormack et al., 2010
Distance to riverine gastronomy	Mean path distance from the cell to the nearest restaurant, bar, pub or café	Study area and 50 m buffer	metres	OSM	Kraemer and Kabisch, 2021
Distance to shoreline	Shortest Euclidean distance from the centroid of the cell to the shoreline	Study area	metres	NDTO	Chang and Olafsson, 2022
Path density	Total length of the pedestrian and bicycle paths per cell	Study area	metres	OSM	Kraemer and Kabisch, 2021
Tree canopy intensity	The proportion between number of LAS points representing high vegetation (2 meters and above) and the total area of the cell	Study area	continuous	National Geoportal	Chang and Olafsson, 2022
Riverscape openness	The ln-transformed area of the viewshed from the centroid of the cell	Study area	squared metres	National Geoportal	Van Berkel et al., 2018

Tab. 1: Overview of the variables
Source: author's elaboration

(39%), while relax and taking photographs were declared by 34.6% and 33.8% of the respondents, respectively. Riverscape was used as a transit corridor by 22.7% of the survey participants, while activities related to water sports were indicated by 22.1% of them. Other activities (e.g. playing music, reading books, skiing) were mentioned by a small group of visitors (5.2%).

Close-living and far-living visitors differed in terms of their recreational preferences (Fig. 2). The former were especially more willing to spend time in the riverscape on routine necessities (+ 21.2 pp), contact with nature (+ 7 pp) and recreational walks (+ 5.9 pp) than the latter. Conversely, social life and entertainment and relax were the activities relatively more popular among far-living visitors (+ 10.8 pp and + 7.9 pp, respectively).

4.2 Urban riverscape recreation: temporal patterns

4.2.1 Seasonal preferences

The survey results suggest that the Vistula in Warsaw attracts a comparable share of visitors in summer (91.7% of close-living visitors, 94.4% of far-living visitors) and spring (91.2% of close-living visitors, 84% of far-living visitors). The other seasons, however, are notably more popular among close-living visitors, with 85.5% of them spending time along the river in autumn (vs. 68% of far-living ones) and 69.4% in winter (vs. 40.9%).

Regarding seasonal differences in demand for particular activities, recreational walks, contact with nature, taking photographs, and transit were found to attract a similar share of visitors regardless of the season; this pattern was observed for both groups of survey participants (Fig. 3). The demand for social life and entertainment and relax was generally higher in spring and summer, while the relative interest in visiting the riverscape for routine necessities slightly increased in winter for both groups. The higher share of close-living visitors did land sports in spring and summer than in the case of those spending time along the river in the other seasons; it was more balanced for far-living survey participants. Water sports peaked among close-living visitors in the summer.

4.2.2 Intraweek preferences

The majority of those surveyed preferred to spend time in the riverscape all week (81.9% of close-living and 64.7% of far-living). Nearly one-third (30.9%) of the latter declared only-weekend visits (vs. 11.4% of close-living respondents), while only a few survey participants appear along the river only-weekdays (3.1% of close-living and 1.5 of far-living).

The general pattern is reflected on the activity level (Fig. 4). For all of them, the share of only-weekend visitors is much higher among far-living visitors than among close-living ones; it is about tripled for routine necessities, social life and entertainment, and

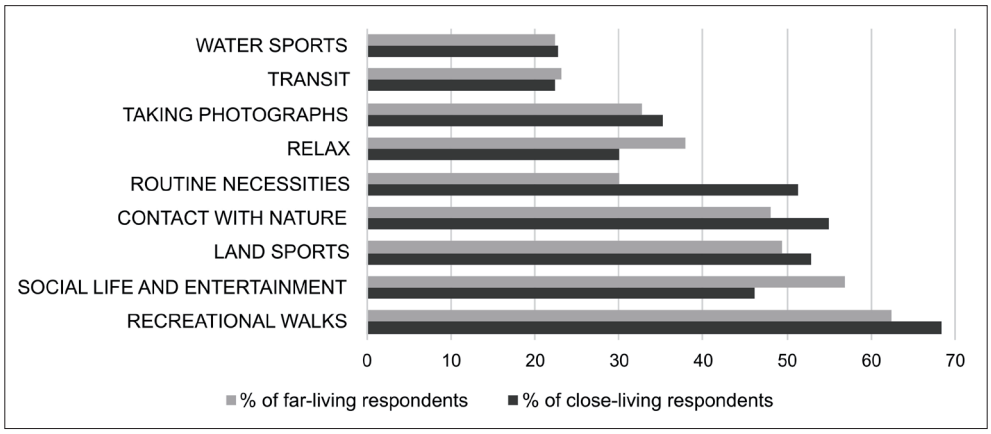

Fig. 2: The comparison of recreational preferences of close-living and far-living riverscape visitors
Source: author's elaboration

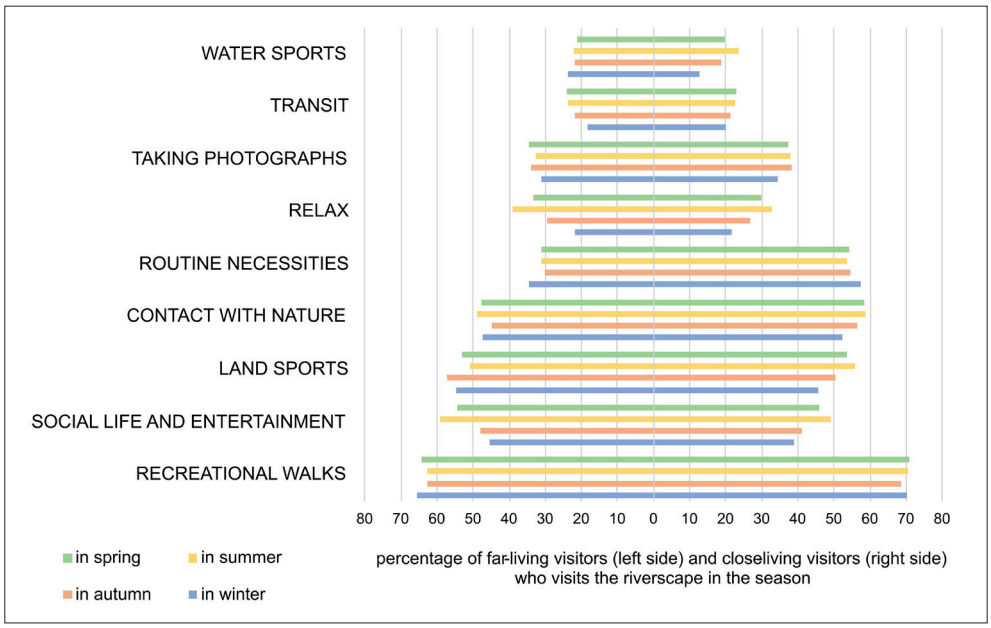

Fig. 3: Riverscape activities by seasonal preferences of close-living and far-living riverscape visitors
Source: author's elaboration

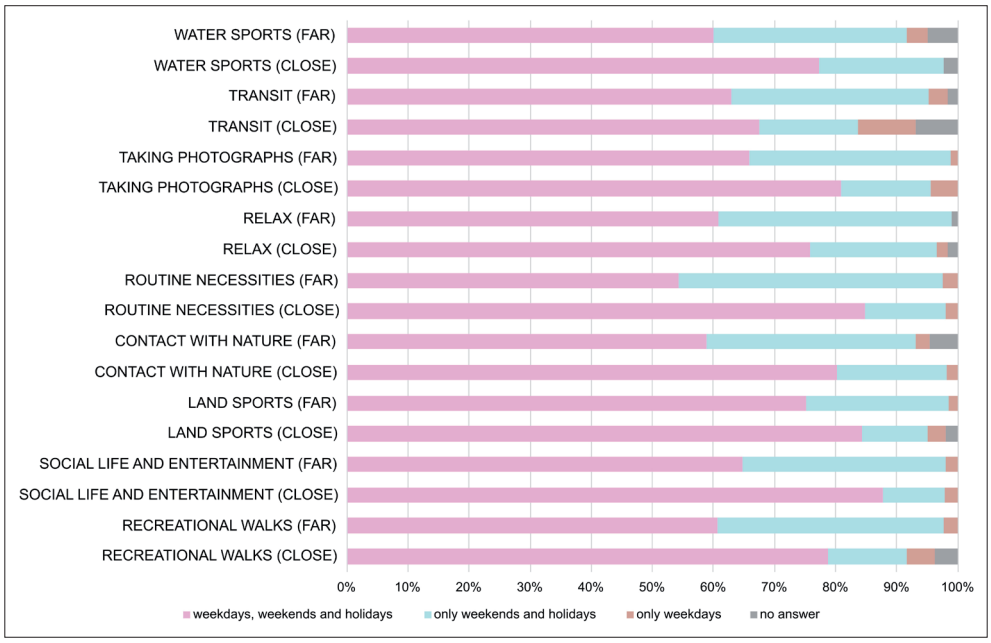

Fig. 4: Riverscape activities by intraweek preferences of close-living and far-living riverscape visitors
Source: author's elaboration

recreational walks. Regarding the shares of all-week visitors, the most temporally universal activities are social life and entertainment, routine necessities and land sports (close-living survey participants), and land sports, taking photographs and social life and entertainment (the far-living ones). The highest share of only-weekday visitors was noted among close-living visitors who declared use of riverscape for transit purposes.

4.3 Urban riverscape recreation: spatial patterns

The results indicated that survey participants were generally more likely to spend time in the city centre, on both sides of the river (Fig. 5). The magnitude of activities (M_x) decreased towards the city peripheries; however, there were differences between banks regarding the extent of the areas with the highest magnitudes. In the case of recreational walks, social life and entertainment, and transit, elongated clusters of high magnitudes have formed along the boulevards on the western bank, while on the opposite shore the agglomerations have formed around the popular urban beaches. Land sports and contact with nature represent the opposite pattern as the visitors concentrated along main communication paths on the eastern bank, with a smaller extent of boulevard hotspot. Routine necessities play the significant role on the boulevards, but they are also prominent on the peripheries, in mixed forests (north) and grasslands (centre-south, south). A unique pattern has formed for water sports, notably related to the riverbed. On-water routes associated multiple activities, however, including land sports, contact with nature, social life and entertainment, and even transit to some extent. Relax was mostly linked to the boulevards in the city core; however, small hotspots of high magnitude can be also found in the southern part of the study area. In the city centre, taking photographs is of high importance on both sides of the river, with the strong role of viewpoints on the Warsaw Old Town; on the peripheries, the magnitude grows on paths on the tops of embankments.

4.4 Spatial drivers of the recreational use of the riverscape

The results of OLS regression suggest low to moderate explanatory power of the used variables as R-squared values did not exceed 0.3 in any case (Tab. 2). The problem of spatial dependence was also found as the distribution of residuals was autocorrelated for all models (Moran's I significant at the 0.05 level), and the Robust Lagrange Multiplier (error) was significant at the same level.

Distance to the entrance/exit points negatively influenced the magnitudes of all activities except contact with nature and water sports. The longer the distance to the public transport stops, the more visitors for routine necessities and taking photographs; the opposite pattern for recreational walks, social life and entertainment and land sports underscored the role of buses, trams, and metro for main riverscape activities. Except for land sports, people's activity was generally interlinked with the proximity to recreational amenities. The closer the shoreline, the higher the magnitude of recreational walks, social life and entertainment, contact with nature and transit; however, the opposite pattern was observed for taking photographs. The key role of paths was manifested in the general positive association between path density and the magnitudes of all riverbank activities. The more intensive tree canopy, the more visitors seek contact with nature; the opposite pattern was noted for social life and entertainment, transit, and water sports. Riverscape openness was in general negatively associated with magnitudes of activities; a positive relationship was found only for water sports as related to the broad viewsheds from the water level.

Spatial error models are considerably better fitted than OLS models as lower AIC values were noted for all activities (Tab. 3). Models also differ in terms of regression equations as coefficient values and significance levels changed in several cases. High spatial dependence is reflected through highly significant Lambda values that vary between 0.73 (water sports) and 0.85 (recreational walks).

When spatial dependence was taken into account, the role of distance to entrance/exit points changed as their proximity only kept stimulating relax, but for recreational walks the coefficient changed its sign. Social life and entertainment, relax and water sports turned out to be more popular closer to public transport stops, while demand for taking photographs kept growing along with the distance. Proximity to recreational amenities significantly stimulated all activities except social life and entertainment, land sports, and water sports. Compared to OLS models, only demand for social life and entertainment remained negatively associated with growing distance to the shoreline, while for the rest of riverbank activities (except transit) the opposite pattern was found. Path density kept stimulating the activities, except water sports. Tree canopy intensity positively

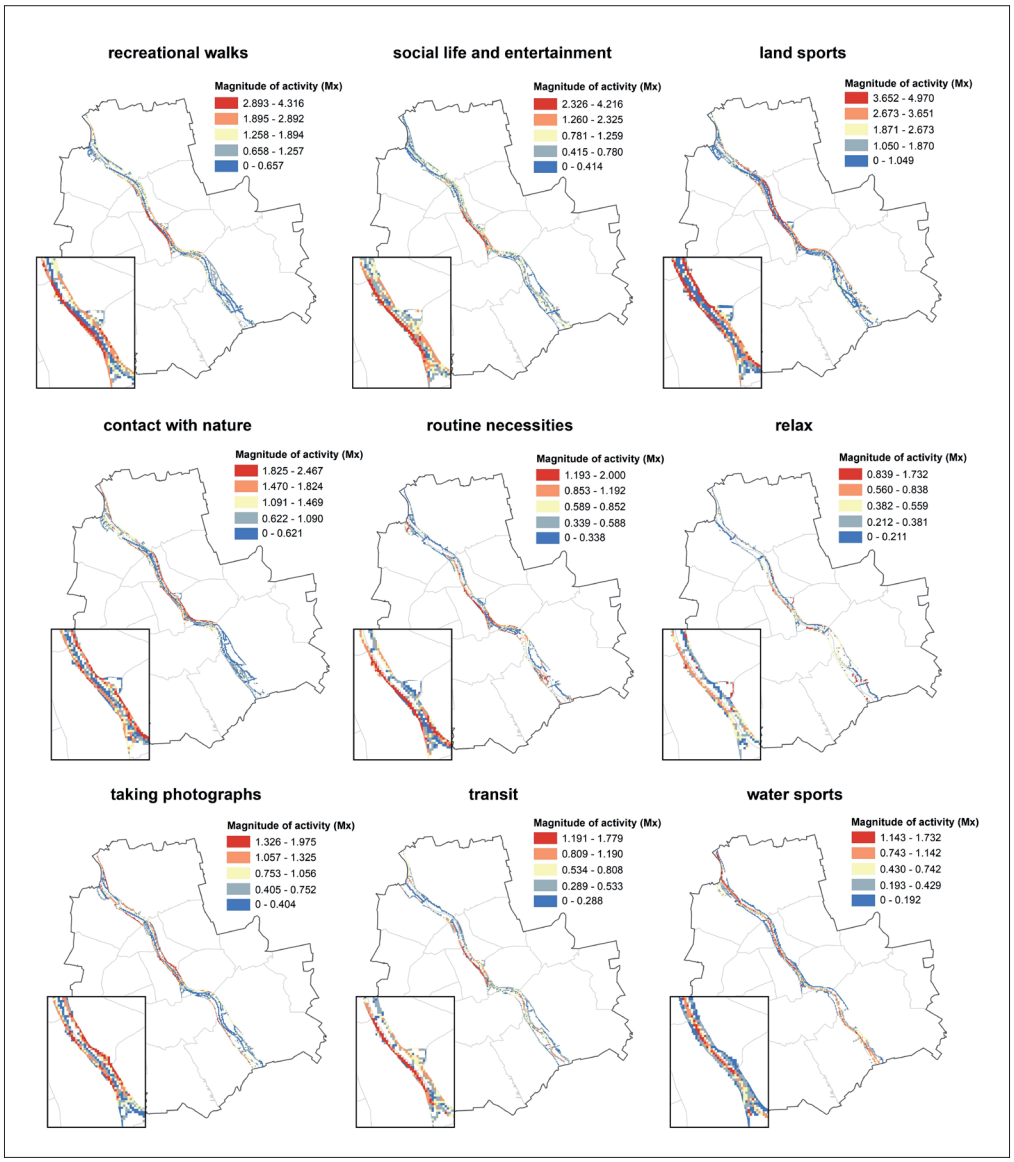

Fig. 5: The magnitudes of the riverscape activities
Source: author's elaboration

influenced recreational walks, land sports, contact with nature, routine necessities and taking photographs, while, compared to OLS models, it turned out to be insignificant for social life and entertainment. The role of riverscape openness narrowed to a positive influence on water sports, and the opposite pattern was found for recreational walks.

5. Discussion

The study revealed that recreational walks, social life and entertainment and, to a lesser extent, land sports and contact with nature were the most prominent activities among the riverscape visitors. This catalogue corresponds to the results of previous studies on urban greenery in Europe (Rall et al., 2019; Fisher et al., 2018; Bertram & Rehdanz, 2015) and blue spaces in particular (Stepniewska & Sobczak, 2017; Hossu et al., 2019). Furthermore, nearly 25% of the survey participants declared water-based activities in the past year. In contrast, the in situ survey of Stepniewska & Sobczak (2017) on the Warta River in Poznań, Poland, revealed that only a few percent of the surveyed declared boating, canoeing, or angling. The high number of water-oriented visitors can be linked to the method of recruitment of participants (the snowballing effect in the most engaged communities, e.g. kayakers).

5.1 When by the urban river? Citywide and local perspectives

The results suggest that the way recreational needs are fulfilled by the urban riverscape is related to the residential proximity of its users. Close-living visitors treat the riverscape as one of the neighbourhood parks. It is visited regardless of the season (and at least once a week by a half of those surveyed), popular both on weekdays and weekends, predominantly accessed by foot, and mostly used for walking (the dog), nature contemplation, and physical activity. From the perspective of far-living visitors, it is rather perceived as a seasonal attraction; visits along the river take place several times a year, preferably in the warm season and with a notable share of only-weekend (cf. Elbakidze et al., 2022). Summer peaks are in line with the other studies on urban blue spaces (Vierikko & Yli-Pelkonen, 2019; Grzyb & Kulczyk, 2023). The set of the most popular activities is similar regardless of the place of residence; however, the role of the Vistula as a place of relaxation and social interactions is much more prominent for the far-living visitors. Also, their slight off-summer preference for sports can be linked to the optimal ambient temperatures for best performances: 10–17.5 °C for running (Valenzuela et al., 2022) and 10–25 °C for cycling (Mantzios et al., 2021). The differences in shares of only-weekend visitors are consistent with insights from previous studies. Bertram et al. (2017) found that Berlin residents

	Recreational walks	Social life and entertainment	Land sports	Contact with nature	Routine necessities	Relax	Taking photographs	Transit	Water sports
Distance to entrance/exit points	− 0.053**	− 0.054***	− 0.067**	− 0.018	− 0.063***	− 0.0041***	− 0.030**	− 0.054***	0.012
Distance to public transport stops	− 0.041*	− 0.097***	− 0.07**	− 0.021	0.021*	0.004	0.106***	− 0.030***	− 0.044***
Distance to recreational amenities	− 0.047**	− 0.033*	0.111***	− 0.128***	− 0.047***	0.003	− 0.071***	− 0.060***	− 0.059***
Distance to shoreline	− 0.071***	− 0.140***	− 0.002	− 0.057***	0.002	0.008	0.043***	− 0.039***	− 0.076***
Path density	0.336***	0.222***	0.502***	0.156***	0.075***	− 0.003	0.114***	0.065***	− 0.115***
Tree canopy intensity	− 0.013	− 0.071***	− 0.025	0.046**	− 0.049	− 0.004	− 0.009	− 0.034***	− 0.035**
Riverscape openness	− 0.130***	− 0.017	− 0.129***	− 0.054***	− 0.021	0.001	− 0.061***	0.017	0.113***
Constant	1.104***	0.693***	1.614***	0.917***	0.564***	0.392***	0.697***	0.513***	0.443***
AIC	3,997.67	2,942.20	5,877.11	2,579.26	1,165.02	− 34.30	1,628.51	514.04	963.65
R-squared	0.27	0.28	0.28	0.20	0.11	0.06	0.17	0.22	0.40
Number of cells	1,957	2,030	2,159	1,960	1,587	1,237	1,708	1,554	1,560
Moran's I (error)	0.278***	0.274***	0.205***	0.272***	0.366***	0.267***	0.364***	0.266***	0.186***
Lagrange Multiplier (lag)	1,251.037***	1,334.547***	621.188***	1,104.244***	1,516.904***	461.097***	1,559.209***	722.484***	270.348***
Robust LM (lag)	73.161***	74.488***	1.118	14.447***	12.365***	1.969	11.541***	31.343***	0.168
Lagrange Multiplier (error)	1,488.103***	1,659.525***	1,009.325***	1,490.121***	1,714.517***	566.668***	1,896.685***	815.896***	500.612***
Robust LM (error)	310.228***	399.466***	388.255***	400.324***	209.978***	107.541***	349.017***	124.755***	230.431***
LM (SARMA)	1,561.264***	1,734.013***	1,009.443***	1,504.568***	1,726.882***	568.637***	1,908.225***	847.238***	500.780***

*Tab. 2: OLS regression models of spatial drivers of urban riverscape recreation. Significance level is marked with asterisks * p < 0.05, ** p < 0.01, *** p < 0.001*
Source: author's calculations

	Recreational walks	Social life and entertainment	Land sports	Contact with nature	Routine necessities	Relax	Taking photographs	Transit	Water sports
Distance to entrance/exit points	0.067**	− 0.015	0.058	0.005	− 0.008	− 0.029*	0.015	− 0.0184	− 0.028*
Distance to public transport stops	0.064*	− 0.117***	− 0.015	0.004	0.001	− 0.045**	0.090***	0.024	− 0.086***
Distance to recreational amenities	− 0.104**	− 0.018	0.072	− 0.103***	− 0.090***	− 0.044*	− 0.068**	− 0.107***	− 0.005
Distance to shoreline	0.157***	− 0.102***	0.309***	0.069**	0.040*	0.034*	0.128***	− 0.025	− 0.192***
Path density	0.268***	0.170***	0.472***	0.159***	0.058***	0.003	0.106***	0.055***	− 0.102***
Tree canopy intensity	0.101***	0.001	0.132***	0.066***	0.023*	− 0.011	0.024*	− 0.011	− 0.081***
Riverscape openness	− 0.053**	0.005	− 0.026	− 0.003	− 0.016	0.008	− 0.005	0.003	0.046***
Constant	1.127***	0.733***	1.634***	0.893***	0.582***	0.418***	0.709***	0.518***	0.392***
LAMBDA	0.846***	0.818***	0.823***	0.821***	0.804***	0.726***	0.819***	0.740***	0.734***
AIC	3,345.43	2,343.38	5,396.04	2,011.27	545.405	− 329.29	943.72	134.60	694.76
R-squared	0.51	0.49	0.45	0.43	0.44	0.31	0.48	0.43	0.52
Number of cells	1,957	2,030	2,159	1,960	1,587	1,237	1,708	1,554	1,560

*Tab. 3: Spatial error models of spatial drivers of urban riverscape recreation. Significance level is marked with asterisks * p < 0.05 ** p < 0.01 *** p < 0.001*
Source: author's calculations

were more likely to contact nature and play sports during the week, while walking and social interactions played a more significant role at the end of the week.

5.2 Where by the urban river?

Survey participants clearly pointed out their preference for spending time along the river in the densely populated city core rather than in the peripheries, and the tendency was observed regardless of the preferred activity. Previous studies found significant links between the density of population in the park neighbourhood and the frequency of visits (Riechers et al., 2019) or social media activity (Hamstead et al., 2018). Analysis for the particular activities, however, provided a more nuanced image. To some extent, the results correspond with the work of Rall et al. (2017) and Riechers et al. (2019), both conducted in Berlin, and Warsaw's study of Bąkowska-Waldmann (2022): social life and entertainment and recreational walks were more important for city centre visitors. According to Pinto et al. (2021), sociodemographic diversity and the multifunctionality of urban nature account for the preference for social interactions. In this case, it applies to the most visited locations along the river; centrally located boulevards with bars and restaurants along them, and to the urban beaches on both shores (Warsaw City Hall, 2020). Since land sports and contact with nature were expected to be prominent in the city's outskirts, however, the results only partially confirmed this assumption. It is probably due to the presence of a quasi-natural riparian zone in the city centre, on the eastern bank of the river, both intensively used as a recreational space and admired from the boulevards on the opposite shore. Conversely, Rall et al. (2017) found in Berlin inner city clusters of sports, while nature experiences, spending time with family, and dog walking were more dispersed.

5.3 Spatial drivers of urban riverscape recreation

There are two major findings concerning how spatial drivers influence riverscape recreation. First, the attractiveness of riverine nature is multifaceted. Spatial error models revealed significant links between tree canopy intensity and a set of movement-related activities (recreational walks, land sports, routine necessities). These links specifically refer to the peripheral part of the riverscape, with paths and trails through the riparian forests and meadows as the main communication corridors. The results also suggest that tree-covered areas are valued both due to their recreational potential and the calming effect they provide, supporting previous studies that underscored the positive role of shade provision for recreational preferences at meso- (lower temperatures in the riparian forests) and microscale (shade provided by one or a couple of trees) (Ayala-Azcarraga et al., 2017; Krellenberg et al., 2021). OLS models proved the negative impact of tree canopy intensity on demand for social life and entertainment, but it turned out to be insignificant when spatial dependence was taken into account. On the other hand, this was the only non-water activity positively stimulated by the proximity of shoreline according to SEM; it is linked to the use of city-centre boulevards and riverine beaches where social life and entertainment strongly clustered. Here, visual contact with flowing water can be the key aspect of experiencing nature; for many, the river is probably treated as a nice background for social interactions rather than the main purpose of visits (Völker & Kistemann, 2013). OLS models also revealed negative associations between riverscape openness and people's activity that could be linked to limited access to shores outside the city core in both physical (wetlands, natural reserves) and visual (main paths are separated from the river by willow-poplar forest) terms. This effect remained significant only for recreational walks in SEM, however.

Second, it is all about accessibility. The study revealed that riverscape visitors stick to the paths regardless of the activity, which is in line with previous studies (Palliwoda & Priess, 2021). Routes drawn by survey participants accounted for 40.4% of all the marks, and some point locations represented places where people decide to stop their routes for various reasons: to rest, to enjoy the view. However, the crowded paths and trails can reduce the tranquillity effect (Åberg and Tapsell, 2013) or generate conflicts between different visitors, such as cyclists and dog walkers (Smith et al., 2022). In terms of reaching the riverscape from the outside, the effects were more nuanced. SEM revealed that demand for predominantly city-core activities (social life and entertainment, relax) was associated with the availability of public transport as the river serves as a citywide attraction (Riechers et al., 2019). Demand for relax grows with the distance to the entrance/exit points and to public transport stops, which may indicate that people seek a calming refuge from the urban buzz (Kaplan & Kaplan, 1989). The lack of importance of public transport availability for recreational walks and land sports can be related to the use of riverscape as neighbourhood green spaces that are mostly reached by foot (Zwierzchowska et al., 2018). Nevertheless, for more distant spaces, insufficient connections were previously raised in relation to the less frequent visits (Elbakidze et al., 2022).

5.4 Methodological considerations

Online PPGIS surveys are a robust source of information on people's attitudes and preferences towards urban green spaces (Brown & Kyttä, 2014). They enable the researcher to broaden the scope of participants through multiple forms of survey distribution (e.g. flyers with QR code, social media posts, mailing lists). This study followed the bottom-up approach by aiming to reach all local communities across the city; in this respect, the questionnaire was submitted to more than 200 communities gathering the members of neighbourhoods, housing estates, and housing cooperatives, supplemented by several district and sport-related groups. This approach succeeded in providing the information on recreational patterns of Warsaw residents based on their residential proximity to the river. The way the questionnaire was distributed, however, also posed a challenge to demographically balance the sample. As a result, its composition was biased towards women and middle-aged people. Therefore, the results cannot be strictly referred to the city population. The recreational preferences of underrepresented groups require more attention as previous studies revealed age-led differences in attitudes towards and use of urban green spaces (see Ode Sang et al., 2016; Palliwoda & Priess, 2021; Hegetschweiler et al., 2022).

As the survey was conducted in late autumn, the participants were asked to synthesise their riverscape activity during the passing year. They marked usually visited locations and indicated seasonal and weekday-weekend preferences for them. Due to the long temporal scope of the research, the preferred time of day was not addressed. As it can vary seasonally, a panel survey conducted every three months could be conducted to get into detail about riverscape preferences in a day-night rhythm.

The study workflow may be easily implemented in management practice in the spectrum of riverine cities of the temperate zone due to the universality of the case study used. The value of online PPGIS surveys lies in their efficiency, convenient distribution, and respondent-friendly interfaces. Their advantage for monitoring urban outdoor recreation is the ability to obtain information about the entire area of interest at once, including locations that are rarely visited and may be difficult to monitor in other ways. Surveys can be conducted in a regular manner to provide information about the temporal patterns of people's recreational preferences, or standalone (e.g. to consult local management changes). Combined with data from other sources (e.g. interviews, field observations), spatially explicit recreational data can help the managers make data-driven decisions for sustainable management of the riverscape.

6. Conclusions and management and policy implications

In this paper, spatial, remote sensing, and survey data were combined to model spatial drivers of the recreational activities in the urban riverscape. Recreational walks, social life and entertainment, and contact with nature were found the most prominent activities along the urban river. Close-living visitors seem to treat the riverscape as a neighbourhood green space, while for those living further away it is rather an occasional attraction to visit on warm weekends. The central part of the city is a core of riverscape activity that spreads outwards along the paths and trails. OLS regression and spatial error models predicting spatial drivers of riverscape recreation showed the multifaceted role of riverine nature and underscored the role of riverscape accessibility. These findings shed new light on the motivations of riverscape visitors and provide knowledge that can support the sustainable planning and management of urban rivers as recreational spaces.

The obtained results indicated three main challenges for the spatial planning in riverine cities in general as well as the recreational policies towards the urban riverscape in particular. First, as dominated by outdoor activities, riverine recreation in the temperate zone is affected by seasonal changes; the off-season decrease of demand for visiting the riverscape is especially the highest in the case of visitors living more distantly from the river. The results underscored that the recreational potential of the riverscape is scalable, what requires the managers to consider both local and citywide perspectives in the preparation of recreational policies. Therefore, one of the solutions to overcome interseason disparities could be further development of the under-roof recreational opportunities taking place in autumn and winter (e.g. organising cultural events on barges tied to the boulevards). Previous studies underscored that the presence of amenities is correlated with the number of urban park users (Cohen et al., 2013), and they are valued regardless of the season (Vierikko & Yli-Pelkonen, 2019).

The other challenge in urban riverscape management is to balance conservation principles with the demand for recreational spaces. The Warsaw study results underscored the influence of centrality as well as the role of paths and amenities in the creation of recreational 'honeypots'. The term originates from conservation studies and defines (intentionally created) sites that attract a larger number of visitors than their surroundings (Williams et al., 2000). Honeypots are mostly used in protected areas to reduce human pressure by directing the flow of visitors to particular amenities or through selected paths and trails. In Warsaw, the central part of the riverscape on both sides functions as a multifunctional recreational honeypot, while outwards from the city centre the traffic is channelised using sequences of delineated paths, mostly led on the tops of embankments. As they are mostly hardened, they are suitable for walking and cycling; it attracts a significant number of visitors, at the same time reducing the direct pressure on the riparian zone. Nevertheless, the domination of the central part of the riverscape as free time destinations remains evident and requires further attempts in order to responsively spread out the recreational demand for the river. In this respect, new recreational amenities outside the central part of the riverscape should be aimed to minimise human impact on the riparian zone (e.g. dog parks, outdoor gyms). The spatial preferences of visitors can be also managed with the creation of the image of an urban riverscape using social media feeds by the local authorities. With knowledge of the patterns of riverscape recreation, specific places can be promoted as attractive to visit in general or for undertaking the particular activity in detail. On the other hand, the change of behaviour that is somewhere unwanted due to the management policies can be persuaded using social media posts that can be viewed by thousands of city residents.

Nature protection principles can also pose a challenge to provide the city residents with physical access to the river. The results indicated that the recreational use of the riverscape increases with distance from the shoreline; also, landscape openness was negatively associated with magnitudes of activities in OLS models. To address this challenge, more viewpoints on the river could be provided beyond the boulevards, with basic recreational infrastructure encouraging visitors to stay a while (e.g. log benches) if possible. To facilitate the access, both new and existing viewpoints should be properly signed. On the other hand, to reduce the human pressure on the riparian zone, some desire paths can be blocked using fallen branches. These insights may guide both the management of relatively natural areas and the planning processes of restoration of river valleys, where recreation is regarded as an important driver (Zingraff-Hamed et al., 2018).

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