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Behavioural mapping and online data as tools for socio-spatial analysis of public spaces – Bratislava, Slovakia waterfront case study

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Abstract

Renewal, revitalisation, or reconstruction of public spaces is an inevitable part of the urban dynamics process. However, before any decision of future development is made, it is necessary to be acquainted with the given place. Mapping urban spaces is essential for recognizing the specifics of a certain area, while a relevant analysis should be performed on the basis of multiple data sources. Nonetheless, identification of relevant data sources as well as their limits, which need to be considered, represent challenges in the process. The study aims to highlight the importance of socio-spatial analyses as tools which help to familiarize place makers with public space as well as with the small nuances of its everyday functioning. Relevant online data sources for urban space analysis (Instasights, Strava) and their limits were explored, described, and applied to the area of interest - two banks of the Danube riverfront in Bratislava, Slovakia. The method was supplemented by mapping of human movement and behaviour. The combination of the methods is a relatively fast and simple way to get to know the spatial, social, environmental, aesthetic, and other dimensions of the given space. The interpretation of data illustrates possible outcomes that can be gained through mapping of public spaces before changes or development plans are proposed. Hence, the paper contributes to the repertory of the possible sources of online data that can be used for recognizing the specific characteristics of individual public spaces. This contributes to responsible decision-making about the future of the urban environment, built on data-based arguments.

Highlights for public administration, management and planning:

- Online data represents a valuable source of city-related information as well as a relevant addition to other mapping methods.
- Mapping an area of interest is a necessary step of the data-based planning process and should always precede any development of urban spaces.
- A combination of data from various data sources which reflect life in public space can support user-oriented planning and contribute to responsible decision making.

Keywords

Mapping,
Waterfront,
Public space,
Online data,
Behavioural mapping

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1 Introduction

Cities are complex and continuously changing systems, consisting of networks of public spaces. These serve mainly to their users and should be therefore adapted to their specific needs. In democratic planning, each public space is a result of social consensus, striving to find a delicate balance among various groups of actors or stakeholders. The topic of creating quality public spaces is dealt with by many participating disciplines (architecture, urban design, urban sociology), where spatial planners play a distinctive role, perceiving the context of the territory, its spatial semiotics, its hidden potential as well as its local nuances

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at a smaller scale. These aspects need to be thoroughly mapped, interpreted, and reflected in any transformation of the area, while people, as the primary users, should be the centre of these transformations.

In European cities in particular, planning is getting back to celebrating the street as the principal and the most important part of urban fabric and city anatomy. Design of our public spaces is returning to the human scale, emphasizing elements such as local culture and identity, authenticity, diversity, place attachment, genius loci and sense of belonging (Lutherová & Hlinčíková 2016). Re-using a project from a different geographical context without an emphasis on local needs and culture can lead to ostensible improvements of public spaces not accepted by the public, spaces not utilized by local communities or even their rejection. Human territoriality is continuously developing and the sense of belonging or place attachment is possible only in highly articulated space, clearly revealing its function, philosophy and meaning. Recognising the context and specific conditions of the respective place as well as needs of its communities and inhabitants from local to the larger scale level appears to be the basis when dealing with a public space of any kind.

With the climate crisis opening questions about sustainability of cities and its public spaces, accurate planning of these spaces´ functioning is becoming incredibly important (Clark 2019). Waterfronts represent linear public spaces, consisting of zones with specific character. These zones – waterfront character areas - include both natural and urbanized areas with different use, user groups or typical day dynamics. They bring variety, sustainability, inclusivity, and room for various reasons to visit the river. Preservation of the specific character of waterfront areas and their development with long-term vision is vital for the urban sustainability, diversity, and balanced ecological conditions of the water ecosystem. Waterfront represents the most intensive contact of natural and artificial elements within a city´s urban morphology, delivering each city a unique identity, profile, and gestalt (typical shape). It is a special opportunity for a city to interact with elements which are not portable, and which are resilient to radical transformation.

In order to identify the local character elements of a place, that are the basis for preserving its identity, multiple methods can be used. Mapping methods such as observing the life of the given public space as well as analysing it through data gathered by contemporary technologies recording human behaviour are some of the available ways to reveal place identity and usership patterns (Cook & Thorsen 2021) and gain relevant background material for the following planning process. Data and new technologies with a combination of local knowledge represent the best options to provide preconditions for creation of sustainable and more livable cities. Mapping, as part of socio-spatial analysis, can define essential aspects of the space, *„uncover realities previously unseen or unimagined, even across seemingly exhausted grounds"* (Corner 2011, p. 89). Careful mapping should therefore precede the decision-making process.

The process of mapping combines various methods of data gathering, requiring different levels of expertise. In this study, behavioural mapping and analysis of online data sources is presented as a relatively accessible approach to public space analysis, which can be applied by a wide spectrum of actors – local governments, urban planners, architects, etc. Recognizing the specific character of individual public spaces can lead to responsible decisions about the future of the urban environment.

2 Theoretical overview

2.1 Waterfronts

Urban waterfronts, a unique type of public space where the water meets the edge of the land, represent a specific combination of urban and natural environment within cities. They have undergone a long development - from places of the first human settlements through areas of an industrial nature, primarily intended for the transport and translation of goods, to popular destinations for pleasant walks. These spaces have taken on new meanings in recent decades. As waterfronts have undergone a long development process, their function, design, or primary use have naturally formed along their entire length within cities. Unique character areas have emerged alongside rivers. They serve as key elements in building the city-river relationship and represent valuable spaces with various identities, complementing each other while contributing to the overall identity of a city.

Apart from forming the city's identity and connections with the city, urban waterfronts bring numerous benefits to the city and its communities, including social, environmental, and economic assets. On one hand, waterfronts play an important role in transforming the structure of cities, on the other hand, successful waterfront projects demonstrate the potential to unlock and mone-

tize urban resources - available land, cleaner water, conservation, and revitalization of cities - and how these elements can be integrated into urban and public life (Wei 2017). However, waterfronts are often the places of spatial conflicts - they are placed on the crossroad of interest of various city actors and stakeholders and their optimal usage is not always obvious (at least in long-term horizons). The question of successful waterfront projects or the whole waterfront areas, therefore, depends on the city's ability to manage these valuable public spaces of meetings, relaxation, culture, activities, or sports.

Cities with a water element are predisposed to tourist and economic growth or growth within the sports and recreational field. With a length of 2857 km (MINZPSR 2018), Danube River is the second longest river in Europe and the longest river in the European Union after the Volga River. It flows through 4 capital cities (Vienna, Bratislava, Budapest, and Belgrade), to which the river offers many opportunities. Each of the cities operates with a space that can significantly contribute to the overall quality of life in the city. Danube is also a massive symbol of historical and cultural heritage, from Roman times through Habsburg monarchy till the Central European identity crystallized during the hectic 20th century.

The special character of Bratislava waterfront, to a large extent, derives from its unique position. The city lies under the Small Carpathian mountains, where the natural character is strengthened by the Danube floodplains area and other natural areas unfolded alongside the river. The Danube waterfront has a special position in the urban composition and visual identity of the city as well. The river forms its main natural compositional axis and with its current or historical urbanization completes its typical image (Juhász 2014).

The special character of Bratislava waterfront also consists of different types of river banks, where the river creates waterfronts of different characters. While the left bank has an urban nature and represents a certain chronicle of the city, preserving its centuries-old story, the right bank, which represented an "unwritten canvas", for many years, is characterized by a rather natural character. We are also witnessing functional specialisation of both banks - looser disposition of right bank is suitable for contemporary activities (beach volleyball, festivals, gatherings...), while a steady and more binding disposition of left bank serves other functions (traffic, undisturbed visual impact of the city etc.). This character, based on different functions as well as the combination of nature and the city is unique, needs to be preserved and the future development of the Bratislava waterfront should build on this advantage. It should reflect the different character of the river´s two banks and adapt the future development to these contrasts.

If the Bratislava waterfront is to be approached comprehensively and professionally, and if this valuable space is to be attractive to diverse user groups, it is necessary to understand how its banks and individual character areas function. It is crucial to be familiar with the typical users, prevalent activities, day dynamics of a space, the users' needs, character elements of waterfront areas that contribute to their unique identity, or natural elements that contribute to the sustainability of the cities themselves. At present, however, there is no socio-spatial study of the Bratislava waterfront that would comprehensively analyse the space from the user's point of view. In fact, in many cases, mapping as a base for further development of a certain area is often underestimated. Yet, it is often the recognition of little nuances of the space that make it possible to design it well, inclusively, and sensitively, therefore make it successful and attractive for people of all age groups, both men and women, or people from different economic backgrounds.

2.2 Mapping urban spaces

"...the surface of the map functions like an operating table, a staging ground or a theatre of operations upon which the mapper collects, combines, connects, marks, masks, relates and generally explores." (Corner 2011, p. 90)

Mapping or a spatial analysis in urban planning should generally precede making of a new project, decision making. Outputs of this process create analytical information, reflecting the spectrum of spatial, social, environmental, or aesthetic and other parameters of a given space. They provide ground for future decision making, enable the construction of an argument and provide material for comparison or evaluation of future interventions in the public space.

The built or physical aspects of an environment obtain new meanings when combined with the everyday realities of the space. Therefore, the space is more than just its physical attributes (buildings, terrain, roads, etc.); it's also the users, ever changing nature of relations and processes on the political, individual, societal, or natural level as well as historical events or stories of local communities. By combining and layering these aspects of a space, a sharper picture of the life within buildings is revealed. The ability to sensibly interpret the gath-

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ered data is, however, an essential part of mapping. This way mapping serves as a creative tool for planners, architects or urbanists which unfolds the hidden realities of a given space.

Mapping as a base for socio-spatial analysis can be, however, carried out in various ways that supplement each other. It should not be understood as a simple accumulation of data, but rather as a *"practice of relational reasoning that intelligently unfolds new realities out of existing constraints"* (Corner 2011, p. 100). The analysis can consist of in person observation of life in the given public space, interviews with its users and main stakeholders, desk research and analysis of various aspects of the place, time-lapse photography and other methods of visual sociology, questionnaire surveys, projective socio-psychological methods (drawing, interpretation of pictures), online data analysis etc. This study presents a socio-spatial analysis in the form of observing human behaviour and life in given space, supplemented by data analysis, collected from online sources (e.g. big data). This way, it is possible to follow up on the traditional mapping methodologies and at the same time there is a potential to improve or move it further by using online data.

2.2.1 Behavioural mapping of public spaces

Urban spatial structure is considered to be composed out of physical and social environment (Sýkora 2001). The physical environment can be understood as the natural elements and man-made components (e.g. greenery, buildings), while the social environment consists of humans and their activities. There is also the third component, which is the "abstract" level (politics, economics, ownership relations etc.). Some phenomena of urban spatial structure can, however, be discovered only through personal experience in the urban setting.

The approach of individual scientific disciplines to the study of public space differs in the theoretical scope, methods and the very goals of the research. In recent decades, geography has begun to tend towards the social sciences and to focus on the relations between space and man. This shift is commonly referred to as the social turn in geography (Šuška 2014). Social sciences such as social anthropology or ethnography, often described as disciplines about the culture of everyday life, have become much closer to human (social) geography in recent decades. They focus mainly on people and their lived reality, they deal with their experiences, social relationships, physical environment, identities, and the way in which they are created, how they are reflected at different levels of human existence (Lutherová & Hlinčíková 2016).

Based on environmental psychology or anthropology, several researchers devoted their research to studying public spaces with a focus on their users. Among the most significant ones, it was W. H. Whyte (observation of life in public space) (Whyte 1980), J. Jacobs (advocating for a place-based, people-centred approach to urban planning) (Jacobs 1961), K. Lynch (mental mapping of the city) (Lynch 1960) or J. Gehl (human scale of cities) (Gehl & Svarre 2013). They promoted the theory that studying people, their behaviour or movement within the urban environment, and thus especially public spaces, is the basis for understanding the way these places function and creating better cities for people. The character of the place is thus defined not only by physical/architectural structures but also by behavioural patterns typical for each place.

Observing human behaviour in public spaces can unfold essential relationships between examined aspects of space, which would otherwise remain seemingly disparate. The relationships between aspects of public spaces as well as the results of such relations are of a great importance for interventions in urban milieu rather than a simple description of the arrangement and position of objects and surfaces (Corner 2011). The approach of W.H. Whyte or J. Gehl was based on the premise that if we know and understand the behavioural patterns of people in public space, we can use this knowledge to create better public spaces.

Researchers use human behaviour observation as a research method in many studies of public spaces. To study waterfront areas as places of public life, scientists and scientific teams often address the topic of waterfront elements in relationship to sustainability pillars (Apriliani & Dewi 2019) or identity (Lacilla 2016), the topic of the social life of public spaces on waterfronts to understand the human interactions (Andini 2011; Wang et al. 2020), or the effect of waterfront development projects on the waterfront itself (Azlina & Abdul Jalil 2016). As an example from Slovakia, the Section of Urban Studies and Participation at the Metropolitan Institute of Bratislava, has used the method of mapping people's movement and behaviour in several of its projects. It was especially useful in the process of finding the most sensible tram tracing within a sensitive locality at the city of Bratislava (Metropolitný inštitút Bratislavy 2020b). By mapping the human movement and behaviour at the locality, conclusions related to the usage of the space as a transit rather than a long-term stay place

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were pointed out. On the other hand, the waterfront area within the mapped locality was described as a place of spending time, recreational ground, place of pleasant walks etc. Therefore, human observation as a mapping method can lead to quality arguments to justify decisions with impact on public space.

However, mapping human behaviour in urban spaces, as a method used in this study, can face multiple challenges or limits. It is the outdoor conditions in a certain time, e.g., weather, outside temperature, season of the year, time of the day etc., which are just some of the factors that influence the way people act in public spaces. Even the fact that people notice somebody observing their behaviour can influence their actions to a large extent (Landsberger 1958). Apart from the named factors, a specific situation of Covid 19 pandemics has a large impact on the usage of public spaces. Lockdowns and other anti-epidemic measures minimize the human movement outside their homes and modify their outdoor behaviour. Therefore, Covid 19 impacts the process of mapping human movement and behaviour as well as online data. All these limits of mapping need to be considered during interpretation of data collected.

2.2.2 Online data and their use in urban studies

Nowadays, it is possible to build on the "typical" mapping methods and use various supplemental innovative methods – e.g., online data. It is data that contains information about the users of public spaces, which are constantly collected, categorized or analysed, often without our utter knowledge. Big data is characterized mainly by their considerable volume, complexity, or growth rate. When collected long enough, it is possible to see the long-term changes of human behaviour, public spaces usage, transportation habits etc., which were once possible to see only in large time periods, for example every 10 years, during population censuses (Batty 2013). Therefore, data can support a real-time view of a particular city and link its citizens with policymakers in a way (Clavier 2020).

At present, for most global companies, not only in the field of IT, big data represents a common part of their infrastructures. However, public sector at the level of local governments (spatial planning of cities, architecture, etc.), uses this potential minimally (Suja 2014). In recent years, companies that collect mobility-related and other types of data started to share them for public purposes. As an example, Uber, Strava, TomTom or Bolt shared their data along with their analyses. All these can be used and analysed for spatial planning purposes. Nevertheless, within the City of Bratislava, for example, the Department of Data Policy and Analysis of the Municipal Office of Bratislava processes the data of the city and publishes datasets on the city portal www.opendata.bratislava.sk. This is one of the good examples of working with online data on a local government level. By creating Open Data Portal, Bratislava joined other world metropoles that openly publish their data.

Nevertheless, spatial online data can tell a lot about a territory and provide space for data-driven decision-making. Combined with observation of human behaviour, online data can be a source of interesting information for urban studies, which would be very difficult to obtain by other methods of data collection (or it would require a long period of time). Among other sources, data from SIM cards[1], social media posts with spatial coordinates (e.g. Instagram, InstaSights), applications for athletes (e.g. STRAVA), data from public Wi-Fi networks, public transport travel cards (Batty 2013), etc. can be used, analysed, and interpreted with the intention of public space analysis. These data sources can help place makers or researchers make causal estimates without the need to run an experiment (Salganik 2017).

Researchers have used online data to analyse urban environments in various ways. For instance, they monitored the park busy hours (Kovacs-Györi 2020), places at which people tweeted more positively, analysed crowd movement patterns for pedestrian modelling techniques (Leeson et al. 2014) or explored habits and patterns of visitors at a specific point in time (Covid 19 pandemics) (Pilvi 2019). There are some studies which have used online data for waterfront research. The analyses usually comprise of data from social networks, which examine the dynamics of these spaces (Marti 2019), differences in ethnicity, gender, education, etc. within individual waterfront zones (Fekete 2018). The methods used to analyse urban spaces are usually traditional questionnaires, interviews, or observation of people. However, combination of findings with online data is rather rare.

The amount of data collected nowadays is widening the opportunities for data-based spatial planning. It can help to understand the behaviour of people in urban areas, such as the use of public spaces, public transport or the interactions between people and natural areas within cities. It therefore matches the concept of people-centred planning (Hao 2015). In addition, big data can reveal individual charac-

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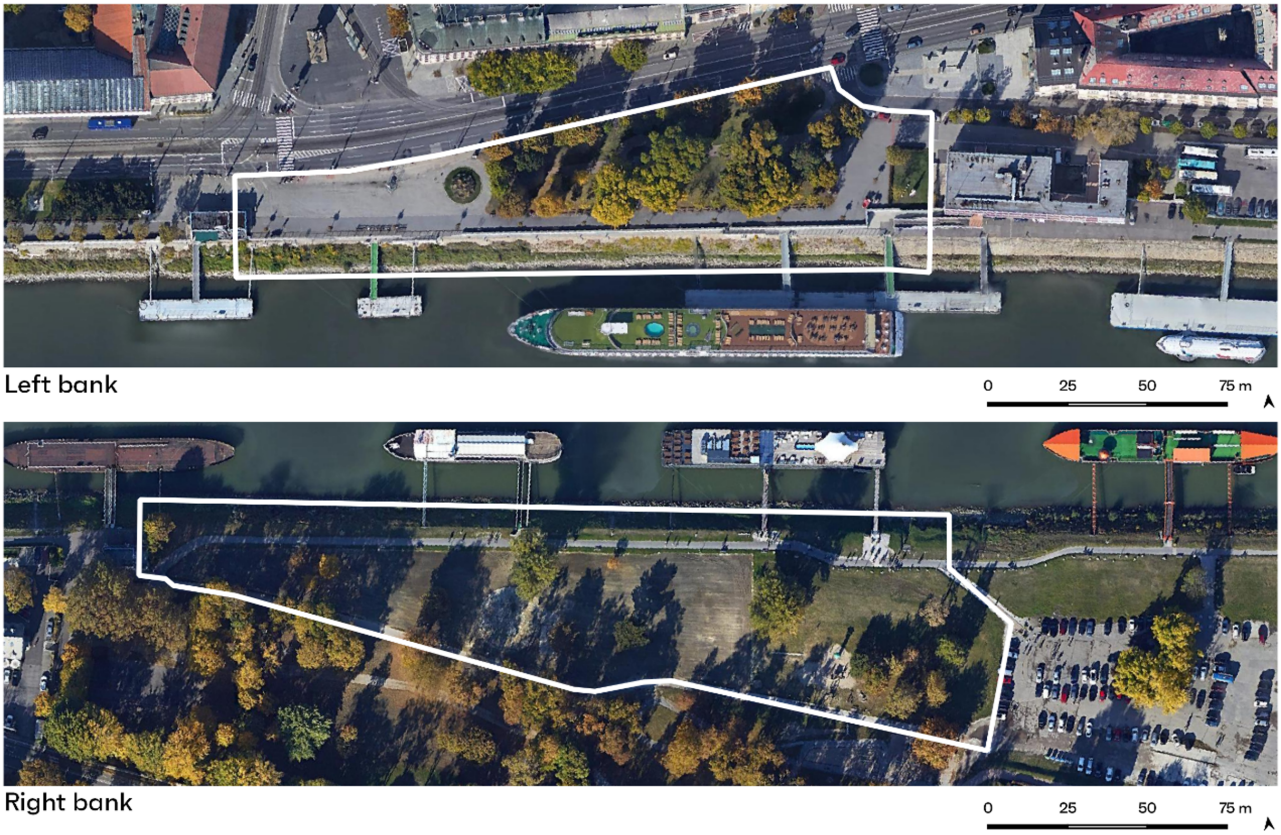

Fig. 1 Examined areas at two banks of Bratislava waterfront

teristics of places rather than a general description of city dynamics.

However, when working with online data, certain principles need to be respected. Among others, there are data ethics which are concerned with data ownership, privacy or openness. Secondly, it is necessary to be able to present the findings in a readable way, therefore data visualisation skills are needed in order to show what the data mean to a broader audience. Another issue is the interpretation of the data, where it is often useful to consult the findings with local actors, who can explain certain phenomena hiding behind the data (Bunn 2019). There are also some limits of online data-based analysis. Certain data are available only within dense urban environments, people of certain age groups can be omitted since the usage of some technologies is common only within the younger generation, etc. The narratives around online data in different contexts can be overwhelmingly male, white, or focused only on certain user groups (D'Ignazio & Klein 2020). Therefore, working with online data requires certain sensitivity, awareness, and local knowledge. Some essential questions to keep in mind include: Data by whom? Data for whom? Data with whose interests in mind?

3 Methodology

The methodology of the research article is divided into 5 phases, which follow each other. Phase 1: The first phase included basic overview and research of the examined area, its borders definition and preliminary photo analysis. Two locations (Fig. 1) were chosen based on their similar location within the length of the river, comparable size and their different character in order to compare natural and urbanised waterfront types.

Phase 2: After obtaining necessary information about the site, research of the online data platforms followed, from which 2 platforms were chosen as relevant to the research topic (more in chapter 4.1 & 4.2).

Phase 3: Selected areas and the context of their surroundings were analysed through the respective online platforms.

Phase 4: In the fourth phase, on-site photo survey and behavioural mapping was conducted. The latter included human activities observation (an example of mapping sheet is showed in the Fig. 2) and note taking 3 times a day for 15 minutes, during a day of the week (Thursday), and day of the weekend (Saturday), for more objective results. For a uni-

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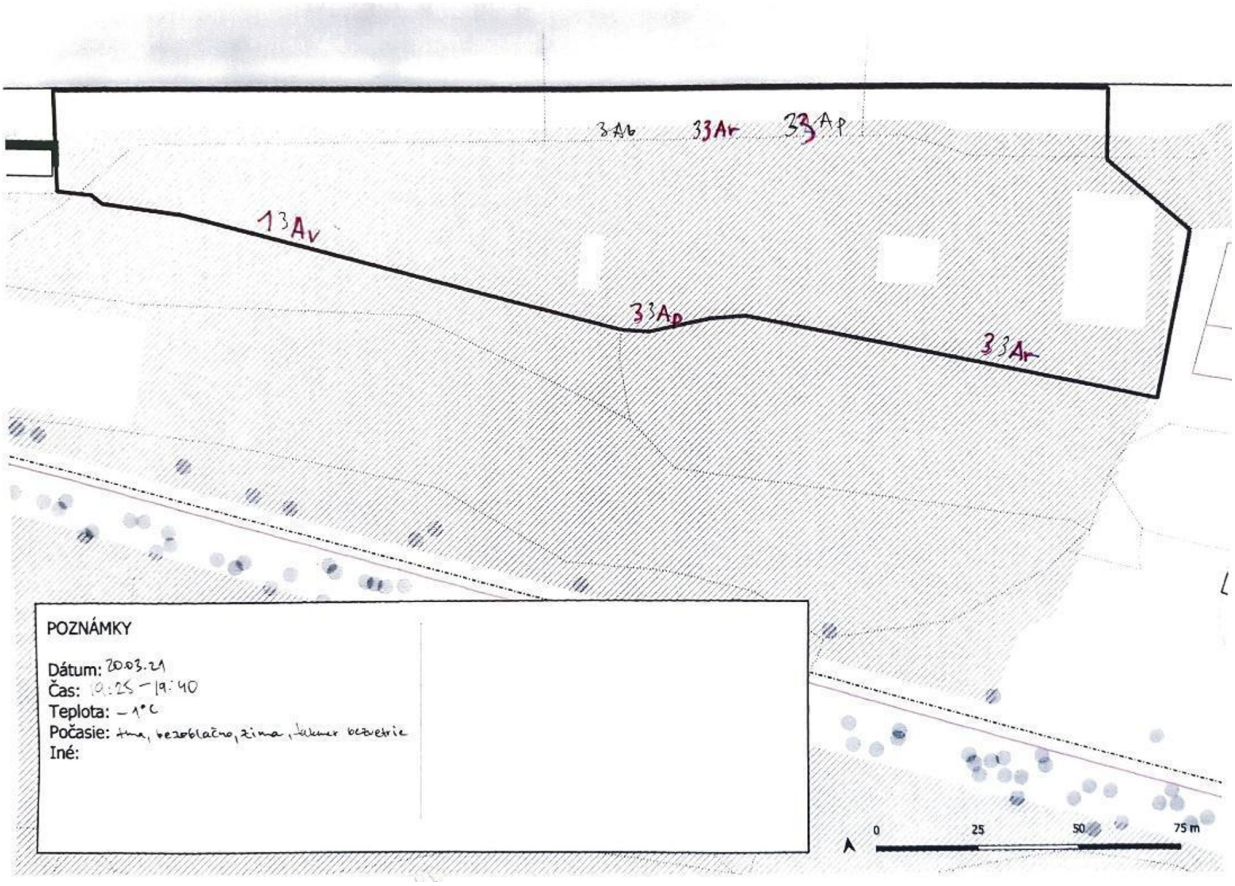

Fig. 2 Mapping sheet - Usage of codes marked in the map of the right waterfront Note: The text frame at the bottom of the figure reads: NOTES; Date: 20.03.2021; Time: 19:25–19:40; Temperature: -1°C; Weather: darkness; no clouds; cold; almost no wind; Others: -

form note taking, codes differentiating gender, age, grouping and activities of people mapped were used (reused from Metropolitný inštitút Bratislavy 2020b). Phase 5: The last phase of the process included the analysis, comparison, and interpretation of data. The "points" of observed people and their encoded activities were transferred into GIS software. This allowed for a better visual representation; however, this step is not necessary – basic statistical findings can be calculated from the data itself. After the data analysis and comparison of the 3 data sources (data from behavioural mapping, Instasights and Strava), the main findings and outputs were defined.

The work uses several methods of data collection and examination, which allow their mutual verification and comparison. The key method is human activities and behaviour observation. An additional method, the analysis of online data obtained from 2 sources (Instasights and Strava) serves to get clearer data-based results and findings. Another method is a photo survey of the examined areas, which allows to study the examined aspects of space off-site[2].

4 Results

4.1 Mapping Bratislava waterfront via online platforms

Online platforms can serve as valuable sources of urban data, which place makers can use without the need to master data science or GIS technologies. It is possible to use these to extract the necessary information for preliminary mapping of the given public space and its broader context. However, *"as of yet, there aren't well-established methods for using social media data to provide place-based insight on people's behavior and perceptions of the built environment"* (Pilvi 2019, p. 1).

4.1.1 Instasights

Powered by TopPlace from AVUXI, a global location rating system that rates the popularity of every place on Earth, the web app www.instasights.com analyses the public online activity of millions of people. Popularity means the most positively

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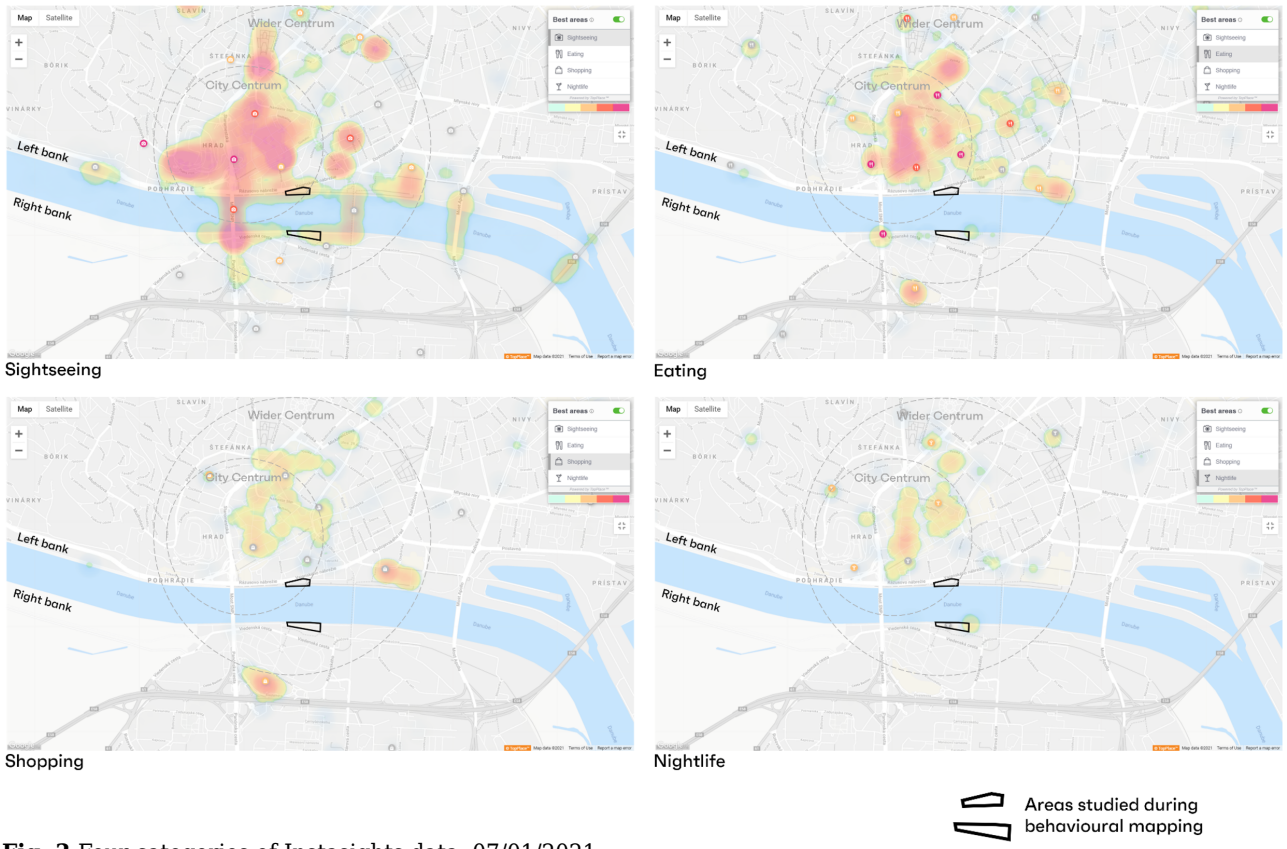

Fig. 3 Four categories of Instasights data, 07/01/2021

mentioned places throughout 4 categories, based on data from tens of thousands and sometimes even millions of people (Avuxi). To achieve worldwide coverage with accurate and categorized results, TopPlace algorithms analyse geotagged signals that are regularly indexed from more than 70 public sources (social media, reviews, photos, events).

On the heatmap, the popularity of a place is divided into 4 categories. It is Sightseeing, Eating, Shopping and Nightlife (see Fig. 3). However, the input sorting algorithm is not available to the public. Therefore, it is not possible to determine according to what key the individual inputs are classified into four categories. The outputs in the application are developed on the basis of new contributions every 24 hours, however, the application does not offer the possibility to view or compare the development of the situation within a certain period of time. As any other source of data, it is important to identify possible limits to the data itself in order to achieve most objective interpretation. At the Instasights web app, the color scale does not indicate the number of inputs, it shows the relative intensity. Therefore, it is difficult to determine whether the area with the darkest red indicates tens, hundreds or thousands of entries. Regarding the accuracy, when looking at a place of smaller scale, the data may be relatively inaccurate. Another issue is the sources of inputs, which are not clearly stated. The authors of the app inform that these are inputs from various social networks. However, individual social networks have different typical users. Thus, it is not possible to characterise the contributors for the research purposes - e.g. predominant age group, ethnicity, gender, education, etc. Nevertheless, it can be assumed that data contributors are to a large extent tourists, which is the reason why most of the data is located in the city centres of cities, places that naturally attract tourists rather than local inhabitants. Therefore, the map can be read as a description of tourist behaviour or preferences and thus to some extent exclude the inhabitants of Bratislava. From the nature of the app, it cannot take into account people who do not use social networks or do not have a smartphone. The main contributors are therefore people of a certain age, economic or education background. A considerable part of the data is represented by the profiles of companies operating in the given area. The restaurant, bar, shop etc. can thus be authors of a large part of the data in the area of its operation (used as PR or marketing).

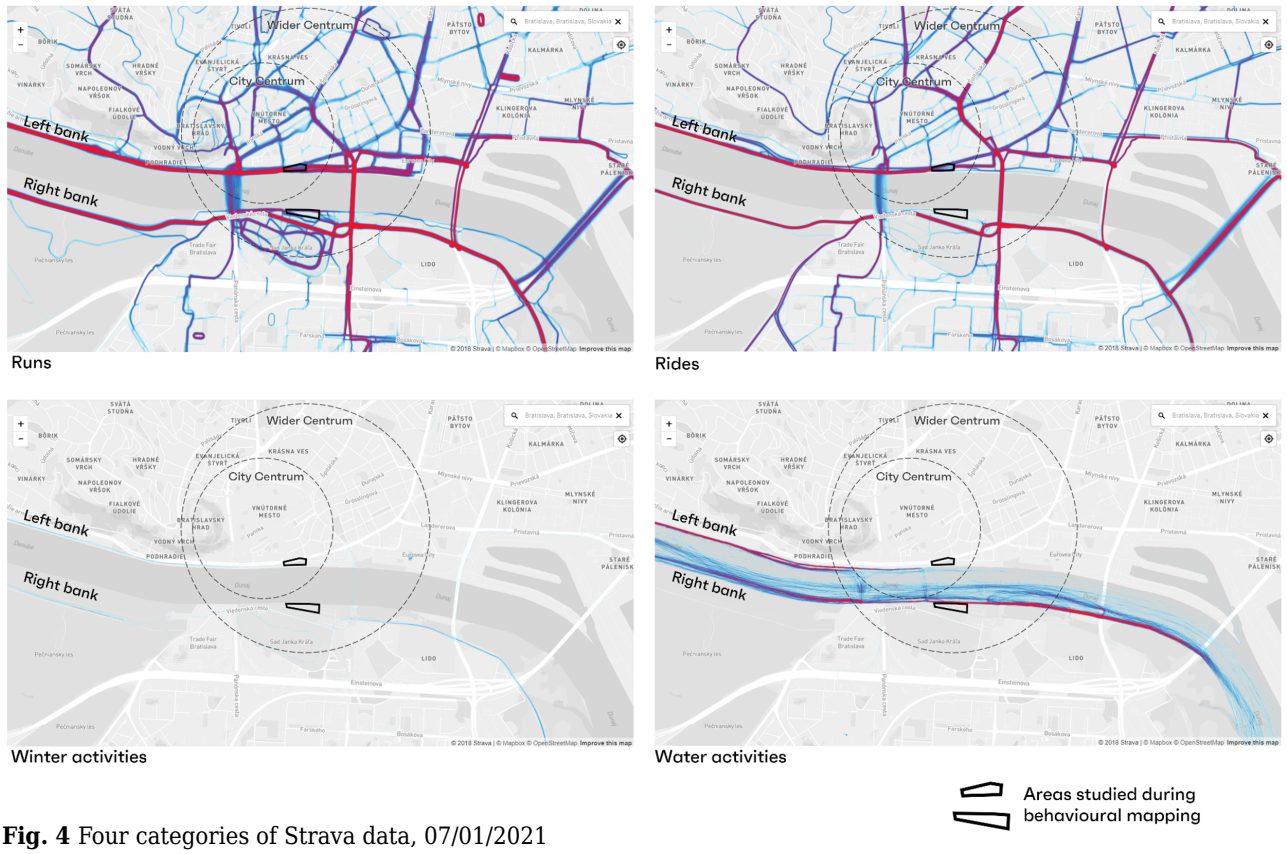

Fig. 4 Four categories of Strava data, 07/01/2021

What does the data say about the waterfront?

Considering all the limitations to the data, the waterfront area in the central part of the city of Bratislava is a dominant attractor to people (whether it is tourists or local inhabitants). There´s an evident preference of the left bank of the river, where the city centre is located, in all 4 categories of data. Partly worse accessibility of the right bank requires "daily planning" when coming there. Bratislava bridges serve as important waterfront viewpoints and landmarks since they are strongly highlighted in the Sightseeing category, while both banks offer views worth sharing on social media. There are certain attempts to improve the visual communication of both banks (Lido-Eurovea), where the landmark of SNP Bridge might be deemed as the primary element of cohesion of urban fabric and morphology as well as urban semiotics of a unique spatial situation. There are multiple smaller focal points of the Eating category on the right waterfront, whereas at the left bank the eating facilities are focused on the shopping centre with waterfront public space and terraces. Pontoon restaurants on the river do not stand out in the map at all. Generally, in the city-scale perspective, the Old City centrum remains the focal point of eating facilities in contrast to the waterfront area. Within the waterfront area, posts tagged under the Shopping category are naturally prevalent in the shopping centre area as well. Nightlife activity is located mainly in the city centre, yet a smaller focal point is seen on the waterfront too – on the right bank, at the city summer beach and event area. This underpins the cultural and recreational function of the right riverbank, which is engraved in its identity. To compare the left (more urbanized) bank with the right (more natural) bank, within this particular group of users (tourists, younger people), the urbanized bank seems to be more popular for most of the activities. The right, natural bank, serves as a nightlife hub and place to eat/drink as well. In addition, it offers distinctive views on the opposite bank. The left bank is part of a natural route for tourists, since it's often the first place to visit and offers beautiful views on the river and its surroundings. From the point of view of noise pollution in the area, the available EUROAKUSTIK s.r.o. data[3] show the left bank being challenged by and in direct contact with both motorised and railway (tram) traffic, while the right bank is more or less separated from these noise pollution sources. This fact might be one of the supporting factors of the leisure function on the right riverbank. In terms of visual smog or safety[4], both banks seem to be on a comparable level.

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4.1.2 Strava

Strava Heatmap (www.strava.com/heatmap) was introduced as an addition to the favourite Strava app – platform for sport men and women to track their sport activities via GPS. Strava Heatmap displays sport activity of millions of users worldwide who have their data set as public. In 2020, there were around 4 billion activities inputs (Knights 2020). The displayed activity include data from the past 2 years while being updated monthly (Strava 2018). The heatmap itself is accessible to the public but only registered users can zoom the map to its full extent – street level, where the data are relatively exact. The Strava application itself is free to use.
Data scientists working for Strava developed a filter for recognizing individual type of activities (or modes of travel – i.e., runs, rides etc.) and filtering out those with incorrect classification. The heatmap therefore shows data categorised into 4 groups: Rides, Runs, Water and Winter activities (see Fig. 4). However, even though the heatmap is being updated monthly, the app unfortunately does not offer the option to look through the development of the situation over months or years. Nevertheless, data from Strava can be valuable for city planners, place makers etc. when planning a cycling network or sport areas, deciding on locations for bike stations/stands (Davies 2019), identifying where gaps in bike or pedestrian networks are located, identifying routes which people favour/avoid for different activities or the most common destinations.
There are certain limitations when using Strava Heatmap as a platform to gain an insight into urban space dynamics. One of the limitations of Strava Heatmaps is the colour ramp, by which the intensity of individual routes usage is distinguished. The ramp does not indicate the amount of inputs but shows the relative intensity instead. Therefore, it is not possible to state whether the route with the darkest red shows tens, hundreds or thousands of activities recorded (note: Strava Metro (Strava 2020) is an additional platform launched in 2014, which governments, planners etc. can use to gain deeper and more detailed insights into the data for the selected area of interest). This is related to the fact that the map is not exactly quantitative – the same colour indicates the same number of activities only locally. When the map is zoomed out, the intensity of colours changes according to the larger area of interest. Another limitation is the user-spectrum of the application - the contributors of the data themselves. It can be assumed that the users are mostly sport oriented men and women, of certain age, economic or ethnic group, therefore certain bias among users of the application can be observed. This means that the data does not give a perfect image of all the cyclists, runners etc., using the public space, but a selected group of people (a sample of the total sport activities), in this case, the users of certain mobile applications. However, the Strava community contains professional sportsmen and sportswomen as well as sport enthusiasts or commuters (Sunde 2019). Nevertheless, *"several independent academic studies have analysed the relationship between Strava Metro data and data recorded by electronic or human bike counters and found robust correlations between the two. This shows that Strava members' travel patterns are representative of the overall population […]"* (Strava (2020, p. 1), Davies (2019)). However, there is an opportunity for similar research outside the USA.

What does the data say about the waterfront?

Taking into account all the limitations of the data source, data from Strava can indicate various information about the space. It can be the patterns of movement or preferences of different groups of sport-oriented people. Combined with the data of bicycle or pedestrian infrastructure, it can serve as a valuable indicator for targeting the places with need of improvement.
Bratislava waterfront area in its central part is a popular destination for both runners and cyclists, nevertheless the waterfront doesn't have a separated bike/pedestrian lane. At the right (more natural) bank, people prefer the continuous flood protection dam for their movement rather than the immediate waterfront promenade. Bridges enable the sportsmen/women to adjust their running and cycling routes to their needs and create movement circles of different lengths. For cyclists, there´s an evident preference of continuous routes, whereas runners seem to not mind changing levels during the run. This is visible on the left (more urbanised) bank, where most cyclists change direction before the middle bridge (Starý most), while runners continue their run to the Eurovea waterfront space, where a barrier in the form of stairs is present. Preference of more natural spaces for runners is visible by the use of nearby park (Sad J. Kráľa) routes and the routes in the river immediate surroundings. Nevertheless, waterfront is seen as an important channel for active mobility, a function that is engraved in its nature.
To compare the left (more urbanized) bank with the right (more natural) bank, within this particular group of users (sportsmen/women), both banks seem to have very similar popularity.

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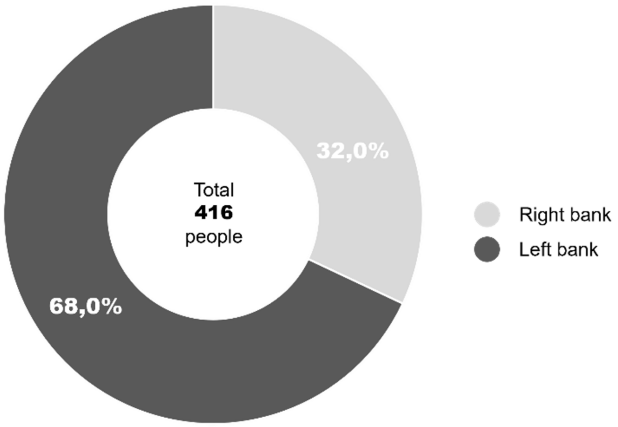

Fig. 5 Proportion of people at both banks of the river

The right, natural bank represents a more welcoming environment for runners because of its natural character and multiple route options. The left bank, on the other hand, includes one straight route on the promenade for both cyclists and runners with no side branches. On both banks, the most prominent lines indicate the preferred routes of sport-oriented people, where the focus of maintenance and further bicycle and pedestrian infrastructure development and improvement need to be aimed at.

4.2 Mapping Bratislava waterfront via behavioural mapping

As another method of data collection, on-site observation - mapping of movement and activities of waterfront users was chosen. This serves as a supplementary, but not secondary method, which contributes to more exact interpretation of the data. It also uncovers mobility and activity patterns of public space users. As during any other kind of public space mapping, the wider context of the area needs to be taken into account during the interpretation process.

The first mapping (out of the planned four) was conducted in spring of 2021 and took place once during weekday and once during weekend; 3x each day. The mapping was done at two different banks of the river Danube in Bratislava - the right bank with a natural character and the left bank with closer proximity to the city centre and more urbanised character. The outcomes of this mapping include the following findings.

There were twice as many people captured at the left (urban) bank of the river (see Fig. 5). The left bank waterfront area represents a transit corridor, a daily route for people working in the city, includes various amenities and has closer connections to the city centre. On the other hand, the right (more natural) bank is less accessible, and the visits of the area can be considered as planned rather than necessary. When the mapping was conducted, there was a Covid19 testing station at the edge of the mapped area of the left waterfront. This partially increased the number of people present and was considered a limit of the mapping process. It was, however, taken into consideration when interpreting the data. Nevertheless, it can be assumed that to a certain extent the preference of the left riverbank waterfront is influenced by the season of the year. Mapping during other seasons of the year will help to gain a clearer image of the space functioning.

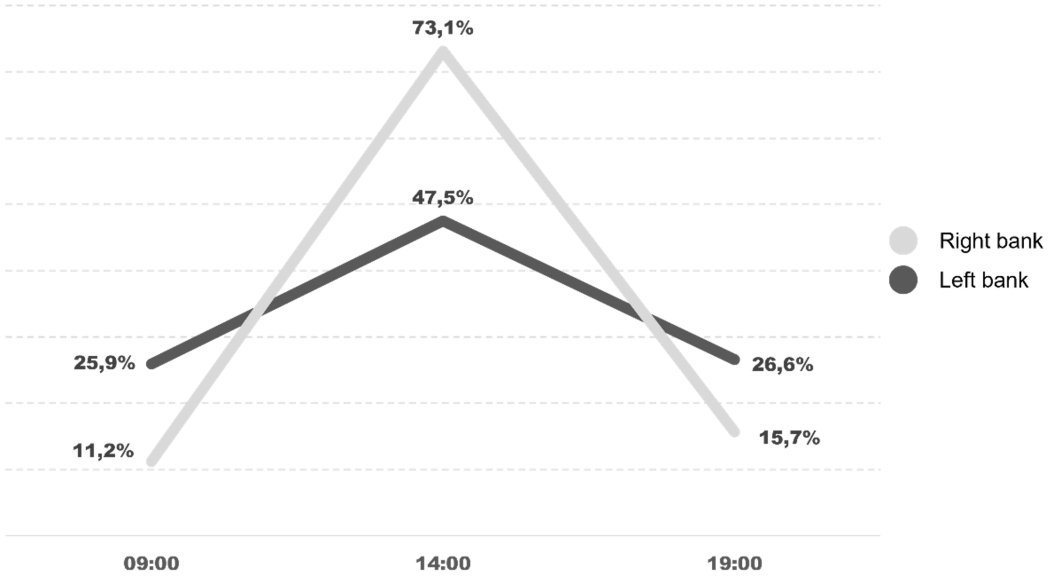

Fig. 6 Day dynamics of left and right bank of the river

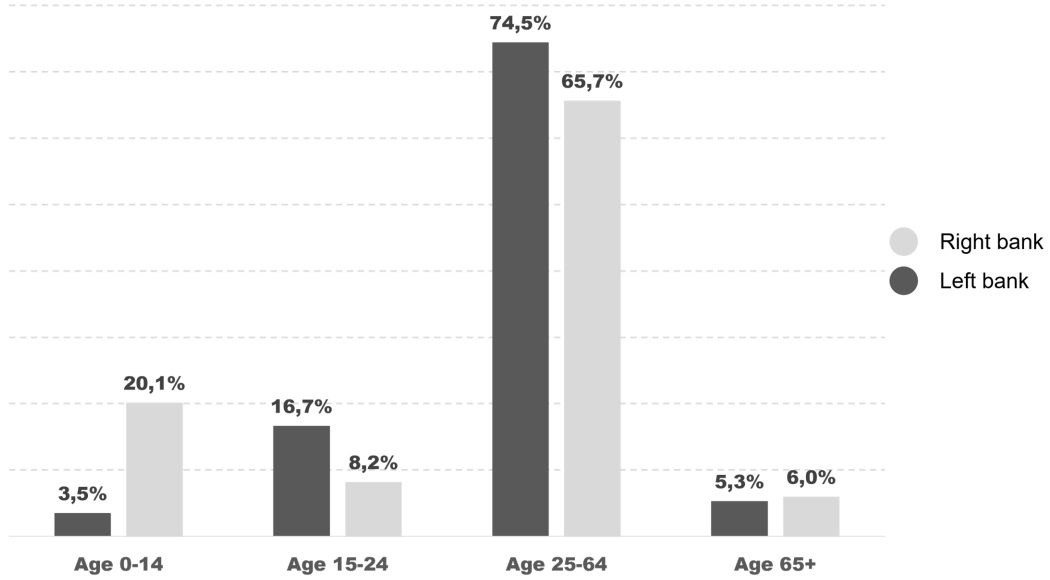

Fig. 7 Age group statistics at both banks of the river

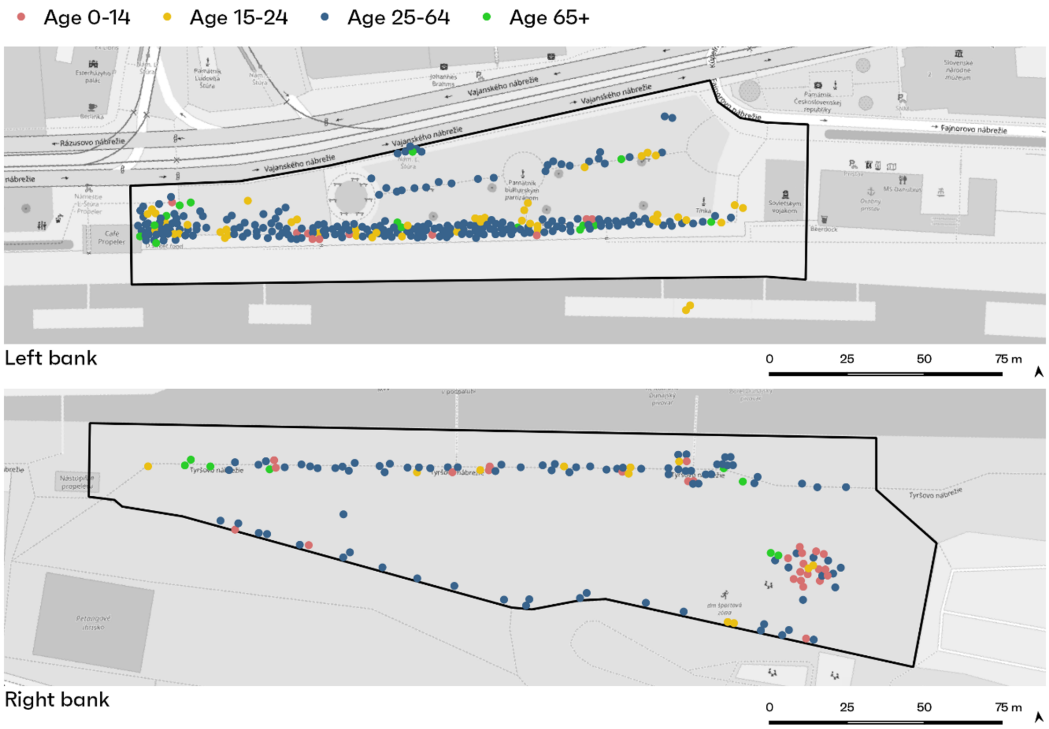

Fig. 8 Space distribution of age groups at both banks

There's a more significant difference at the amount of people present during morning and evening hours vs. during midday hours at the right bank than at the left bank (see Fig. 6). In other words, the right bank is dominantly used during the day, whereas the left bank usage throughout the day is more balanced. During midday, there are various possibilities of how to spend time at the right bank (playground, buffet, natural area). However, during evening hours, it becomes a quiet place, buffet and surrounding businesses are closed and even though there are promenade lamps present, the area becomes dark and abandoned. This area is also located further from the housing area than the left bank, which limits the presence of people walking a dog or short-distance evening walks from home. This finding can indicate the need for program content throughout the day, to a large extent connected with the need for improvement of security at the given bank of the river.

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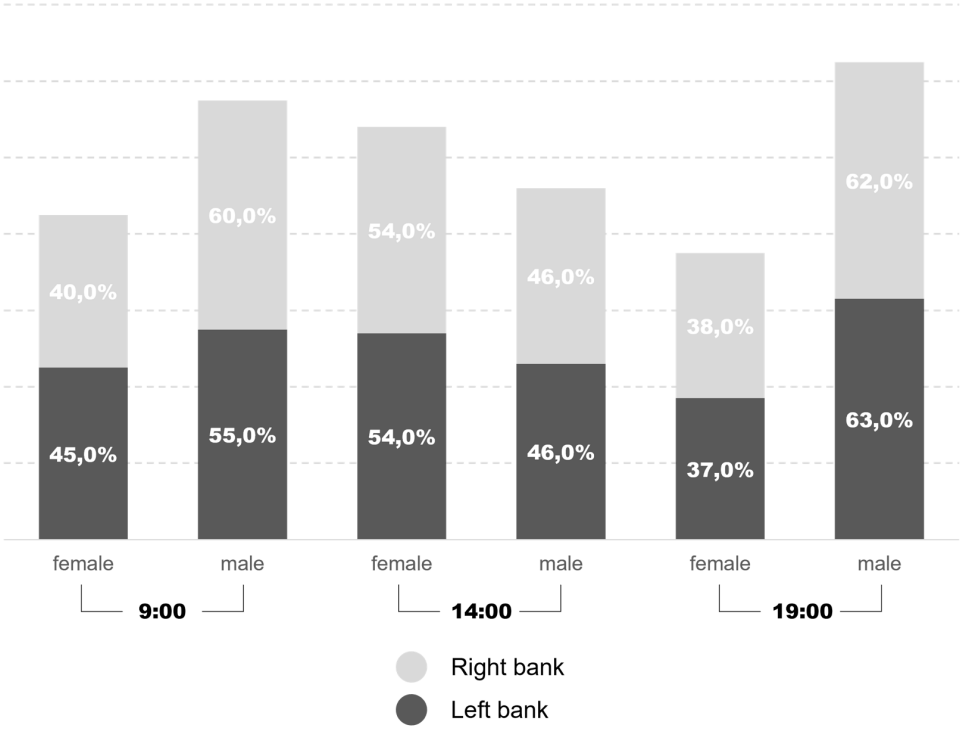

Fig. 9 Proportion of males and females at both banks of the river

There's a notably larger proportion of children present at the right bank of the river (see Fig. 7). The space at the right bank is adapted for children's presence - there's a playground, large green area and various visual impulses. On the other hand, the left bank is more "sterile" and serves as a transit space.

The proportion of other age groups is balanced, however, older people (65+ y.o.) tend to prefer the routes in the proximity to the water (see Fig. 8). These routes therefore should be considered as calmed spaces with barrier free surface and opportunities for rest. Absence of a certain age group in the given public space can be indication of the space exclusivity. This might be caused by a hostile environment, multiple barriers within the space or lack of play or other elements sought after by certain age groups.

At both banks, male presence dominated in the evening hours (see Fig. 9). Women naturally avoid places in which they don't feel safe, places which are dark or abandoned (YouGov plc 2019; Metropolitný inštitút Bratislavy 2020a). The finding of a lower percentage of women in the public space of the waterfront in the evening hours can indicate low sense of security at both banks of the river. Security in public spaces can be improved by sufficient lighting of the area, program content, open space to avoid the feeling of entrapment, clear sightlines, etc.

Top 3 activities at both banks were transit, standing and strolling (see Fig. 10). However, strolling is the most represented activity at the right, natural waterfront, while transit is the most prevalent at the left waterfront. This might be explained by many people commuting through the urbanized area (to work or other places). These two activities differ in their intention and set the overall atmosphere of the space - space of leisure vs. transit space. Cycling and running, which stood out at the left bank as well, correlates with the claim and justifies the waterfront as an active mobility corridor. At the right bank, after the top 3 activities, other prevalent one was children playing as opposed to left bank, where no children were playing. As mentioned above, there was a higher number of children playing at the right bank due to the presence of a playground and other play opportunities. Nevertheless, both banks serve as recreational places and many of the activities have a "longer-term" character (strolling, dating, walking a dog etc.).

Even though the first mapping brought various findings which can serve as a base for defining the waterfront areas character and the way these areas function, another mappings need to be carried out in the following seasons. This will confirm, deepen, or disprove the findings and balance the specific conditions of the first mapping (Covid19, spring weather etc.).

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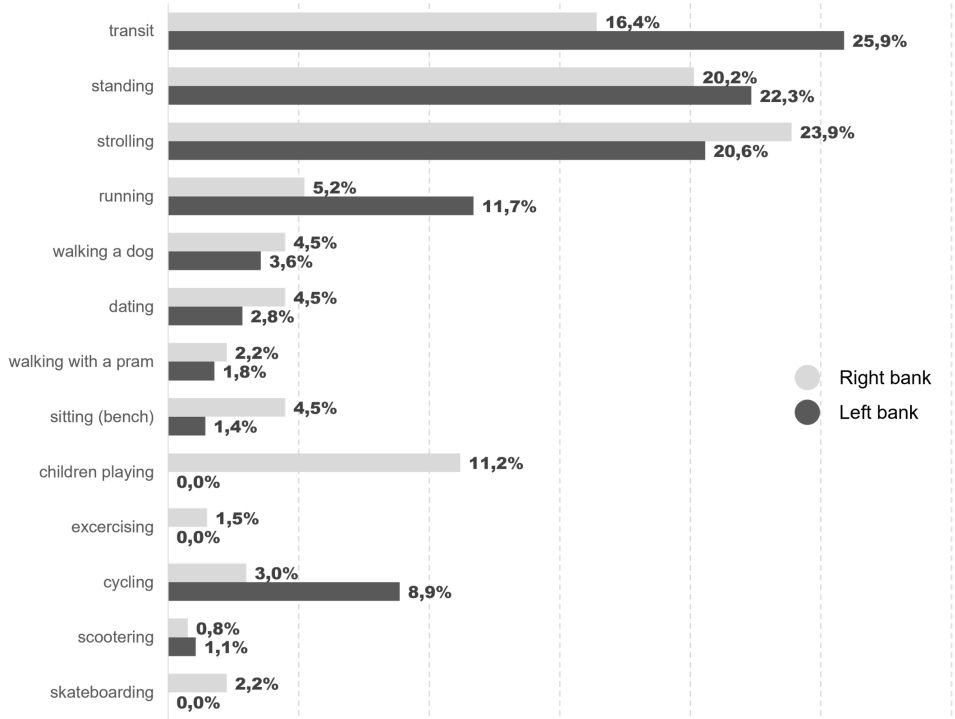

Fig. 10 Activities spectrum at both banks of the river

5 Discussion and conclusion

Mapping an area of interest is a necessary step of the data-based planning process and should always precede any development of urban spaces. Online data represent a valuable source of city-related information as well as a relevant addition to other mapping methods. Combination of data from various data sources which reflect life in public space can support user-oriented planning and contribute to responsible decision making.

The study brings an innovative approach to mapping through combining information from multiple sources, where the method of behavioural mapping supports the findings of online data interpretation and vice versa. The study also introduces mapping platforms – Instasights and Strava - that can be used to analyse public space as well as their limits. The combination of methods used is a relatively fast and simple way to get to know the spatial, social, environmental, aesthetic, and other dimensions of a given space. As a result, description, and exemplary use of two online data sources that are relevant for urban space mapping as well as illustrative analysis of two Bratislava waterfront locations are presented. The interpretation of data illustrates possible outcomes that can be gained through mapping of public spaces before any changes or development plans are proposed.

However, the behavioural mapping data need to be interpreted with regard to their limits such as lack of long-term perspective, since the study presents an illustrative sample only (1 /spring/ out of 4 /all-seasons/ mappings). Another issue that needs to be considered is the lack of raw data in the online data analysis. Raw data would bring a higher precision during the interpretation process. In further research, it would also be recommended to explore other waterfront locations in order to compare the findings within the whole area as well as to explore other relevant online data sources and their limits.

The exploration of Bratislava waterfront via the presented methodology shows the difference between Bratislava left and right bank waterfronts. They remain distinctive places with (partly) separate historical, morphological as well as socio-cultural development. While the left bank is a “face of the city”, the primary place of the dialogue between the city and its inhabitants/visitors, the right bank has gone through a long transformation process especially during the last two decades. Once the mere borderline between land and river, it is becoming the place, the spot to go for nature, leisure time activities and culture. Its semiotics are dynamically evolving, enriching the city identity with new connotations. For many people, the left bank is a scenographic element of their everyday movement within the city (driving the car along the waterfront, walk-

ing through the old city) while right bank remains more of a "place to go", agreeable spots of activities which are irregular or are bound to specific purpose (jogging, cycling).

To conclude, the successful future of waterfront spatial planning or planning of public spaces in general resides in establishment of a place identity and sustainable development, both through the development with broader context and conceptual approach, practice of making places designed for people, and respecting the character of individual places. These aspects are associated with taking into account people's connections to locations, quality urban design as well as nature and historical values protection. Mapping urban spaces is thus essential for recognizing specifics of a certain area. However, various limits, which need to be considered, represent a challenge for interpretation of these data.

Footnotes

[1] E.g. https://www.marketlocator.sk/ wp-content/ uploads/2020/04/ Analyza-lokalizacnych-dat_BID.pdf

[2] The human activities observation is considered as a "springtime" mapping, which is to be repeated during summer, autumn and winter for objective results and definition of year-round dynamics of the respective waterfront space. This will also result in more satisfactory comparison material with online data since these are collected the whole year as well.

[3] See http://www.laermkarten.de/bratislava/

[4] See criminality data on street level - https://magba.maps.arcgis.com/apps/webappviewer/index.html? id=d15ea47326 d1438585d580c3fe21d819

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