

Multi-attribute analysis of waterfront public spaces in historic core of the city of Kraków

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Abstract

For riverside cities, their waterfront public space becomes one of the main public domains. This cultural heritage constitutes the city's identity. Based on the richness of its heritage, are cities developing an adequate functional offer aimed at the modern user?

The article presents the results of a study of the functional quality of the public space of the Vistula River Boulevards in Kraków. The level of functional complexity of the Boulevards was determined by defining the types of its fragments in spatial-functional and historical terms, and then subjecting them to the author's multi-criteria valorization. The results of the valorization of the functional resources of the riverside public space made it possible to formulate conclusions for determining the potentials and threats of the studied riverside public space.

Keywords: riverside city, waterfront, public space

1. Introduction

Urban waterfronts are still one of the dominant areas of public space activation in the modern city (Matusik et al., 2020). Usually located in a central historical area, they are associated with rich urban and architectural heritage resources. For cities traditionally located along the river, this space is the core of the city (Pancewicz, 2004). The public space of the waterfront, which is an important resource of the urban heritage of cities, is often one of the largest continuous elements in their structure (Dudzic–Gyurkovich, 2023). For this reason, its high quality is so important. The studies of these zones undertaken today are multidisciplinary and take up an extremely wide range of issues. Thus, optimizing the use of the potential of urban waterfronts can intensify the process of city integration.

Some researchers indicate that determining the degree of vitality of the waterfront is crucial for undertaking planning activities within it (Ding et al., 2023). This is important in terms of breaking down the phenomenon of the urban barrier that a poorly functioning water's edge public space can become (Gyurkovich et al., 2021). Waterfronts are also not homogeneous spaces – their integral part is their industrial past which has often led to their degradation. Their reintegration into the life of the city also means implementing alternative and friendly modes of financing (Chen, 2022). Urban waterfronts are also unique spaces due to their thermal variability, linking the dense downtown fabric with natural areas (Peng et al., 2022). Finally, the intersection of a city by a river opens up opportunities for perception of the surrounding structure – both to the opposite parts of the city, just as it also provides the opportunity to perceive the city from the water surface, which is now becoming a measurable value (Ji, Sun, 2024). Contact with the waterfront space is important for the formation of social attachment of residents. Researchers point to the connection between human coexistence from childhood with the waterfront neighborhood and the formation of pro-environmental attitudes (Stehl et al., 2024). In accordance with this context, the article is part of the work on studying the functioning of the public space of inner-city waterfront zones.

Research on the functioning of public space prompts the following research questions:

- ▶ is the studied section of the Vistula River spatially and functionally homogeneous?
- ▶ what is the identity of the studied public space?
- ▶ is the public space of the waterfront a “living room of the city” with a rich and diverse functional offer?

2. Study materials and method

2.1. Kraków and the city's coastal space

Krakow is the second largest city in Poland with a population of 769,396. It is a city characteristic of the structure of European cities because of its cultural and historical significance, as well as its scale (World Population Review). Like many European cities, Krakow has been linked to the river since its inception. Until the 20th century, its development proceeded perpendicular to the riverbed. Only the decision to build the industrial and residential structure of Nowa Huta on the eastern side of Kraków forced a change in its development direction to parallel to the river (Motak, 2019). This remains clear in the course of development on both riverbanks, although much of it has been tied to industrial functions (Gyurkovich & Gyurkovich, 2021). The central part of Kraków's section of the Vistula River – the Vistula Boulevards (Fig. 1, 2) – is now one of the city's most culturally and scenically valuable public spaces. This is reflected in the prepared local plan for this section. Among the key directions of development for the area were: striving

to create a “living room of the city”, strengthening links with the surrounding city structure, and strengthening and reviving functions related to culture, recreation and historical education (Krakow City Council, 2013).



Fig. 1. The central part of the Vistula Boulevards in Krakow (photo by W. Matusik)



Fig. 2. The central part of the Vistula Boulevards in Krakow by night (photo by M. Gyurkovich)

2.2. Research method

These research is interdisciplinary in nature. The data is drawn from three disciplines and is quantitative in nature (Table 1).

Table 1. Classification of disciplines (own elaboration)

Discipline	Data
Spatial geography	Basic geographic data: distances, terrain profiles
Land use	Fixed and temporary functions
Environmental psychology	Spatial legibility

The research method is based on two stages. In stage one, a spatial and historical survey was conducted to collect basic data on the studied waterfront section and derive a typology of sections. Contemporary and historical cartographic materials were analyzed. Field surveys were also conducted to complement the cartographic studies. On the basis of spatial and historical analysis, landscape interiors (sections) characteristic of the studied river section were selected for further valorization in stage two. For each section, the following were determined: spatial type of riparian (1-, 2-level), type of river edge (natural, artificial), type of flood protection (flood wall, earthen flood wall), dominant type of riparian frontage (structural, green), length of the section.

In stage two, the previously diagnosed sections are subjected to valorization. The evaluation system is based on criteria proposed by the Project for Public Spaces program (Madden, 2021) such as:

- ▶ cubic public functions (the impact of the building's public function on the revitalization of the surrounding space),
- ▶ the dominant function of the development (the function that dictates the character of the waterfront and its public perception – determines its trans-local / local character),
- ▶ use of the waterfront in the rhythm of the year/day (adaptation of the waterfront to the changing seasons through appropriate functional programming and day–night accessibility, e.g.: lighting),
- ▶ spatial/functional flexibility (e.g.: solutions that allow for variability like a folding stage, allow for functional changes)
- ▶ creative amenities (appropriately located benches, lighting properly addressed, art in the space, etc.),
- ▶ pedestrian, bicycle waterfront access,
- ▶ local identity of the waterfront (whether it functions in the public perception, whether it attracts users because of its character)
- ▶ bringing the user closer to the water (use of traditional waterfront forms such as piers, drop-offs, and functions: fish market and others),
- ▶ multifunctionality of iconic buildings (maximizing the program offerings of important public facilities),
- ▶ management of the public space of the waterfront (urban, social, grassroots strategies).

On the basis of the above criteria, categories for evaluating the public space of the waterfront were proposed and assigned corresponding factors. The number of factors was varied within each category. Each factor was given a score from 0 to 2 points. As part of the valorization, the relation of the points obtained to the total value and the percentage of their contribution to the total were determined, which allows a more objective comparison of the results obtained. Six qualities were selected along with 27 factors. These are:

- ▶ Q1_accessibility with 5 factors [total: 6 pts.]: pedestrian/bicycle path (separated) [2 pts.], pedestrian/bicycle path (integrated) [1 pt.], convenient access to city structure [2 pts.], limited access to city structure [1 pt.], pedestrian/bicycle bridge [2 pts.];
- ▶ Q2_activity with 2 factors [total: 4 pts.]: year-round/seasonal activity [2/1 pts.], daily/daily activity [2/1 pts.];
- ▶ Q3_creativity with 6 factors [total: 7 pts.]: art in public space [1 pt.], linear purposeful lighting [1 pt.], spot lighting [1 pt.], seating associated with scenic elements [1 pt.], shaded seating [1 pt.], variety of seating [2 pts.];
- ▶ Q4_functionality with 4 factors [total: 4 points]: public building linked to waterfront [2 points], public building not linked to waterfront [1 point], city frontage linked to waterfront (active first floor) [2 points], city frontage not linked to waterfront [1 point];
- ▶ Q5_flexibility with 3 factors [total: 4 points]: cyclical events [2 points], temporary comprehensive solutions [1 point], temporary individual solutions [1 point];
- ▶ Q6_water level access with 7 factors [total: 8 pts.]: surface facilities (barges) [2 pts.], fixed descents (piers, city stairs) [1 pt.], mobile descents (platforms) [1 pt.], water sports [1 pt.], water streetcar (stop) [1 pt.], commercial water excursions (stop) [1 pt.], mooring points [1 pt.].

3. Results of the study

3.1. Stage I – spatial and typological analysis. Selection of sections

The first phase of the research diagnosed the downtown section of the Vistula riverfront in Krakow in terms of historical and physiognomic-landscape aspects. The research showed considerable spatial diversity of the studied space. The division into sections coincides with the sections between the main crossings. This division also coincides with the historical naming of successive boulevards. The distinction between the left-bank (Table 2) and the right-bank (Table 3) was adopted for the analysis. The predominant spatial type is a two-tiered waterfront formation, usually associated with a stone flood control wall. Only in the final, eastern sections do natural riverbanks appear along with earthen floodwalls. In almost all sections there is a significant proportion of greenery – both in the form of flat grassy areas and green slopes. The downtown section of the Vistula is also characterized by extremely variable frontage. Throughout its entire course, it is sharply offset from the river's edge. On the left bank, residential frontage dominates in sections 1 and 4, while in the middle section (sections 3 and 4) the iconic public facility becomes the dominant feature. A similar arrangement is found on the right-bank. Only section 5 has no discernible and legible frontage.

Table 2. Spatial-functional analysis of the left-bank of the Vistula River (own elaboration)

Name of riverine boulevard	Spatial type	Type of river edge	Type of flood protection	Dominant type of frontage		Lenght of the section
				structural	green	
Rodła (S_{L1})*	2 – level	adjustable	Stone wall	residential	Narrow strip of grass	Rudawa Mouth – Dębnicki Bridge
Czerwieński (S_{L2})	2 – level	adjustable	Stone wall	Iconic public building	strip of grass / green slope	Dębnicki Bridge – Grunwaldzki Bridge
Inflancki (S_{L3})	2 – level	adjustable	Stone wall	Iconic public building	strip of grass / green slope	Grunwaldzki Bridge – J.Piłsudskiego Bridge
Kurlandzki (S_{L4})	2 – level	adjustable / natural	Stone wall / earth levee	residential	strip of grass / trees	J.Piłsudskiego Bridge – Dąbie Barrage

* S_{L1} – Section 1 of the left-bank of the Wisła River.

Table 3. Spatial-functional analysis of the right-bank of the Vistula River (own elaboration)

Name of riverine boulevard	Spatial type	Type of river edge	Type of flood protection	Dominant type of frontage		Lenght of the section
				structural	green	
Tyniecki (S_{R1})*	2 – level	adjustable	Stone wall	residential	strip of grass	(Szwecka St. – Dębnicki Bridge)
Poleski (S_{R2})	2 – level	adjustable	Stone wall	Iconic public building	strip of grass / green slope	Dębnicki Bridge – Grunwaldzki Bridge
Wołyński	2 – level	adjustable	Stone wall	Iconic public building	strip of grass / green slope	Grunwaldzki Bridge – Wilga Mouth
Podolski (S_{R4})	2 – level	adjustable	Stone wall	Iconic public building / residential	strip of grass / trees	Wilga Mouth – Zabłocie Railway Bridge
Lotników Alianckich (S_{R5})	1 – level	natural	earth levee	–	Unordered green	Zabłocie Railway Bridge – Kotlarski Bridge

* S_{R1} – Section 1 of the right-bank of the Wisła River.

3.2. Stage II – Valorization of the public space of the Downtown Vistula riverfront in Krakow

The downtown Vistula River waterfront was studied with a separation into a right-bank and a left-bank part. The left-bank part was divided into four sections. The right-bank part into five sections. These sections, are contained between

the crossings and coincide with the historically accepted nomenclature. They are referred to hereafter as sections.

The public space of the left-bank side of the waterfront has a pulsating character. The principle of increasing the potential of public space in successive sections has not been observed. The accumulation of this potential is variable – it descends and rises in successive sections (Fig. 3).

Accessibility (Q1): The study showed that the subsequent sections of the left-bank waterfront area follow a similar pattern. Only the first section (S_L1) shows a lower level of accessibility. The next three are characterized by similarly high levels of accessibility (S_L2 , S_L3 , S_L4). The dominant accessibility parameter is clear access to the city's structure and a clear separation of pedestrian and bicycle routes.

Activity (Q2): In terms of activity, the left-bank sections show a pulsating character. Sections S_L1 and S_L3 have significantly lower activity because they have limitations in annual activity. Sections S_L2 and S_L4 show a high potential for year-round activation, a phenomenon unique to the entire boulevards.

Creativity (Q3): Creativity on the left-bank of the Vistula is severely limited. Only the last section (S_L4) stands out. This section has solutions for both the use of art in public space and a variety of seating solutions, which stimulates diverse types of social behavior.

Functionality (Q4): Functionality potential is very low on the left-bank of the Vistula River. Only in the last section (S_L4) does it show increased parameters in terms of access to services. Neighborhood of public buildings, shown in S_L2 section rather visual impact than real public connection.

Flexibility (Q5): Solutions to this quality only appear in the S_L2 and S_L4 sections. Section S_L2 is mainly flexibility related to public events. The S_L4 section is dominated by temporary solutions that enable a variety of applications.

Water level access (Q6): The potential for this quality is significant in three sections. Only in the first is it limited to the freedom to moor watercraft. In the other three sections (S_L2 , S_L3 , S_L4) it shows a high level of diversity and variety of possibilities for using the water surface. This is realized both at the individual level (platforms, pier, beach) and at the collective level (water streetcar stops, commercial tours, barges with public services).

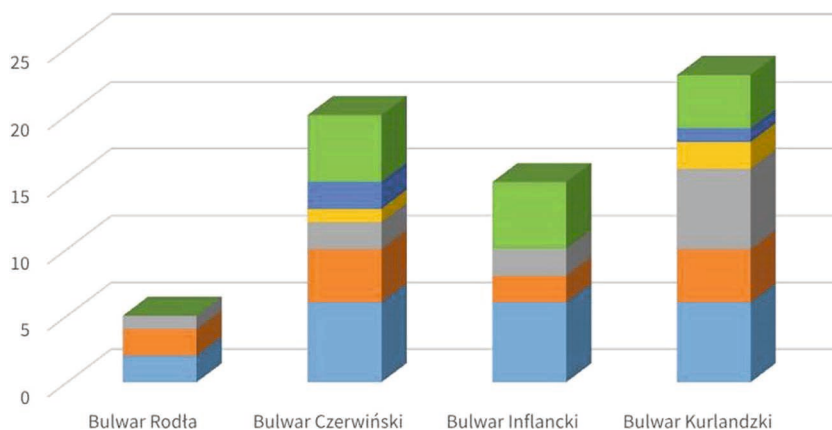


Fig. 3. Valorization of the potential of the public space of the left-bank of the Vistula River. Compiled by Authors.
Legend; Light blue: Q1_accessibility, orange: Q2_activity, grey: Q3_creativity, yellow: Q4_functionality, dark blue: Q5_flexibility, green: Q6_water level access (own elaboration)

The right-bank part is characterized by a different distribution of potentials. While the left-bank part had a pulsatile character – the right-bank part is more stable in distribution and shows a sinusoidal model with a definite dominance of potentials in the central part (Fig. 4.).

Accessibility (Q1): The accessibility of the right-bank of the Vistula is distributed very unevenly. The weakest potential is in sections S_R2 and S_R5 where there is no segregation of pedestrian and bicycle traffic and there is a very low level of legibility of access to the city structure. Only the S_R3 and S_R4 sections have a high level of accessibility (especially in the S_R4 section).

Activity (Q2): The activity potentials are distributed differently. The highest activity is in the S_R2 and S_R3 sections where it occurs in both daily and annual rhythms.

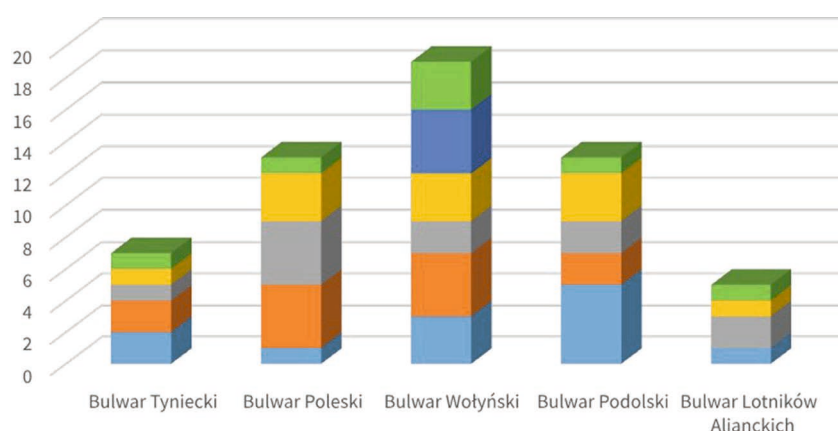
Creativity (Q3): Creativity is rated highest in the S_R2 section, where there is art in the public space and a significant share of seating diversification. These elements affect the effect of retaining participants in public spaces. In the other sections, the share of this potential is similar although half that of the S_R2 section. The exception is the S_R1 section where the share of using creativity-based solutions is very low.

Functionality (Q4): The distribution of potentials in the functionality layer is stably distributed. Dominant is the central part (sections S_R2, S_R3 and S_R4) where there are public facilities well integrated with the waterfront. Of particular importance is the S_R3 section having the only public facility on the entire waterfront linked seamlessly to the public space of the Vistula edge. Sections S_R1 and S_R5 have very low potential compared to the middle sections.

Flexibility (Q5): The research did not show significant potential for solution flexibility. The only contrasting section is S_R3 where the level is very high. There are both individual and comprehensive solutions here, and it hosts cyclical events of supra-local scope. In this respect, the flexibility of the S_R3 section correlates with its level of activity. The other sections show no flexibility.

Water level access (Q6): In terms of access to the water surface, the research indicated a similar relationship to that of activity (Q2) and flexibility (Q5). The highest level of accessibility was observed in the S_R3 section, where it is stimulated by floating functions (mobile wather hotel). The other sections show minimal levels.

Fig. 4. Valorization of the potential of the public space of the right-bank of the Vistula River. Compiled by Authors.
Legend; Light blue: Q1_accesibility, orange: Q2_activity, grey: Q3_creativity, yellow: Q4_functionality, dark blue: Q5_flexibility, green: Q6_water level access (own elaboration)



In order to objectify the results of the analysis, they are presented in percentage terms. The results of the study show that the public space of both Vistula riverbanks is very heterogeneous and diverse in nature. Differences exist both between the two banks and between their respective sections. On the left-bank of the Vistula, the highest indicators were received by the S_L4 section where only one of the categories received a score of 25% (Q5) while the vast

Table 4. Valorization of the potential of the public space of the left-bank of the Vistula in the downtown area (own elaboration)

Section	Q1 (T/TO/%)	Q2 (T/TO/%)	Q3 (T/TO/%)	Q4 (T/TO/%)	Q5 (T/TO/%)	Q6 (T/TO/%)
S _L 1	6/2/33	4/2/50	7/1/14	4/0/0	4/0/0	8/4/50
S _L 2	6/4/60	4/4/100	7/2/29	4/1/25	4/2/50	8/5/62
S _L 3	6/4/66	4/2/50	7/2/29	4/0/0	4/0/0	8/5/62
S _L 4	6/6/100	4/4/100	7/6/85	4/2/50	4/1/25	8/4/50

* T/TO/% – number of points total / number of points obtained/percentage.

majority achieved scores above 50% including two of 100%. The lowest potential is shown by section S₁ where the highest score reaches 50% (Table 4).

The right-bank part is characterized by a significantly lower level of potentials. The best results – 100% – were received by the central part in activity (Q2) and flexibility (Q5). Unfortunately, the flexibility category in the other sections received 0%. In contrast, in Functionality (Q4), the right-bank is significantly better developed than the left-bank part (75%). Functionality potential correlates here with accessibility scores, which are also high in the central part (50%, 83%). The survey also did not show much potential in terms of water level accessibility (Q6). The middle section has the highest retained score, and it is only 38%. In the other sections, direct access and use of the water level is minimal (Table 5), which is a contrasting result for the left-bank section.

Table 5. Valorization of the potential of the public space of the right-bank of the Vistula in the downtown area (own elaboration)

Sekcja	Q1 (T/TO/%)	Q2 (T/TO/%)	Q3 (T/TO/%)	Q4 (T/TO/%)	Q5 (T/TO/%)	Q6 (T/TO/%)
S _{R1}	6/2/33	4/2/50	7/1/14	4/1/25	4/0/0	8/1/12,5
S _{R2}	6/1/16	4/4/100	7/4/57	4/3/75	4/0/0	8/1/12,5
S _{R3}	6/3/50	4/4/100	7/2/29	4/3/75	4/4/100	8/3/38
S _{R4}	6/5/83	4/2/50	7/2/29	4/3/75	4/0/0	8/1/12,5
S _{R5}	6/1/16	4/0/0	7/2/29	4/1/25	4/0/0	8/1/12,5

* T/TO/% – number of points total / number of points obtained / percentage.

4. Conclusion

The quality of the functioning of the public spaces of urban waterfronts is still a key point in urban planning strategies. Their resources are an important component of the city's heritage. Despite their often industrial past, waterfronts have often preserved significant greenery resources, which are now becoming the basis for sustainable functioning of public space. Greenery in these zones is also one of the main stimulators that activate public space (Zielinski 2023). Precise planning activities based on an optimized diagnosis of the quality of public space can contribute to increasing the degree of integration of this space into the city structure. Thus, these activities make it possible to increase the degree of integration on a city-wide scale.

The survey showed surprising variability in the potential of public space on both sides of the studied waterfront. The different categories scored very unevenly. The accessibility survey (Q1) showed that the Boulevards have significant differences. The profound differences are in the following sections, which means that the studied space does not show characteristics of continuity. Similar conclusions emerge after analyzing the quality of Q2 (activity). The nature of this category is pulsatile. It applies to selected sections and, unfortunately, does not form a continuous system. Rather, it has an island character. Very low rated is the creativity category (Q3). The research indicates that there are very significant gaps in the use of solutions that take advantage of the visual heritage of a place. There is also a lack of solutions that support social integration. The Q4 (functionality) category showed significantly better results. Although it does not form a coherent, continuous system, but is capable of producing bands. This is due to high activity in the middle sections. Unfortunately, both sides of the waterfront have a low or even nonexistent proportion of frontages with first floor services. Equally residual solutions are in the flexibility category (Q5). It is noteworthy that the quantity and quality of these solutions are increasing (barges, hotel on the water). Turning cities towards water is still a vibrant trend in Central European cities. In this regard, the Q6 (water level access) category is so important. In the case of the Vistula boulevards, it is represented quite

significantly. Noteworthy is the fact that it is mainly implemented by sports functions and various forms of access to the water table.

The spatial-functional research conducted made it possible to diagnose the existing potentials of the Vistula riverfront public space. They also revealed significant deficiencies in the functional offer. In the phase of the next research it would be necessary to supplement it with social research. Feedback from the users of this space would make it possible to conduct comparative studies between existing resources and their actual reception and functioning. Public perception should be an important element in guiding development strategies for this type of public space (Yang, Duarte & Ciriquián, 2022).

The rich urban heritage of Krakow's Vistula riverfront is still a dominant element in building the attractiveness of this space. Appropriate use of the results of the analysis of the potential of the waterfront public space would make it possible to link this heritage to the expectations of the contemporary user of urban space.

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