



Assessing public perceptions of the cultural ecosystem services waterfront spaces provide along the Huangpu River in Shanghai, China, in support of urban waterfront planning and design

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Abstract

Urban waterfront green space is a critical component of urban ecosystems and can provide various types of cultural ecosystem services (CESs). In this study, the CESs of six waterfront green spaces with different planned functions in different areas along the Huangpu River were assessed, and a framework of CES types applicable to the assessment of waterfront green spaces was proposed. Based on an investigation of the basic indicators of different waterfront green spaces and the differences in planning in the regions where they are located, we explored the factors affecting the public's perception of CESs. We found that a waterfront green space with a clear theme and amusement facilities with special features improved public perceptions of CESs. Improved water accessibility and many winding walkways can increase the diversity of outdoor activities. The discrepancy between public perceptions of CESs and the CESs that city managers hope waterfront green spaces to provide in urban planning may be due to a lack of a detailed introduction to facilities for public within green spaces. We suggest promoting the public perception of CESs provided by waterfront green spaces through improved water accessibility and enhanced descriptions of their facilities. The results and suggestions generated from this study offer insights into the future planning and design of urban waterfront green spaces.

Keywords Urban waterfront green spaces · Cultural ecosystem services · SolVES · Waterfront area construction suggestions

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1 Introduction

Historically, most major cities have developed along water networks, with urban waterfront spaces developing along with them (Cialdea and Pompei 2022). These linear open spaces along water networks have served as critical industrial districts and shipping ports but have experienced periods of decline due to overdevelopment. As cities have grown and more attention has been given to ecology, the redevelopment of urban waterfronts has often been accompanied by the planning and construction of urban green spaces; related research indicates that these efforts promote urban development and enhance urban vitality (Hagerman 2007). Green spaces are widely seen as integrated areas composed of any natural, seminatural, or artificial vegetation (Han et al. 2023). Waterfront green spaces, which combine green and blue spaces, are receiving increasing attention due to their important and powerful roles in ecosystem functions (MU et al. 2024). Several researchers have explored the impact of blue–green infrastructure on the urban thermal environment

(Wu et al. 2018). Studies have also shown that urban green spaces and surrounding water have cooling effects on the environment (Gao et al. 2016; Liang et al. 2015), which alleviate the urban heat island effect (He 2019). Urban blue–green spaces can also improve air quality, reduce water pollution (Abhijith et al. 2017), and control urban flooding (He et al. 2019). Additionally, Smith et al. (2022) indicated that these spaces can help connect ecosystems as a whole since green spaces and water often converge. In addition to performing natural functions, waterfront green spaces can promote the physical and mental health of residents (Pouso et al. 2021) by providing cultural ecosystem services (CESs). The millennium ecosystem assessment (MEA) described CESs as providing the “nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences” (MEA 2005, p 39). These services play an important role in connecting ecosystems and social systems (Costanza et al. 2017). Intangible experiences, such as a sense of place, recreation (Ghermandi 2018), aesthetics (Figueroa-Alfaro and Tang 2017), and spiritual beliefs that people gain through their interactions with nature, are components of the benefits people derive from nature (Summers et al. 2012). CESs provide insight into these issues, and qualifying and assessing this insight, as with all ecosystem services in urban areas, give managers with a deeper understanding of the connection between residents and waterfront green spaces.

Fish et al. (2016, p 209) developed a conceptual framework for assessing and understanding the interaction between human well-being and the ecosystem. Hegetschweiler et al. (2017) considered the ways in which the perceptions and evaluations of visitors to a waterfront green space were relevant to the size and shape of that space as well as the associated recreational infrastructure and diversity measures within it. Previous research has also focused on spatial characteristics, such as accessibility (Elliot et al. 2022), connectivity (Yencha 2019), and the frequency of residents’ visits to riverside spaces (Elliot et al. 2022). In addition to the characteristics of waterfront green space, demographic characteristics (e.g. age, sex, and socioeconomic status) and socioeconomic status (e.g. income, education, and occupation) have recently been accounted for in studies (Dou et al. 2017; Oviedo et al. 2022). The above studies indicate that public perceptions of the CESs of urban waterfront green spaces are affected by many factors, including spatial attributes and the sociodemographic characteristics of visitors (Hegetschweiler et al. 2017). However, few studies have explored whether urban planning for waterfront green space influences people’s actual perception of CESs. In addition, clarifying the actual values, patterns, and potential of CES usage can contribute to the design and management of urban areas and enhance the well-being of different user populations (Rall et al. 2017). Further exploration

of the relationship between planning objectives and public perception is needed to determine the impact of the physical characteristics of waterfront green space on public perceptions of CESs (Gai et al. 2022). In this study, we focus particularly on the following questions: Do the distributions of CESs in waterfront green spaces along strips of urban rivers differ? Are there discrepancies between designers’ plans for waterfront green spaces and residents’ perceptions of those spaces? What factors might influence residents’ actual perceptions of waterfront green space CESs? The goals of this study are to (i) propose a framework of CES types adapted for waterfront green space to quantify and assess the CESs of six waterfront green spaces along urban rivers, (ii) explore the impact of basic waterfront green space indicators and planning on the actual perception of CESs, and (iii) advance proposals for the construction or renovation of waterfront areas.

We believe, based on social ecology, that an assessment of urban waterfront green spaces from the perspective of CESs can provide a foundation for urban green space planning that allows for more equitable and sustainable use of these green space resources. In addition, the results of this study show how different factors influence public perceptions of CESs. As the socioecological perspective is central to CESs, a comprehensive understanding of the factors influencing such services and public preferences can help promote socioecological research in urban areas. Furthermore, the results of this study provide insight into how future urban waterfront green spaces can better realize the value of ecosystems, especially in developing countries.

2 Data and methods

2.1 The study area

This study was conducted in Shanghai, which is the centre of China’s international economy and a prime location for finance, trade, shipping, and scientific and technological innovation. The Huangpu River, which flows through Shanghai and is its central river, has witnessed the growth of and change in the city. Since the mid-nineteenth century, the advantages of Shanghai’s geographical location and the feasibility of water transportation have enabled modern industries to emerge and develop along the river. The Huangpu River played an important role in port transportation, but at the same time, pollution and overdevelopment seriously damaged its ecological function. In recent years, the waterfront area of Shanghai has begun to undergo functional and spatial reconstruction. The pertinence and representativeness of this development make this area useful for studying the management and planning of waterfront green spaces.

In this study, we comprehensively considered the planning and design of waterfront spaces on both sides of the Huangpu River and selected six waterfront spaces with different geographical locations (Fig. 1) and functional positions as the research sites. These spaces are the Wusong Pao-taiwan Wetland (WPW) park, North Bund Riverside (NBR) green space, Lujiazui Riverside (LR) park, Xuhui Riverside (XR) green space, Qiantan Leisure (QL) park, and Pujiang Country (PC) park. They are located along different sections of the Huangpu River, and each has been planned differently. According to the *Huangpu River Waterfront Area Construction Plan* (2018–2035, p 15), different colours are used to indicate that these six parks belong to different planned ecological spaces. They are divided according to the location conditions, functional characteristics, scale, and construction progress of the waterfront shoreline. These waterfront green spaces have their own characteristics and facilities and provide a range of CESs.

2.2 Evaluation indicators

By combining field investigations and GIS technology, we were able to conduct a detailed survey of the six waterfront green spaces to evaluate certain basic indicators

and facilities within them (Table 1). Green infrastructure includes greenbelts, lawns, and trees, which enhance ecological diversity and serve important ecological functions (Den Hartog 2021, pp 7–8); furthermore, the greening rate is one of the most important metrics for assessing urban green spaces. It reflects the construction of green infrastructure and its capacity to supply CESs. A waterfront walkway serves as a transition from the urban landscape to the natural landscape. It encourages people to approach the river (Zeballos-Velarde 2022), thus influencing visiting patterns and enhancing interactions between residents and urban natural landscapes (Wang et al. 2020, pp 10–15). We used shoreline curvature (number of curved segments/total length of shoreline * 100%) to reflect the diversity of the studied waterfront walkways (Yang and Shao 2018). The level of access to water is based on shoreline openness (4 levels in total, with 1 indicating inaccessibility owing to solid walls, 2 indicating inaccessibility owing to railings, 3 indicating accessibility with railings, and 4 indicating direct water contact); it reflects the level of opportunities for the public to access the river. Gao et al. (2020, p 12) found that dynamic water spaces and the combination of water and surrounding elements are attractive. Previous studies have demonstrated that facilities affect the public use of parks (Kerishnan and

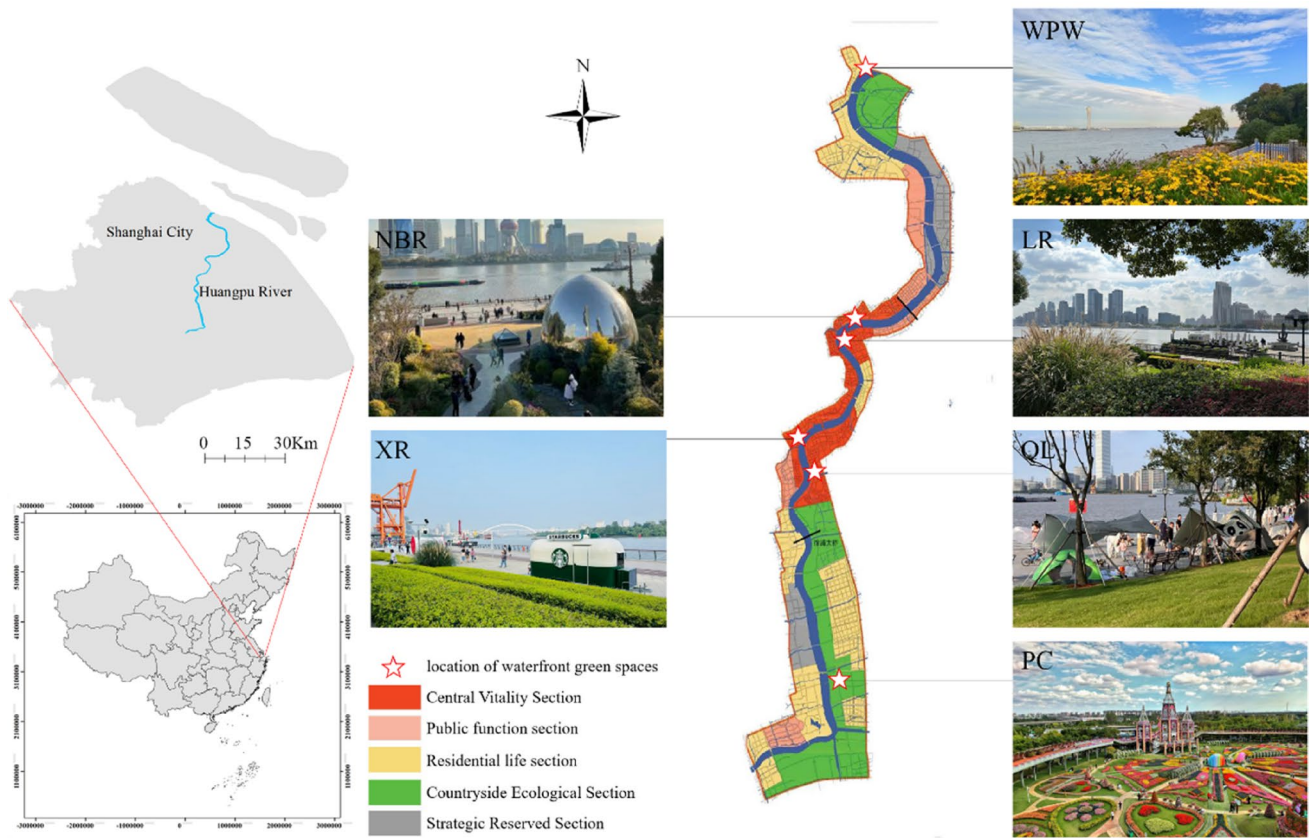


Fig. 1 Location of the Huangpu River and the six waterfront green spaces

Table 1 Indicators for evaluating waterfront green spaces

Indicators	Evaluation indicator for survey questions	Calculation method/tool	Preferences for indicator setting
Area	Total area of green spaces	ArcGIS 10.3	Yang and Shao (2018)
Greening rate	Reflects the area and construction of green infrastructure	$\frac{\text{Greening area}}{\text{Area}}$	Den Hartog (2021)
Shoreline curvature	Reflects the diversity of waterfront walkways	$\frac{\text{number of curved segments}}{\text{total length of shoreline}} \times 100\%$	Yang and Shao (2018)
Level of access to water	Reflects the relationship between open space and water	4 levels in total: 1 denotes inaccessibility owing to solid walls; 2 denotes inaccessibility owing to railings; 3 denotes accessible with railings; and 4 denotes direct water contact	Durán Vian et al. (2021)
Facility richness level	Reflects diversity and quantity of facilities	4 levels in total: 4 denotes over 5; 3 denotes 3–5; 2 denotes 2–3; and 1 denotes less than 1	Oviedo et al. (2022)

Maruthaveeran 2021; Liu et al. 2021). Parks with outdated facilities are not conducive to improving the public's mental health, while well-endowed facilities attract park visitors (Guo et al. 2019; Yang et al. 2021). Therefore, attractiveness to visitors is based on facility richness level (4 levels in total, with 4 indicating more than 5 facilities, 3 indicating 3–5, 2 indicating 1–3, and 1 indicating less than one).

2.3 Data collection regarding public preferences and progress

2.3.1 Social data sources

In recent years, emerging big data technology, such as social media platforms, has provided a means of obtaining usage patterns in urban ecosystems. The CES perception data in this study were collected through Dianping, one of the most widely used social media platforms in China; this platform includes consumer reviews. These data reveal preferences that can be used for research purposes. On Dianping, users can upload photographs or videos that they have taken during or after park visits and share their experiences and feelings; thus, the platform is a good source for gaging public perception. The survey was conducted by analysing the documents and photographs uploaded by users to Dianping. The advantage of conducting a study based on data from social media platforms is that the database provides a large amount of relatively easily accessible information. The large sample has good statistical feasibility and enables our research results to better represent the public's perception; furthermore, this approach can be expanded to more urban waterfront green spaces.

For this study, we conducted an analysis that coupled photograph analysis with document analysis (Tian et al. 2020) on the basis of the social media comments of each user. First, we excluded photographs taken outside green spaces and inside buildings, as well as those with only buildings

and no blue–green environment or where the subject of the image was a person who was not interacting with the natural environment (e.g. selfies). Next, we identified where valid photographs had been taken and distinguished the value types (Table 2) associated with each location by analysing each image. We assigned scores of different types of CESs by multiplying the proportion of each type of CES value assessed for each user by 100. Along with photographic data, relevant text uploaded by the same user was considered additional evidence. We analysed the various CES value types found in the text and assigned a score to each value type by multiplying the ratio of each type of CES value assessed for each user by 100. Finally, we added the two scores of the photograph and text analysis to calculate the final allocation of each value type. Together, the value type tables and the value assignment tables, which comprise the preference data used for the following CES evaluation, show people's perceptions of CESs and the levels of different value types.

2.3.2 Spatial data sources

Distance can effectively reflect the spatial relationship between points with social value and natural resources (D. Cheng et al. 2018). By comprehensively considering the geographical and environmental features of the six selected waterfront spaces, we were able to create three environmental layers to represent distance from the road, distance from the water body, and distance from attractions. These environmental layers were calculated with the Euclidian distance tool, one of the ArcGIS Spatial Analyst Tools. The survey points from the social preference data were also digitalized in ArcGIS 10.3.

2.3.3 Mapping and value quantification

We used the SolVES (<http://solves.cr.usgs.gov>) tool to map and value CESs. SolVES is “a tool that was designed to

Table 2 Examples of CES types analysed in this study

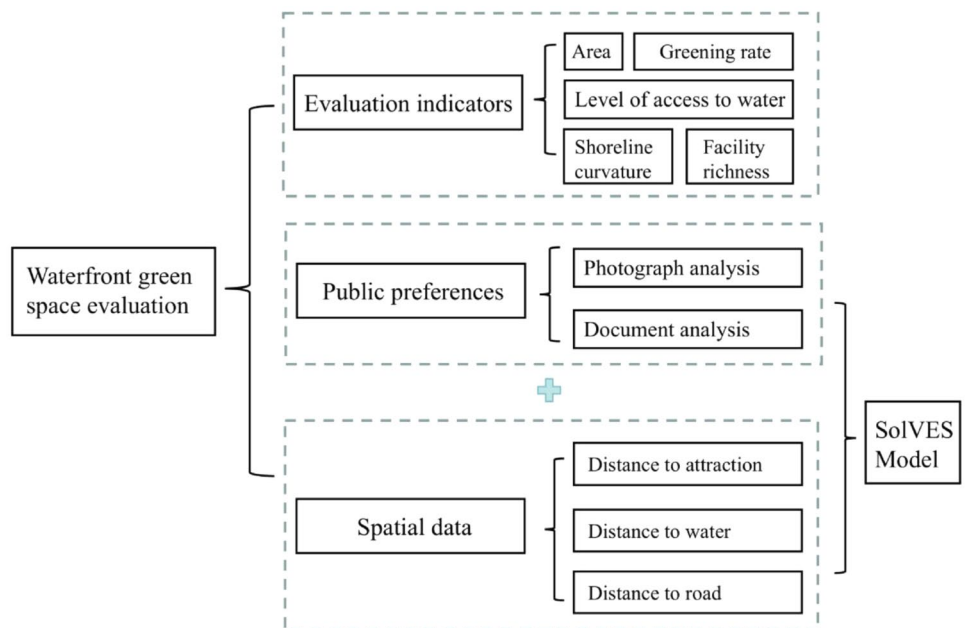
International CES types	Waterfront green space CES value types	Detailed description
Aesthetic value	Architectural environment	Harmonious landscape formed by river ecosystem and architecture
	Waterside view	Scenery alongside the Huangpu River, including bridges and cruise ships
Recreational value	Green landscape	Natural or human-made green landscape combined with riverside space
	Activities in amusement areas	Activities in riverside leisure facilities
	Landscape interaction along the riverside	Interaction between humans and riverside landscapes, including taking photographs with the river in sight
Therapeutic value	Social bonding	Possibility of spending time with other people or joining social activities in waterfront green space
	Thematic sports activities	Independent and characteristic sports venues
Historical value	Being physically active outdoors (less intensive)	Activities along the whole waterfront area, such as cycling, running, and walking
	Riverside historical sites	Industrial historical relics of the waterfront construction, such as tower cranes and old shipyard sites
	Sense of place	The recognition that the Huangpu River is the "mother river" encourages a personal connection to the place; the cultural exhibition board

assess, map and quantify social values” (Sherrouse and Semmens 2015), particularly the values of cultural services. We employed the value mapping model to output a VI map and to explore the relationships among environmental metrics. The model reflects the spatial distribution of areas within parks that may be capable of providing different types of CESs.

The data used for operating SolVES were stored in a geodatabase source file named SolVES.gbd. It included a study area layer, a survey point layer, a value type table, and a value allocation table. These data were obtained and prepared through social and spatial data.

Figure 2 shows the evaluation framework of this study, including waterfront green space evaluation indicators and data for running the SolVES model.

Fig. 2 Evaluation indicator framework for this study



3 Results

3.1 Basic facilities and environmental quality survey

Table 4 shows that the waterfront green spaces were quite distinct from each other, ranging from the available facilities to the infrastructure they contained. WPW and PC provided the highest number of facilities and had the largest size and greening rate. They are theme parks containing diverse terrains, which allow for a greater variety of infrastructure, such as amusement parks, picnic spaces, and public restrooms. Residents can also enjoy water activities such as boating and fishing, which provide further opportunities to access the water. No specific themes were found in the other four urban central green spaces, which were planned and designed according to local cultural characteristics. Because their main functions may be solely to provide open spaces for residents to socialize and engage in free activities, these green spaces contained fewer amusement facilities. In addition, they have less green infrastructure and a lower greening rate. Because these green spaces were constructed along the Huangpu River, flood walls were built along the riverside shoreline to provide flood protection; thus, the shoreline curvature and level of accessibility to the water are low.

3.2 Ranking and distribution of various value types within the waterfront green spaces

3.2.1 User survey

The number of survey users varied (Table 3) by waterfront green space. WPW had the most investigated users (2174) and CES value points (9493), while PC had the highest effective data rate (95.77%). These two waterfront green spaces embody certain themes that attract more visitors and thus receive more comments. Compared to these two theme parks, the other four green spaces yielded far fewer valid users and CES value points. The effective data rates of these four green spaces were also significantly lower than those of WPW and PC. NBR, LR, XR, and QL are linear

strip waterfront green spaces that are often connected by bridges to other green spaces. These spaces are difficult to separate; thus, photographs uploaded by social media users often included other areas, which may have led to low data efficiency.

3.2.2 Planned function public perception survey

In accordance with the high values calculated by the SolVES tool, Table 5 shows the significant differences among the various CES value types in waterfront green spaces. Each waterfront green space has different rankings according to the CES high value indexes. Some CES value types are not identified in every waterfront green space. Some CES types of green spaces with high value indexes are closely related to the functional positioning of their construction plans, while others are not. The WPW is an oval-shaped park with a historical education theme. The type of value in this green space perceived to have the highest value index is the “sense of place”, which is a historical value consistent with the planned function of the WPW. In addition to its historical value, the WPW, a very popular urban green space, is better perceived by the public in terms of “activities in amusement areas”, which are of recreational value. The NBR and LR are located in the centre of the city, and their main function is to provide space within which residents can relax and socialize. The evaluation results indicate that their recreational and therapeutic values have received increased public attention. However, the area containing NBR is the most reflective of Shanghai's local history and culture; many historical buildings and cultural landscapes are distributed around and within the green space. This green space is recognized to have the highest value for “sense of place”. For QL, which was planned as a cultural and creative centre, the values of “being physically active outdoors”, “sense of place”, and “architectural environment” have high values. Although it contains children's playgrounds with features such as slides and sandpits, the value of “activities in amusement areas” is seldom perceived by the public in QL. In XR, aesthetic value (i.e. green landscape) and recreational value (i.e. interaction with the landscape along

Table 3 Survey of the basic functions and indicators of the six waterfront green spaces

Name	Area (m ²)	Greening rate (%)	Shoreline curvature (%)	Level of access to water	Facility richness
WPW	696,244	85.53	1.80	4	4
NBR	249,406	35.05	0.34	1	3
LR	170,508	33.73	0.87	2	2
XR	285,675	33.75	0.69	2	2
QL	500,627	36.01	0.31	2	3
PC	464,485	50.03	2.23	3	4

the riverside) are more commonly perceived by the public. The planned function of XR is as a “cultural and sports center”; however, historical values are less perceived by the public in XR. PC has a rich woodland and grassland landscape and thematically focuses on the integration of ecology into society. The types of CESs that the public primarily perceives in PC, such as “green landscape”, “water view”, and “activities in amusement area”, are in keeping

with the main services that urban planning desires this green space to provide.

In terms of the distribution of value types, Figs. 3, 4, 5, and 6 show similarities in the hotspot distribution patterns within different waterfront green spaces. Among these six waterfront green spaces, areas of high aesthetic and therapeutic value are distributed mainly along walkways. In addition to promoting running and cycling, winding walkways are likely to attract visitors to linger and take

Fig. 3 Distributions of high-value areas of aesthetic value within the six waterfront green spaces

Aesthetic value

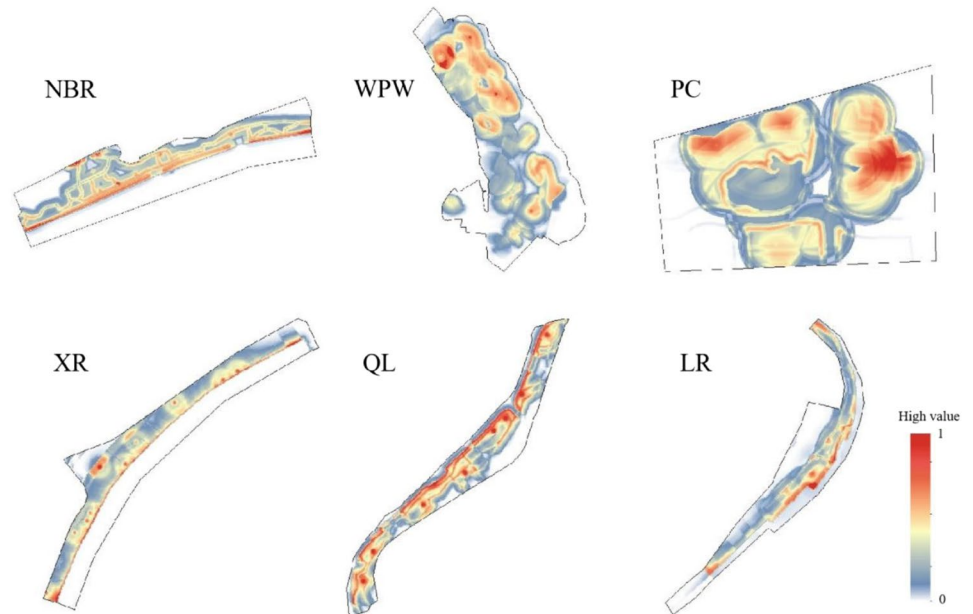


Fig. 4 Distributions of high-value areas with historical values within the six waterfront green spaces

Historical value

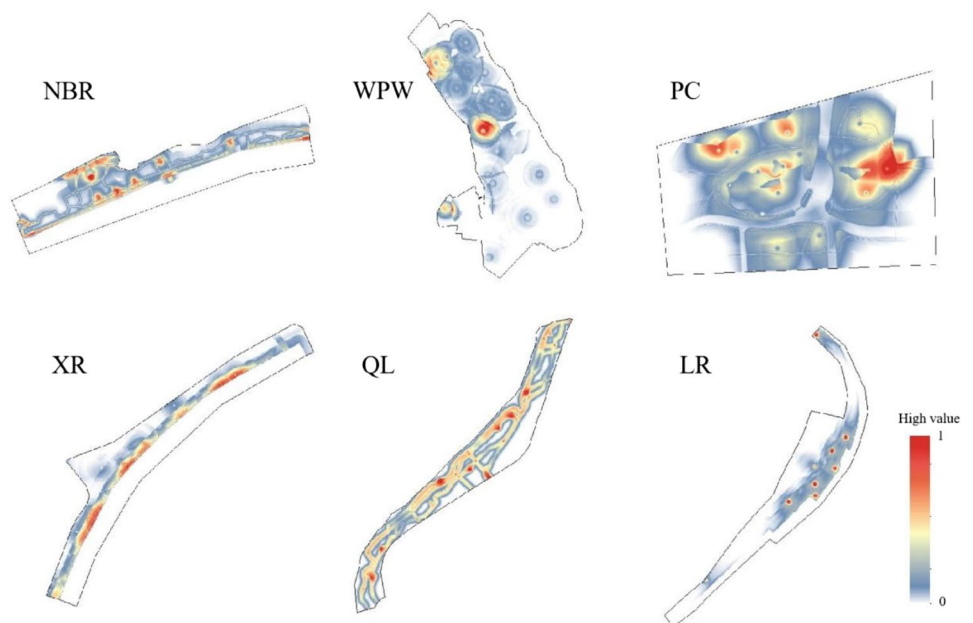


Fig. 5 Distributions of high-value areas with recreational value within the six waterfront green spaces

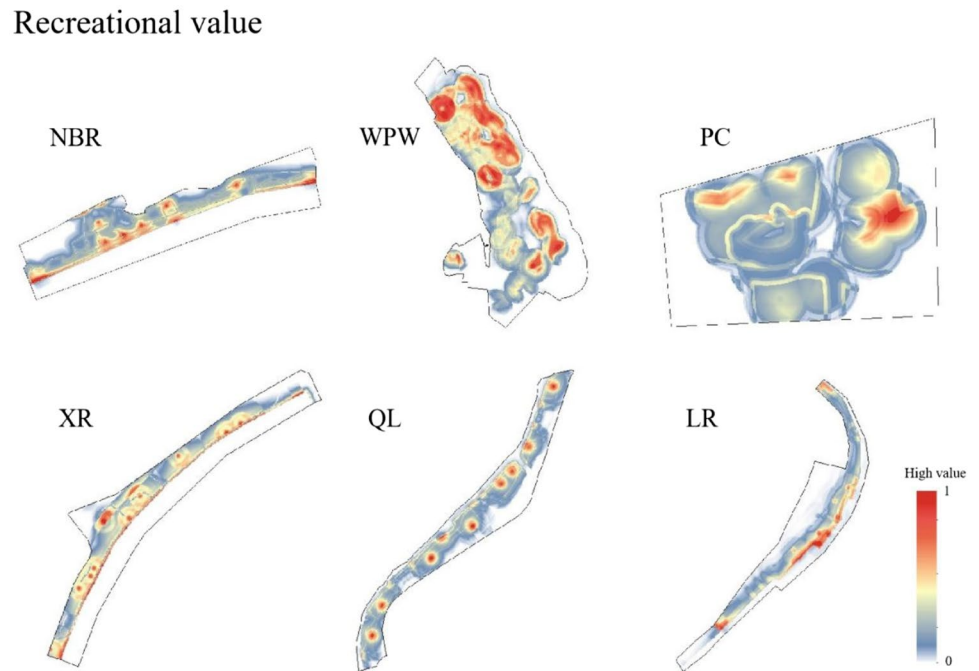
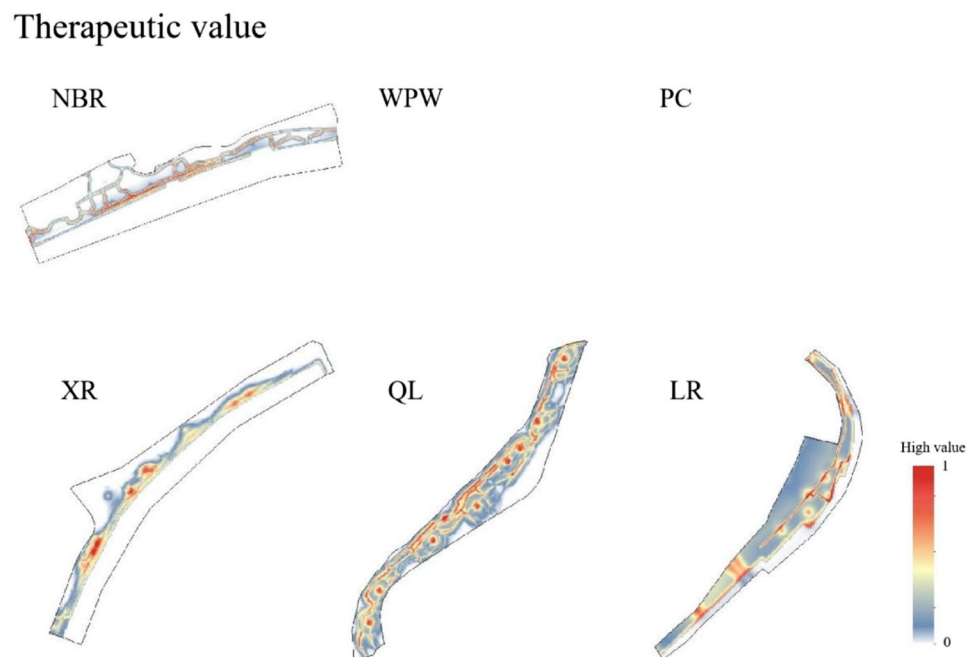


Fig. 6 Distributions of high-value areas under therapeutic value within the six waterfront green spaces



photographs. In this study, distribution maps of therapeutic value could not be created for WPW or PC due to a lack of value points. High-value recreational and historical values are concentrated around the main attractions, while low-value recreational values have a wider distribution. Among the four types of CES values, aesthetic and recreational values are most widely perceived in each green space.

4 Discussion

4.1 Exploring the factors influencing the perception and distribution of CESs in waterfront green spaces

The goal of traditional planning for open space is to provide a high-density, well-connected open space that

enriches people's outdoor activities, such as cycling, jogging, and walking, thereby increasing the frequency of social interactions (Jian et al. 2020). However, Bahrini et al. (2017) found that high accessibility alone cannot guarantee the high usage of space. The findings of this study revealed that although the two theme parks are quite distant from the central city, they saw a greater number of survey users than did the other areas. We believe that a waterfront green space with a clear theme is more likely to attract visitors, thereby increasing its visit frequency. The results of field research showed that the public perception of CESs is also influenced by the theme of the waterfront green space. WPW was planned as a historical and patriotic education base and therefore contains many historical sites and related background presentations. Higher “sense of place” and “historic site” values are perceived by the public in WPW. QL has many special infrastructure elements along the waterfront, such as skateboard parks, and rock-climbing facilities in the woods, so it is easy for people to perceive its outdoor sports value. In addition, amusement facilities and road signs affect public perceptions of different CES value types. Based on the CES value types adapted to the waterfront green space survey results, although amusement facilities with special features and road signs presenting introductory information decrease the diversity of CES types, they may enhance visitors' perception of various CESs, resulting in an increase in the magnitude of attention given to those specific CESs. Although the design of the four downtown waterfront green spaces varies, these parks do not have clear themes. People perceive many different types of CESs when visiting these green spaces. The recreational and therapeutic values provided by their blue–green infrastructure are perceived more often, while other specific values provided by the site's facilities, such as historical value, are only moderately perceived. It is not to say that recreational and therapeutic value is not important. Barton and Pretty (2010) reported that green exercise has health benefits. Zhang and Xu (2023) emphasized that urban green parks are preferred by residents for outdoor activities and have positive effects on regulating emotional states. In addition, we must emphasize that all the “facilities” mentioned above refer not only to the facilities but also to the areas in which they are located, including the surrounding blue–green environment. When evaluating the CESs that people perceive based on artificial facilities, recreational facilities or historical buildings cannot be separated from blue–green spaces. Because artificial facilities themselves cannot be regarded as ecosystems, the services they provide are not considered CESs; this situation creates problems in many CES studies. Our study avoids this problem by eliminating photographs without blue–green environments during

the screening of valid images, ensuring that the services people received met the definition of CESs.

As these green areas were built next to the water, “fresh” and “open” visual sensations stood out, especially along the shoreline. Moreover, combining walkways and green landscapes improves the aesthetic experience. As shown in Figs. 3, 4, 5, 6, among the four value types, the high-value areas are distributed along the riverbank. The high-value areas for therapeutic value in Fig. 6 are distributed largely along walkways and waterfronts, suggesting that better water accessibility and winding walkways can increase the variety of outdoor activities. Visitors prefer landscapes near water and consider areas near water landscapes more suitable for recreational activities (Wang et al. 2016). Table 4 shows that PC has the highest rate of shoreline curvature and a higher level of access to water, with water and outdoor activity values receiving more attention in its functional value rankings. Increasing shoreline curvature while ensuring public access to water can enhance people's interactions with both botanical and water landscapes, thus strengthening visitors' aesthetic experience and therapeutic activities.

4.2 Understanding the gap between public perceptions of CESs in waterfront green spaces and the planning of these spaces

The waterfront green spaces in this study have clear planning objectives. Infrastructures with specific themes have been constructed within these spaces to provide one or several types of CES value. Table 5 shows the planned function of the six waterfront green spaces and the ranked values of their perceived CES value types. For WPW, NBR, LR, QL, and PC, the public perception of CESs matched their planned function. In general, waterfront green spaces meant for aesthetic experience and recreational activities provide CESs that match expectations.

However, there are still some discrepancies between planning and actual public perception. XR is located in a region with many historical and cultural sites and was planned as a cultural and creative centre. The examples of industrial heritage along the riverside, such as tower cranes, are intended

Table 4 Quantitative information for the six waterfront green spaces

Name	No. of investigated users	No. of valid users	Effective data rate (%)	No. of CES value points
WPW	2174	1953	89.83	9493
NBR	680	581	85.44	2832
LR	718	557	77.58	2692
XR	1033	635	61.47	2783
QL	1230	820	66.67	3907
PC	1254	1201	95.77	4989

Table 5 Planned function value rankings of waterfront green spaces

Name	Planned function	Rank	CEs value type in waterfront green spaces	High value
WPW	Historic and patriotic education	1	Sense of place	0.964818
		2	Activities in amusement area	0.955353
		3	Architectural environment	0.855802
		4	Riverside historical sites	0.850499
		5	Green landscape	0.836659
		6	Interaction with riverside landscape	0.807625
		7	Social bonding	0.776195
		8	Water view	0.703281
LR	Arts and culture business port	1	Activities in amusement area	0.94107
		2	Being physically active outdoors	0.934681
		3	Green landscape	0.918221
		4	Interaction with riverside landscape	0.88707
		5	Sense of place	0.886815
		6	Architectural environment	0.885999
		7	Social bonding	0.882374
		8	Riverside historical sites	0.828514
NBR	International financial centre	9	Waterside view	0.783815
		1	Sense of place	0.945359
		2	Social bonding	0.944706
		3	Activities in amusement area	0.93723
		4	Architectural environment	0.921951
		5	Interaction with riverside landscape	0.921331
		6	Being physically active outdoors	0.900086
		7	Green landscape	0.893875
		8	Riverside historical sites	0.862326
QL	Cultural and creative centre	9	Waterside view	0.816336
		1	Being physically active outdoors	0.962772
		2	Sense of place	0.942127
		3	Architectural environment	0.938323
		4	Water view	0.930692
		5	Social bonding	0.919835
		6	Green landscape	0.911333
		7	Interaction with riverside landscape	0.888367
XR	Cultural and sports centre	8	Activities in amusement area	0.731783
		1	Green landscape	0.959993
		2	Interaction with riverside landscape	0.932901
		3	Architectural environment	0.912571
		4	Thematic sports activities	0.870826
		5	Social bonding	0.856902
		6	Waterside view	0.848019
		7	Riverside historical sites	0.83325
		8	Sense of place	0.829265
		9	Being physically active outdoors	0.769518
PC	Ecotourism destination	10	Activities in amusement area	0.696386
		1	Green landscape	0.976902
		2	Waterside view	0.957399
		3	Activities in amusement area	0.957055
		4	Social bonding	0.908838
		5	Architectural environment	0.858792
		6	Interaction with riverside landscape	0.817931
7	Sense of place	0.759999		

to provide the public with a sense of place. Facilities within green spaces can also provide “hard recreationists” (Dick et al. 2022) with energy-intensive fitness activities such as rock climbing and skating. Nevertheless, Table 5 shows that the top three M-VI values contained neither historical nor therapeutic value. Rather, both “water view” and “green landscape” are types of aesthetic value, and “interaction with the landscape along the riverside” is a type of recreational value. Facilities are at the centre of people’s activities, but activity type is not completely related to facility type. People can rock climb in XR; however, its “thematic sports activities” value ranked only fourth, which was unexpectedly low. This may be because locals and visitors are unaware of the symbolism of the tower cranes. In addition, rock climbing is not suitable for everyone who visits XR. This illustrates that detailed planning for different regions and populations is necessary.

In summary, the assessment of CES value types adapted to waterfront green spaces in this study reflects regional differences and highlights the importance of carefully planning and designing waterfront green spaces.

4.3 Rethinking the planning and design of waterfront green space.

Studies have shown that the CESs of waterfront green spaces are not only related to the facilities within those spaces, the degree of water accessibility, and the curvature of the shoreline but also influenced by planning to a certain extent. High-quality open waterfront green spaces with unique characteristics and activity areas serving different functions result from careful landscape planning and adequate facility support; they also benefit from consideration of the functional characteristics of different zones and the interactions among different plans.

To ensure that waterfront green spaces have features that attract visitors and can provide various types of CESs, planners first need to improve landscape diversity according to regional characteristics. Studies have shown that landscape diversity increases visual focus, which means that greater heterogeneity can increase the attractiveness of green spaces (Qiu et al. 2023). In addition, in this study, the provision of clear themes, open spaces, waterfront activities, and resting places enhanced the use and perception of CESs. Another study on urban green spaces also showed that urban forests, water bodies, and parks are preferred as urban green spaces (Syrbe et al. 2021).

Different types and locations of waterfront green spaces require different planning directions. A waterfront green space in the city centre is surrounded by dense buildings, so harmonious, complex scenery formed by intertwining plants and buildings should be considered (Qiu et al. 2023). This type of scenery may help city dwellers relieve stress.

High-quality green space will attract people to participate in various sports activities and enjoy socializing in the area (Brindley et al. 2019). Therefore, an outdoor area needs to provide a certain amount of open space to provide a place for residents to socialize. Areas rich in history and culture should consider displaying industrial remnants along the shoreline or combining waterfront landscapes with historical industrial sites to provide a richer recreational experience. The upstream and downstream areas of the river are used mainly for ecological construction. Combining family activities and special sports facilities while fully developing the green landscape enhances the quality of these green spaces.

5 Conclusions and limitations

In this study, we assessed CESs through data obtained from a social media platform and explored the influence of planning and interior facilities on urban waterfront green space CESs by using the regeneration of Shanghai’s Huangpu River waterfront as a case study. We found that waterfront green spaces with specific themes attract more visitors and provide a greater variety of CESs. In waterfront areas, high levels of accessibility to water and winding walkways enrich visitors’ activities, thereby increasing the recreational and therapeutic value of the area. The combination of building features with green landscapes and a good view of the water provide visual aesthetics. Additionally, we suggest that in planning, using a specific theme and providing an introduction about open spaces should be considered, as these approaches have been shown to improve residents’ perception of CESs, especially those associated with historical value.

This study was conducted along the Huangpu River. The reconstruction of this waterfront area is a typical city renewal project, and the results can provide a planning reference for other cities. However, there were limitations in the research process. The survey data, including photographs and text, were collected from a social media platform, which leads to bias in aesthetic value because the photographs were classified by the researchers (Clemente et al. 2019). Yoshimura and Hiura (2017) noted that when using photographs as proxies for CESs, there is an inevitable tendency to lean towards aesthetic values. Ultimately, photographs tend to exhibit pleasing and beautiful characteristics. In future research, traditional methods such as questionnaires, interviews, and social media surveys should be combined to more comprehensively measure public opinion and perception (Cheng et al. 2019). Moreover, only a few common green space assessment metrics were used. Future research should construct a metric framework for waterfront green space assessment to improve the accuracy and comprehensiveness of these types of studies.

In general, this study conducted a survey on CES perception to provide a basic understanding of the CES performance of existing urban waterfront spaces, explore the influences of these spaces on public perception, and offer suggestions for the future construction of urban spaces. The results should encourage government agencies and urban planners to build urban open spaces that are resilient, sustainable, and diverse.

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Author contributions Dr. Yue Che is responsible for the study conception and design, and providing critical revisions; Tian Tian is responsible for the acquisition of data, analysis of data, creating graphs, and drafting manuscript; Tao Yu is responsible for the acquisition and analysis of data; Yuzhen Qian is responsible for the interpretation of data and providing critical revisions; Lingzhi Deng is responsible for providing critical revision.

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Declarations

Conflict of interest Yue Che is a member of the Editorial Board of Socio-Ecological Practice Research. He was not involved in the review or handling of the manuscript. All authors have no conflict of interests to declare that are relevant to the content of this article.

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