

On the Core Concepts and Implementation Strategies of Waterfront Space Reconstruction: Taking Dujiangyan as an Example

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Abstract. Against the backdrop of the integration of urban renewal and the concept of healthy cities, the sustainable management of waterfront spaces—as complex carriers of ecological, cultural, and social functions—has increasingly become a common challenge for small and medium-sized cities with cultural heritage. This study focuses on the Min River waterfront space in the Dujiangyan, a World Cultural Heritage site, and employs a mixed-methods of field research, questionnaire surveys, to systematically diagnose its governance challenges and the mechanisms behind the mismatch between supply and demand. Based on a comparative analysis of "importance-satisfaction," this study found that spatial usage exhibits a "core-periphery" demand gradient. While ecological conditions, infrastructure, and safety measures constitute baseline requirements, satisfaction levels are generally low, resulting in a core mismatch characterized by "high expectations versus low experience." The main problems include monotonous vegetation, hardened riverbanks, insufficient facilities, and a lack of cultural carriers. Accordingly, this study transcends the traditional one-dimensional framework of "spatial production" by integrating perspectives of cultural ecology and environmental justice. It constructs a four-dimensional, synergistic sustainable governance paradigm centered on "enhancing ecological resilience—optimizing facility services—revitalizing cultural heritage—empowering long-term governance," and develops a "assessment-planning-governance" toolkit tailored for small and medium-sized cities in the upper Yangtze River region. This study provides an actionable pathway for balancing ecological conservation, cultural continuity, and social justice, offering theoretical reference and policy insights for the high-quality development of similar waterfront spaces.

Keywords: Dujiangyan, waterfront space, the Sustainable Management, supply-demand matching, Importance & satisfaction analysis

1. Introduction

With the acceleration of urbanization, the renewal and sustainable development of waterfront spaces—as core venues where urban ecology and culture intersect—have become a global issue. The development of urban waterfront spaces not only presents opportunities for economic growth and

environmental beautification but also plays a crucial role in the overall development of cities and the optimization of their regional structures [1]. From a historical perspective, the development of waterfront areas worldwide has undergone a transformative process characterized by "industrial dependence—deindustrialization—ecological revitalization" [2]. Current research largely focuses on economically driven transformations of waterfront spaces or macro-level ecological restoration, yet pays little attention to the governance conflicts surrounding waterfront spaces in small and medium-sized cities, which are caught between cultural heritage preservation and the pressures of urbanization. For example, Tang Yanan et al. point out that waterfront renewal often falls into a "gentrification trap," leading to the marginalization of indigenous residents' spatial rights [3]; Chen Shuxiang et al., through a comparison of domestic and international cases, reveal that Chinese waterfront planning faces the dual dilemma of "disruption of cultural gene carriers" and "lack of social participation mechanisms" [4]. Since the beginning of the 21st century, the concept of healthy cities has further reshaped the design paradigm for waterfront spaces. Research indicates that waterfront environments influence public health through a three-tiered mechanism of "natural foundation—spatial guidance—place satisfaction" [5]. Urban waterfront areas are the most dynamic and vibrant parts of a city; they are regions where natural elements are most concentrated, natural processes are most abundant, and the ecological environment is most sensitive [6]. This has driven the establishment of "health-oriented" design frameworks, such as the BEAT assessment tool developed by the European "Blue Health" project, which quantifies the health benefits of waterfront spaces from the perspective of the interaction between environmental carrying capacity and human behavior [7].

The core question of this study is: How can we construct a governance paradigm for Dujiangyan's waterfront spaces that balances ecological resilience, cultural continuity, and social equity? Theoretically, this study breaks new ground by incorporating "spatial production" with cultural ecology and environmental justice; practically, it constructs an "assessment–planning–governance" toolkit for reference by small and medium-sized cities in the upper Yangtze River region. By addressing the tensions between globalization and regionalism, and relying on the "integration of the three lives" (ecological, social, and economic) through "catalytic development," the study establishes a full-cycle governance framework to achieve a transition from spatial renewal to the symbiosis of people and water.

2. Methodology

To investigate the current state and existing issues of the waterfront spaces in Dujiangyan and explore effective solutions, this study employs two research methods: field research, and questionnaire surveys. Through on-site visits and surveys of the waterfront spaces in Dujiangyan, we gained insights into user behavior and activities as well as the various facilities within the spaces. This provided more targeted data for the subsequent questionnaire design and helped ensure that the study was conducted in a more standardized and comprehensive way. By combining field research with a comprehensive analysis of relevant literature, the research team developed a targeted questionnaire assessing the importance of the waterfront spaces. Following the distribution and scoring of this questionnaire, a satisfaction survey was designed and administered to provide data support for further analysis.

2.1. Construction of the evaluation index system

Based on Mr. Wu Liangyong's classification of evaluation factors into three major categories—physical environment, social environment, and spiritual environment—as outlined in *General Architecture*, and in light of the actual conditions of the Dujiangyan waterfront area, this study adopts four perspectives: the built environment, the natural environment, the socio-psychological environment, and human activities. It identifies water environment, vegetation landscape, climatic comfort, recreational facilities, supporting services, transportation accessibility, cultural vitality, safety, and management as primary indicators. Based on the characteristics of the Dujiangyan waterfront area, secondary evaluation factors are established accordingly as shown in figure 1.

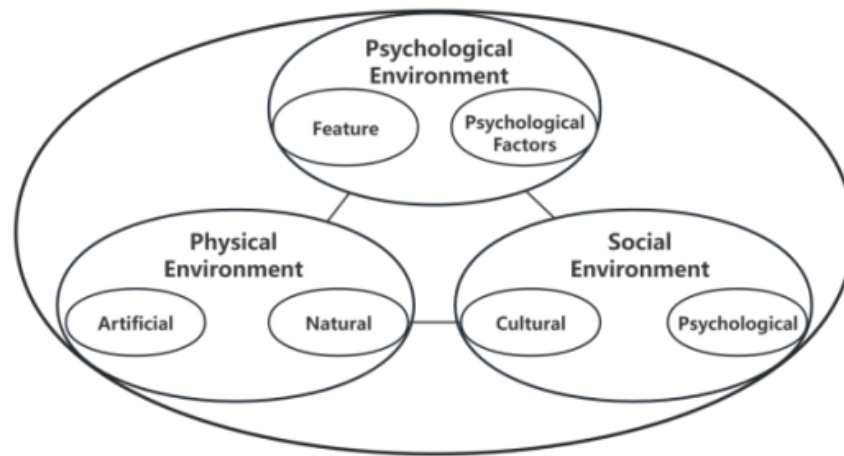


Figure 1. Systematic relationships among three sets of evaluation factors

A total of 118 questionnaires were distributed to assess the importance of influencing factors in Dujiangyan's waterfront spaces. These included 17 questionnaires for students majoring in architecture and urban planning at universities; 33 online questionnaires for residents and tourists; and 68 on-site user questionnaires. Of these, 116 valid questionnaires were returned. The distribution of questionnaires adhered to the principle of randomness to ensure the research results were as objective and impartial as possible. The Likert scale method was used for quantitative analysis, assigning a score of 5 to "very important," 4 to "important," 3 to "moderately important," 2 to "not very important," and 1 to "not important at all." Statistical analysis was ultimately performed on the 116 valid questionnaires, yielding the mean importance scores for 28 evaluation factors, which were ranked in descending order (Table 1).

Table 1. Importance rating table for evaluation indicators of Dujiangyan's waterfront spaces

No.	Item	Adjusted Average Score	Number of Cases	Standard Deviation
1	Water Clarity	4.63	116	0.694
2	Air Freshness	4.62	116	0.698
3	Shade and Shelter Facilities	4.61	116	0.692
4	Safety	4.6	116	0.673

Table 1. (continued)

5	Number of Seating Areas	4.59	116	0.721
6	Clarity of Signage	4.41	116	0.803
7	Aesthetic appeal of flowers and plants	4.39	116	0.806
8	Accessibility by public transportation	4.39	116	0.802
9	Walkway Width	4.38	116	0.798
10	Public Order	4.38	116	0.812
11	Lighting Brightness	4.37	116	0.801
12	Waterfront Accessibility	4.36	116	0.815
13	Accessibility of bike lanes	4.13	116	0.934
14	Flood Control Facilities	4.12	116	0.937
15	Water Surface Cleanliness	4.12	116	0.931
16	Trash Can Distribution	4.11	116	0.936
17	Convenience of the snack bar	4.11	116	0.935
18	Frequency of Cleaning	4.11	116	0.932
19	Staff Attitude	4.1	116	0.924
20	Preservation of Historic Buildings	4.09	116	0.926
21	Cleanliness of restrooms	4.08	116	0.921
22	Wind Protection	3.5	116	1.042
23	Parking Convenience	3.49	116	1.039
24	Tree Density	3.48	116	1.033
25	Seasonal Variation	3.47	116	1.031
26	Cultural Promotion	3.46	116	1.045
27	Children's Playground Equipment	3.44	116	1.048
28	Soothing Effect of Water Flow	3.43	116	1.046

Based on the average scores of the 28 indicators, they were categorized into different levels according to the criteria shown in Table 2. Factors with an average score below 4 were identified as unimportant and were excluded or consolidated. Ultimately, five factors were identified as particularly important: water clarity, air freshness, shade shelters, safety, and the number of recreational seating areas; seven as moderately important, nine as generally important, and seven as unimportant. This resulted in a final set of 21 evaluation factors, which were used to establish the Dujiangyan City Waterfront Space Satisfaction Evaluation System (Figure 2). Satisfaction surveys were distributed and data was compiled, yielding the satisfaction data shown in Table 3.

Table 2. Evaluation indicator factors

Evaluation Description Level	Average Score
Extremely Important	Greater than 4.5
Fairly Important	4.25–4.5
Moderately Important	4.0–4.25
Not Important	Less than 4

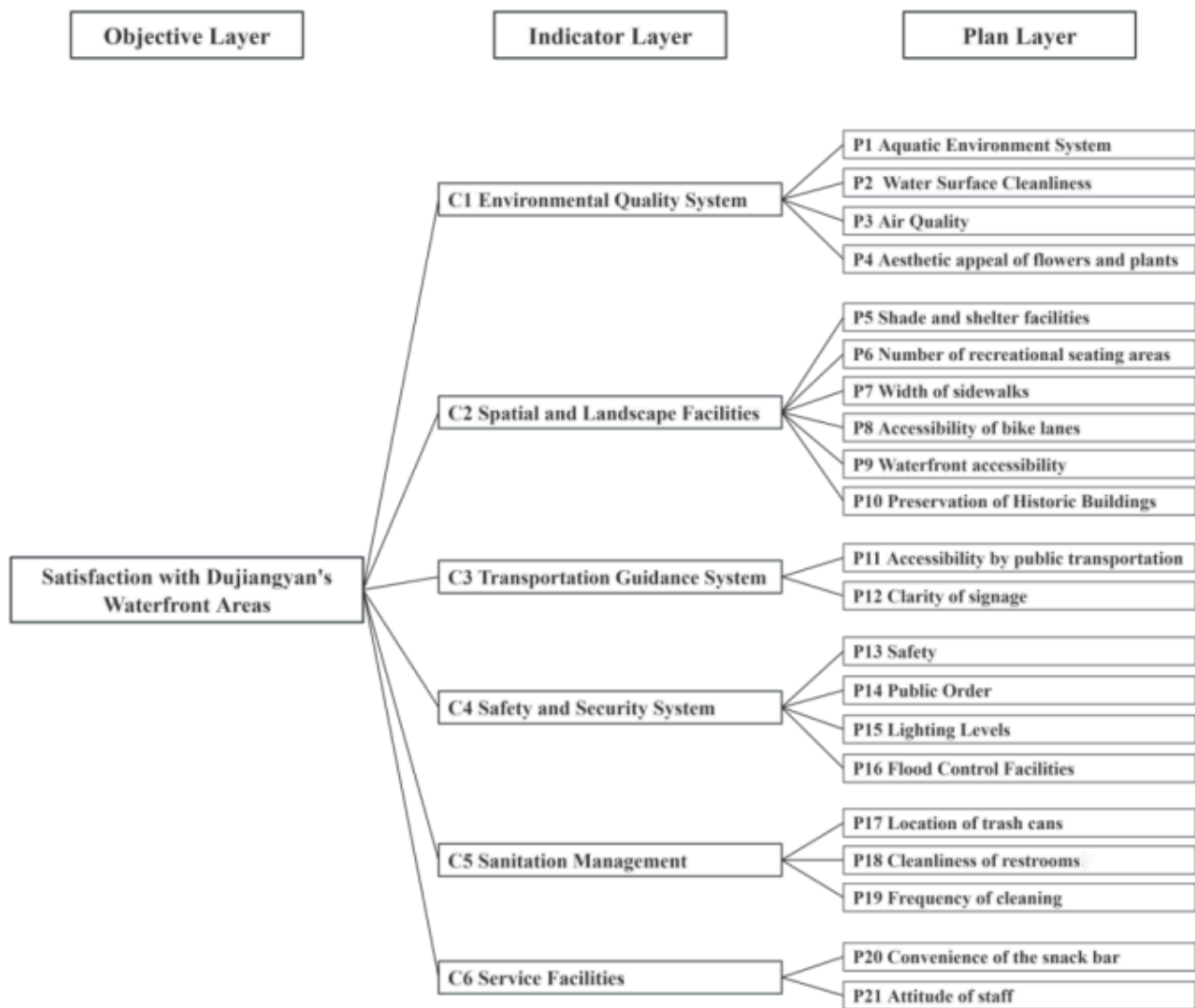


Figure 2. Satisfaction evaluation system for the Dujiangyan waterfront area

Table 3. Satisfaction ratings for Dujiangyan waterfront space

Evaluation Factors	Average
Water Clarity	3.64
Air Freshness	4.08
Shade and Shelter Facilities	3.66
Safety	3.93
Number of Benches	3.84
Clarity of Signage	3.72
Aesthetic appeal of flowers and plants	3.80
Accessibility by public transportation	3.94
Width of Sidewalks	3.64
Public Order	4.01
Lighting Brightness	3.5
Water Accessibility	3.75
Accessibility of bike lanes	4.05
Flood Control Facilities	3.73
Water Surface Cleanliness	3.86
Distribution of Trash Cans	3.59
Convenience of the snack bar	3.73
Frequency of Cleaning	3.92
Staff Attitude	4.11
Preservation of Historic Buildings	4.02
Cleanliness of restrooms	3.64

2.2. Analysis of importance evaluation results

The importance evaluation reveals a distinct "core-periphery" gradient in user needs: there is a high degree of consensus on core needs, while significant individual differences exist regarding non-core needs. Factors rated as particularly important (>4.5 points) focus on ecological fundamentals (water clarity, air freshness), infrastructure (shade and shelter facilities, number of recreational seating), and safety (security), constituting the "baseline requirements" for space usage. Factors rated as relatively important or lower revolve around ease of use, landscape experience, and supporting functions; their standard deviation is significantly higher than that of core factors, which reflects the personalized nature of these needs. Overall, the results demonstrate a pattern of "ecological priority and functional adaptation."

2.3. Analysis of satisfaction evaluation results

Overall satisfaction is characterized as "above average but with a mismatch between supply and demand": supply fails to meet core needs, while supply and demand are well-aligned for non-core needs. Satisfaction levels for factors ranked high in importance—such as ecology, infrastructure, and safety—are generally low, creating a "high expectations–low experience" mismatch; conversely, satisfaction with non-core factors (such as staff service attitude and the preservation of historic buildings) aligns with or even slightly exceeds their perceived importance. This mismatch essentially stems from a misalignment in the planning and construction sectors' understanding of user priority needs, characterized by an excessive focus on ancillary functions while neglecting the quality of core functional offerings.

2.4. Key issues in the current situation

Based on a comparison of importance and satisfaction scores, the core issues of Dujiangyan's waterfront spaces are "insufficient provision of core functions" and "structural imbalances between supply and demand."

Weak Ecological Functions of Planting Schemes and Unreasonable Retaining Wall Design. Regarding plant arrangements, the aesthetic appeal of flowers and plants received a score of 4.39 for importance but only 3.80 for satisfaction; the selection of plant species is limited, there is insufficient use of native species, and the landscape lacks continuity and stability. In terms of retaining wall design, the water accessibility aspect received a score of 4.36 for importance but only 3.75 for satisfaction; there is a high proportion of hard landscaping, the waterfront platforms lack variation in elevation, and there is an imbalance between accessibility and safety.

Insufficient Provision of Basic Recreational and Safety Facilities. High-frequency infrastructure such as shade and shelter facilities and the number of recreational seating ranked among the top three in importance, but satisfaction scores were all below 3.9 points, indicating that configuration and distribution failed to meet demand; there was a significant gap between supply and demand for safety factors such as lighting brightness and security, and the safety and comfort of nighttime use require further improvement.

Insufficient Refinement of Accessibility and Service Support. There is a significant gap between importance and satisfaction scores for accessibility-related factors such as walkway width and waterfront accessibility, reflecting deficiencies in the design of circulation spaces and accessibility; there is a supply–demand mismatch for service support factors such as sign clarity and restroom cleanliness, indicating that the quality of refined services needs to be further improved.

Structural Mismatch in Functional Supply and Demand. The average gap between importance and satisfaction scores for "particularly important" factors reached 0.78, whereas that for "generally important" and lower-priority factors was only 0.26; satisfaction scores for some non-core factors were slightly higher than their importance ratings. Planning and construction failed to accurately prioritize user needs, leading to disproportionate resource allocation to non-core areas, while insufficient provision of core functions has become a key bottleneck for spatial quality improvement.

In summary, the correlation analysis between importance and satisfaction indicates that the current issues align with problems such as "monotonous plant arrangements, scientifically inadequate retaining wall designs, lack of management and maintenance, and imbalanced layout of service facilities," while also revealing new issues such as "insufficient refinement of access and supporting services" and "structural imbalances between supply and demand of functions."

Accordingly, by drawing on established domestic and international practices, we have formulated optimization strategies tailored to the unique characteristics of Dujiangyan's waterfront spaces, thereby providing a practical foundation for addressing these core issues.

3. Comprehensive strategies for the sustainable management of the Min River waterfront

Strategies for Enhancing Ecological Resilience. To address the issues of monotonous plantings and overly rigid riverbanks, we will draw inspiration from the layered vegetation along the Seine in Paris, the tiered shoreline of the Suzhou River in Shanghai, and the use of native species along the Jinjiang Greenway in Chengdu. We will promote the ecological arrangement of vegetation to enhance ecological and landscape connectivity; implement tiered renovations of the riverbanks to balance flood control, ecological connectivity, and public access to the water.

Optimization Strategies for Facilities and Services. To address issues such as insufficient infrastructure, poor connectivity, and a lack of refined services, we will draw inspiration from Paris's Seine River model—which prioritizes public transit and is designed to be accessible to people of all ages—and implement a "core-periphery" approach to expand high-frequency facilities, ensuring both safety and recreational opportunities. We will also incorporate Shanghai's Suzhou River model of barrier-free amenities and Chengdu's Jinjiang Greenway model of three-network integration to advance the refinement of services and accommodate diverse and inclusive needs.

Cultural Heritage Revitalization and Integration. In response to the lack of cultural venues and insufficient regional characteristics, and drawing on the immersive approach of the Singapore River, the scenic design of Shanghai's Suzhou River, and the "cultural stations + themed sections" model of Chengdu's Jinjiang Greenway, the following recommendations are proposed: Establish a systematic cultural exhibition framework, integrate key nodes and corridors, and highlight water conservancy culture; create immersive experiential settings that incorporate festivals and nighttime activities to enhance cultural appeal.

Ensuring Long-Term Governance and Empowerment. To address the mismatch between supply and demand and the tendency to prioritize construction over operations and maintenance, we will draw on Shanghai's statutory guidelines and Singapore's interdepartmental coordination to establish a demand-driven planning coordination mechanism; build a multi-stakeholder governance framework involving the government, the market, and the public; and establish a smart, full-cycle operations and maintenance system to strengthen dynamic monitoring and routine maintenance, thereby ensuring long-term stability.

4. Conclusion

This study focuses on the waterfront area of the Dujiang Ancient Irrigation System, a World Cultural Heritage site. Addressing the governance challenges arising from the interplay of its ecological sensitivity, cultural heritage value, and urban service functions, the study employs a research approach combining field surveys, and questionnaire surveys. It systematically identifies the key issues of the area's "hierarchy of needs" and "core service supply gaps and structural supply-demand mismatches," pinpointing core problems such as insufficient ecological efficacy of species composition, a shortage of basic service facilities, and the absence of regional cultural carriers. This study draws on classic European waterfront renewal practices, Southeast Asian waterfront governance models, and waterfront optimization experience from major Chinese cities, establishing a four-dimensional collaborative sustainable governance framework of "Strengthening Ecological Resilience - Upgrading Service Facilities - Cultural Heritage Revitalization and Transmission -

Empowerment for Long-Term Governance," providing a practical pathway to balance ecological conservation, cultural continuity, and social justice. This study overcomes the one-dimensional limitations of traditional waterfront area research. The "assessment–planning–governance" technical tools and the waterfront governance paradigm tailored for small and medium-sized cultural heritage cities established herein can provide theoretical references and practical insights for the high-quality development of waterfront areas in similar cities along the upper Yangtze River. Long-term follow-up evaluations are required to further refine the dynamic adaptability of these strategies.

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