

Zhengxi GE^{1*} and Zilong XIN¹

THE SPATIAL ECOLOGICAL ENVIRONMENT DESIGN OF THE WATERFRONT PUBLIC AREAS OF RURAL RIVERS

Abstract: To revitalise established urban areas in the context of stock planning, the river surges in established urban areas play an irreplaceable role. In recent years, the water systems of rivers and surges in established urban areas of many international metropolises have undergone transformation and regeneration. The formerly hardened river banks have begun to be transformed into post-industrial places of integrated residence, leisure, and work, reshaping the ecological landscape and the functions of leisure activities of the rivers and urban spaces. By selecting typical representative cases for analysis and research, this paper determines the research angle and conducts a comparative study of waterfront open space in small and medium-sized cities and large cities from the perspectives of spatial layout, functional structure, ecological restoration, and artistic style, summarises the characteristics and current problems of waterfront open space in small and medium-sized cities at the present stage, and takes the problem as a guide, combining urban design, place theory and other theoretical studies as a guide. Planning and design strategy for waterfront open space in small and medium-sized cities is proposed. This paper selects representative waterfront open spaces and open waterfront spaces for field research. It uses the waterfront open space planning strategy proposed in the paper as a guide to provide a basis for waterfront open space planning and design and, at the same time, selects typical lots for optimal design to verify the implementation ability of the strategy. This paper digs into the rich historical, and geographical information contained in the sample villages in each area summarises the site selection characteristics of traditional villages in Hebei at the mesoscopic level between different areas and analyses the characteristics of the overall layout of villages dominated by natural factors such as mountains, hills and plains, and human factors such as ancient defile post roads, military defences, industries and temples. The spatial skeleton structure of the single-axis type, multi-axis type, organic network type, regular network type, and the fortress-wall enclosed village is extracted. The characteristics of its subtypes are summarised with sample cases. The elemental composition of village centres and boundaries is summarised.

Keywords: spatial ecological, waterfront public areas, rural rivers, ecological environment

Introduction

The dual urban renewal focuses on "making life better" with a more comprehensive and progressive design approach, constantly improving the public space in the city, adjusting the urban structure, sorting out the urban fabric, and improving urban functions [1]. During the period of stock planning, urban development changed from rough development to refined renewal and is gradually getting rid of the dependence on urban expansion and land economy and paying more attention to the quality of urban life and social development [2-5]. In recent years, due to the concept of green, ecological, and

¹ Hebei Academy of Fine Arts, School of Architecture and Art Design, Shijiazhuang, 050700, China, email: gezhengxi2023@163.com, xinzilong1990@126.com, ORCID: ZG 0009-0000-5183-5903, ZX 0000-0003-1230-5285

* Corresponding author: gezhengxi2023@163.com

healthy cities, urban open space has been attracting attention because of its "green effect". Under the guidance of urban double repair and stock planning, the discussion and practice projects on the renewal and transformation of open space are blooming everywhere [6]. The new concept of "the city is the people's city, people's city for the people" is the latest concept to guide urban construction in the new era, showing that the development of urban construction is paying more and more attention to the needs of people [7]. As an essential part of urban construction, the planning and renovation of public space is an important place for social interaction and other social activities, and it pays more attention to the embodiment of the concept of humanisation [8]. Especially for small and medium-sized cities because of their relatively slow development compared with large international cities and small population flows. Relatively simple social structures and public spaces in small and medium-sized cities mainly provide services for residents, so it is more important to pay attention to implementing the city's humanisation concept and providing residents with high-quality places that reflect the spirit of the city [9].

In recent years, the rapid development of small and medium-sized cities has significantly improved people's quality of life [10]. After basic life, such as clothing, food, housing, and transportation, has been secured, urban residents have started paying attention to spiritual life's needs. The rich diversity of urban life has become the focus of urban residents at this stage, and people are full of expectations for high-quality outdoor spaces. Under the impetus of urbanisation, the planning and renovation of public space in small and medium-sized cities are in full swing [11]. However, in this process, the lack of guidance on the planning and design of public spaces in small and medium-sized cities has led to the planning and design of public spaces in small and medium-sized cities to imitate large cities, lacking their spatial characteristics and cultural heritage, resulting in the status quo of a thousand cities [12]. Not only wasting money and capital but failing to get the spiritual recognition of the space from the citizens of small and medium-sized cities, resulting in idle public space failing to achieve the use effect. With the improvement of the quality of life, the current public space can no longer meet people's pursuit of quality of life, so it is increasingly urgent to improve the existing problems in small and medium-sized cities [13]. Rivers and lakes develop many cities, and waterfront open space plays an irreplaceable role in the construction process of cities and is also an eternal topic of human life. Planning and designing urban waterfront open space is often an important symbol of urban development and construction [14]. Waterfront open space is closely related to human activities; people have characteristics of pro-water since ancient times, happy to kiss water, swim in the water, and enjoy the water, its space is a collection of social, cultural, ecological, leisure in one place, and residents of social interaction is closely linked, for people to carry out outdoor activities, a vital space carrier of social interaction. Planning waterfront open space is an excellent way to enhance the contact between people and nature and promote interaction between people [15]. In cities where rivers exist, waterfront open space is often the focus of development and construction in the city. Especially in small and medium-sized cities, because the scale of urban space is limited, the number of open waterfront spaces is relatively small, and the location of space is also more concentrated, so it will become an important place to provide outdoor public space for citizens in the city [16]. The necessity of waterfront open space for transforming small and medium-sized cities is also prominent [17]. At this stage, some rivers and lakes in small and medium-sized cities are still idle or even polluted, so the planning and design of open waterfront spaces are conducive to protecting natural environmental elements [18]. Plants as natural

environmental elements in open waterfront spaces are the basis of the urban ecosystem, which can reduce environmental pollution, improve local water quality, purify the air, effectively alleviate the "urban heat island" effect, and improve urban microclimate [19].

Integrating the sponge city concept in open waterfront spaces and linking the green space landscape with the overall form of the city and the greenway system promotes the creation of urban ecological demonstration areas [20]. For the planning and design of open waterfront spaces in small and medium-sized cities, it can make the natural environmental elements such as water bodies, vegetation, and organisms in the space form a good balance within the urban ecosystem, which is conducive to creating an ecological environment where people and nature live together in harmony [21-23]. This paper takes the waterfront open space of small and medium cities as the research object by selecting large representative cities and small. Medium cities waterfront open space for case comparison study, analysing and summarising the characteristics and problems of small and medium cities waterfront open space in China at the present stage, taking the problems found as the guide, based on the existing planning strategy research, sorting out and putting forward the planning strategy for small and medium cities waterfront open space. Furthermore, choose the typical case Dancheng County Lluvia river waterfront open space for field research, under the guidance of the above strategy, propose the way and method of Lluvia river waterfront open space optimisation, and choose the specific case area for waterfront open space optimisation design practice. This article enriches the theoretical research on the waterfront open space planning and design strategy of small and medium-sized cities in China. In order to attract more attention of city managers as well as urban planners, in the planning and design of waterfront open space, we should pay attention to the ecological improvement of small and medium-sized cities, inherit local characteristics, inherit historical culture, create high-quality urban space, and build the city more healthy and more suitable for the life of residents.

Research methodology and framework

This paper has four main research methods: literature research method, case study method, field research method, and practice verification method, as shown in Table 1. This paper summarises the characteristics and current problems of waterfront open space in small and medium-sized cities through case study and field research analysis, puts forward the strategy of planning and design for waterfront open space in small and medium-sized cities with the problem as the guide, and conducts research on waterfront open space, puts forward the direction of Lluvia river renovation for the current problems as the guide, and selects typical lots for planning and design.

Table 1

Summary of research methodology

Research methodology of this paper	Number of cases [-]	Open space area [m ²]	History problems
Literature research methodology	25	183.1	None
Case study methodology	25	182.52	None
Field research method	25	124.2	Several
The empirical verification method	25	145.6	None

Through collecting and reading relevant books, journals, master's and doctoral theses, and other materials, understanding the development history of waterfront open space at home and abroad, studying the relevant theories and research results, then integrating and classifying the literature, organising the theories that have guiding significance for waterfront open space planning and design, as the basis of the research. This paper analyses representative waterfront open space cases in large, small, and medium-sized cities. Through comparative research, the characteristics and problems of waterfront open space in small and medium-sized cities are found and summarised, and the research angle of this paper is determined. The current problems and situation of waterfront open space in small and medium-sized cities are studied through field research and photo interviews. The collected information is combined with the existing information to lay the foundation for further in-depth research. Through practice for verification, the Dancheng County Lluvia river in the case study is selected as a typical representative for the practice verification of the strategy. The strategy is used as a guide to refine the optimisation direction of the planning and design of the Lluvia river waterfront open space. The typical lot is selected for optimisation design.

Concepts that need clarification concerning open space are open, exterior, and public space, as shown in Table 2. These concepts have both parts that cross-fold each other and parts that formulate their research. They are the concepts various scholars propose at different research periods according to their research contents and characteristics. Open space and open space are more widely used in foreign academic research. From the comparison of the original meaning of their words, openness concerning space means to lift the blockade and restriction. And open means open or unobstructed. Open space emphasises the freedom of behaviour, free from outside prohibitions, and open space focuses on the freedom of vision. Although the two do not emphasise the same emphasis, they are seen as the exact definition in many countries for research and exploration. The concept of external space was first proposed in a book by Japanese architect Yoshiharu Ashihara, which stated that external space is a spatial environment created artificially by an individual and that such space is created with a purpose and is more relatable and meaningful than natural space.

Table 2

Proportion of waterfront open space

Type of space	Number of spaces [-]		
	High	Normal	Low
Open space	10	5	0
Outside space	6	3	0
Public space	5	2	0

There is no precise and uniform description of public space. Relevant books indicate that public space is a broad concept with both a narrow interpretation and a broad definition. Specifically, the narrow level of public space is focused on areas such as communities where people are more active daily and usually refers to open outdoor places used for people's daily activities, including parks, event venues, squares, etc. This public space level is usually divided into two forms: open and dedicated. As mentioned earlier, open space mainly refers to parks and squares, while the latter includes only places such as sports grounds. In the broader sense, public space extends to the urban level and includes public

facilities, green spaces, and commercial centres. The word "waterfront" in the western dictionary is "waterfront", which refers to the land or buildings adjacent to the sea, lakes, rivers, etc., and is part of the town near the water body. In "Urban Waterfront Landscape Design Research", Guo Hongyu defines waterfront from the perspective of people as a 200 m - 300 m water space and its adjacent land space, with a human-inducing distance of 1 km - 2 km, which is a more recognised distance of 15 min - 30 min on foot. The waterfront can be divided into riverfront, riverside, lakeside, and waterfront, according to the type of waterfront. This paper takes the riverfront as the object of study in the waterfront category, i.e., the area adjacent to the river, the part near the water body. Furthermore, the waterfront is the area in the city connected with the river water for a specific spatial scope.

Ecological design of public areas along the waterfront

As an essential medium for the public activities of residents, urban waterfront open space is related to the design of green space systems and public space in urban design. In recent years, the pedestrian system in the city has been developing and progressing, and the quality of the public environment in the city is getting more and more attention, adding new requirements and content to the development of open spaces in urban design. In his book on the subject, Roger Transik has organised several theories related to urban design, including the theory of connection, the bottom of the map, and the theory of place. Connection theory explores the linear patterns between various elements in the city. Such linear connections can be traffic lines, linear spaces, view corridors, or architectural entities - for example, roads at all levels in the city, landscape axes, etc. The first level is both the intuitively visible linkages, which are real, and most belong to the first level, such as roads, axes, etc. The second level is not only the linkages themselves but also the inner motives, i.e., the various "flows" that exist on the linkages, such as human flow, traffic flow, information flow, material flow, etc. The second level is not only the connection line itself but also the inner motivation. The various "flows" in the connection line, such as the flow of people, traffic, information, material flow, etc., have an inherent organisation function, linking the many elements of space into a whole through the inner motivation flow. The linkage theory analyses all aspects through these two levels of linkage lines to build the linkage system between urban spaces, establish the spatial order of the city, and link various spatial elements into a whole. That is, it can improve the efficiency of urban space and organise the mutual control between building entities and space. The essential thing in urban design is to find the connections that can bring each others together among isolated individuals. Using connection theory for urban design can create connections in the city, but using only connection theory lacks the construction of peacefulness for space. Therefore, theories in urban design must be combined to create a good urban space.

Conclusion

This paper analyses representative cases of waterfront open space in large cities and small and medium cities, compares and studies the differences between waterfront open space in terms of spatial layout, functional structure, ecological landscape, and artistic style, and summarises the characteristics and problems of small and medium cities in these aspects:

(1) Taking the problems found as the guide and using the theories of urban design, urban imagery, and organic renewal as the guidance, the planning and design strategies for waterfront open space in small and medium-sized cities are proposed.

(2) Selects the waterfront open space of Lluvia river in Dancheng county of small and medium cities for planning practice, summarises the current problems in the waterfront open space of Lluvia river through field research, provides direction for the planning and design of the waterfront open space of Lluvia river in Dancheng county with the proposed strategy as a guide, and selects the specific area of the waterfront open space of Lluvia river to optimise the design and verify the implement ability of the strategy.

(3) The research object of this paper is the waterfront open space of small and medium-sized cities. When selecting typical cases, the difference in location between the north and the south and the spatial layout of the city's waterfront open space is considered.

However, our country is vast, and small and medium-sized cities, as the basis of our national urban system, are widely distributed and large in number, so the selected cases can hardly cover the characteristics of waterfront open space in small and medium-sized cities nationwide, and the study has certain limitations. Secondly, the research in this paper starts from the common problems and characteristics of open waterfront spaces in small and medium-sized cities. It proposes relevant optimisation strategies, but it needs to analyse the impact of the differences between the north and the south and the spatial location of the waterfront open space in small and medium-sized cities in a targeted way. Therefore, it is hoped that more scholars will conduct targeted research in these aspects.

References

- [1] Li P, Tong L, Guo Y, Guo, F. Spatial-temporal characteristics of green development efficiency and influencing factors in restricted development zones: a case study of Jilin Province, China. *Chin Geogr Sci*. 2020;30(4):736-48. DOI: 10.1007/s11769-020-1142-z.
- [2] Vélez A, Martín-Vide J, Royé D, Santaella O. Spatial analysis of daily precipitation concentration in Puerto Rico. *Theor Appl Climatol*. 2019;136(3):1347-55. DOI: 10.1007/s00704-018-2550-1.
- [3] McLaren JD, Buler JJ, Schreckengost T, Smolinsky JA, Boone M, van Loon EE, et al. Artificial light at night confounds broad-scale habitat use by migrating birds. *Ecol Lett*. 2018;21(3):356-64. DOI: 10.1111/ele.12902.
- [4] Martinez RN, Etingen B, French DD, Vallette MA, Bidassie B, Cozart HT, et al. An ecological perspective on implementing environmental control units for veterans with spinal cord injuries and disorders. *Disability Rehabilitation: Assistive Technol*. 2020;15(1):67-75. DOI: 10.1080/17483107.2018.1527956.
- [5] Eagan T. Evaluation of enrichment for reptiles in zoos. *J Appl Anim Welfare Sci*. 2019;22(1):69-77. DOI: 10.1080/10888705.2018.1490182.
- [6] Shieh MD, Chen CN. Based on environmental value to discuss the effect of product design attitude on purchase intention. *Ekoloji*. 2018;27(106):1047-53. Available from: <http://www.ekolojidergisi.com/article/based-on-environmental-value-to-discuss-the-effect-of-product-design-attitude-on-purchase-intention-5391>.
- [7] Zhao J. Design and implementation of geo-spatial information technology in marine ecological environment monitoring. *J Coastal Res*. 2018;(83 (10083)):50-6. DOI: 10.2112/SI83-009.1.
- [8] Wang F, Wong CS, Chen D, Lu X, Wang, F, Zeng EY. Interaction of toxic chemicals with microplastics: a critical review. *Water Res*. 2018;139:208-19. DOI: 10.1016/j.watres.2018.04.003.
- [9] Wang P, Tian X, Peng T, Luo Y. A review of the state-of-the-art developments in the field monitoring of offshore structures. *Ocean Eng*. 2018;147:148-64. DOI: 10.1016/j.oceaneng.2017.10.014.
- [10] Liu K, Liu R, Liu Y. A tailings pond identification method based on spatial combination of objects. *IEEE J Selected Topics Appl Earth Observations Remote Sensing*. 2019;12(8):2707-17. DOI: 10.1109/JSTARS.2019.2904297.
- [11] Wu H, Jones LO, Wang Y, Shen D, Liu Z, Zhang L, et al. High-efficiency gold recovery using cucurbit [6] uril. *ACS Appl Mater Interfaces*. 2020;12(34):38768-77. DOI: 10.1021/acsmi.0c09673.

-
- [12] Zhao C, Zhou J, Yan Y, Yang L, Xing G, Li H, et al. Application of coagulation/flocculation in oily wastewater treatment: A review. *Sci. Total Environ.* 2021;765:142795. DOI: 10.1016/j.scitotenv.2020.142795.
- [13] Wang J, Wei X, Guo Q. A three-dimensional evaluation model for regional carrying capacity of ecological environment to social economic development: Model development and a case study in China. *Ecol Indic.* 2019;89:348-55. DOI: 10.1016/j.ecolind.2018.02.005.
- [14] Zhao Y, Yang J, Ma S, Zhang S, Liu H, Gong B, et al. Emission controls of mercury and other trace elements during coal combustion in China: a review. *Int Geol Rev.* 2018;60(5-6):638-70. DOI: 10.1080/00206814.2017.1362671.
- [15] Luo S, Liu Y, Zhu Y, Niu Q, Cheng M, Ye S, et al. Perspectives on palladium-based nanomaterials: green synthesis, ecotoxicity, and risk assessment. *Environ Sci: Nano.* 2021;8(1):20-36. DOI: 10.1039/D0EN01048K.
- [16] Wang Z, Zhang Y, Yin J, Yang Y, Luo H, Song J, et al. A novel camphor-based “turn-on” fluorescent probe with high specificity and sensitivity for sensing mercury(II) in aqueous medium and its bioimaging application. *ACS Sust Chem. Eng.* 2020;8(33):12348-59. DOI: 10.1021/acssuschemeng.9b07843.
- [17] Wong WC, Cheung CS, Hart GJ. Development of a quality assessment tool for systematic reviews of observational studies (QATSO) of HIV prevalence in men having sex with men and associated risk behaviours. *Emerg Themes Epidemiol.* 2008;5:1-4. DOI: 10.1186/1742-7622-5-23.
- [18] Wang D, Wu T, Zhao L, Mu C, Li R, Wei X, et al. A 1 km resolution soil organic carbon dataset for frozen ground in the Third Pole. *Earth System Sci Data.* 2021;13(7):3453-65. DOI: 10.5194/essd-13-3453-2021.
- [19] Lu S, Liu Y. Evaluation system for the sustainable development of urban transportation and ecological environment based on SVM. *J Intelligent Fuzzy Systems.* 2018;34(2):831-8. DOI: 10.3233/JIFS-169376.
- [20] Wu VCS. The geography and disparities of community philanthropy: A community assessment model of needs, resources, and ecological environment. *VOLUNTAS: Int J Voluntary Nonprofit Organizations.* 2014;32(2):351-71. DOI: 10.1007/s11266-019-00180-x.
- [21] Tian F, Lu Y, Hu H, Kinzelbach W, Sivapalan M. Dynamics and driving mechanisms of asymmetric human water consumption during alternating wet and dry periods. *Hydrol Sci J.* 2019;64(5):507-24. DOI: 10.1080/02626667.2019.1588972.
- [22] Wu CH, Tsai SB, Liu W, Shao XF, Xia YK, Waclawek M. Green environment and sustainable development: methods and applications. *Ecol Chem Eng S.* 2021;28(4):467-70. DOI: 10.2478/eces-2021-0030.
- [23] Liu W, Tsai SB, Wu CH, Shao X, Waclawek M. Corporate environmental management and sustainable operation: theory and application. *Ecol Chem Eng S.* 2022;29(3):283-5. DOI:10.2478/eces-2022-0020.