Research Paper

RESEARCH ON STRATEGIES OF LOW-IMPACT URBAN DESIGN IN CHINA

Take Beijing waterfront urban design evaluation as an example

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Abstract

This paper aims to provide theoretical method support and practical experience for creating environment friendly urban space by low-impact urban design methods, and discussed on two aspects of theory and practice.
Firstly, the definition of low-impact urban design in the context of Chinese cities is expounded by combing the development stage of urban design environment view and analysing the development needs of Chinese cities. Then, it discusses the framework content and evolution process of low-impact urban design in China, and puts forward the view that low-impact development elements and low-impact design control elements are mutually dependent and mutually reinforcing. Next, the objects and related characteristics of low-impact urban design are explained from multiple perspectives, as object system, object composition and basic characteristics. Relevant strategy formulation is the focus of this paper. First, it is necessary to establish a low-impact urban design system in coordination with legal planning, so as to help implement the low-impact design concept with the seriousness and execution of legal planning. Secondly, the framework of low-impact urban design control elements including 5 different layers is established, which can effectively evaluate and optimize the impact of design results on the city. Thirdly, the value evaluation mechanism of dynamic cycle is proposed, which is helpful to the implementation of low-impact urban design and the restoration of design intention. Finally, the paper takes Beijing waterfront urban design evaluation as an example to apply the low impact evaluation model proposed in this paper, and satisfactory results were obtained.

Keywords

Low-impact urban design, urban design, strategy, China

In recent years, global climate change had brought severe test to the living environment development, the city both responsible for climate change, but also slow down the crisis. China is one of the world's most active countries on the exploration and construction of low-impact urban design. Low-impact construction represents China’s commitments to international community about energy-saving and carbon emission reduction, also in line with the national strategy of ecological civilization construction and urban development

trend in the future. In the context of such research, the innovation need for method and theory of Low-impact urban design was even more necessary and urgent.

Low-impact urban design described in this study is based on the ecological urban design strategies, to address the complexity and uncertainty issues, which generated in the process of construction and development of Chinese cities. And build the pattern framework with sustainable characteristics based on the view of flexibility and adaptability, which does not adhere to the traditional urban design processes or programming, instead combining flexibility with sustainable design actions to be applied to different urban spaces.

1. The definition of low-impact urban design

1.1. The evolution of environmental view of urban design

The definition of "environment" here refers to the totality of various natural and social factors surrounding the space of people and which can directly or indirectly affect human life and development. While "environmental view" refers to the sum of people's views and concepts on the environment itself. Stern & Dietz divides environmental values into three levels as self-centred values, human-centred values and ecology-centred values. There is a progressive relationship among the three different levels, the ecology-centred values are the most advanced and most in line with the development concept of low-impact urban design. In the course of its development, the environmental view on space, nature and human value of urban design are constantly changing, and different views have been generated along with this process. Based on the principle of time division, the evolution process of environmental value of urban design is summarized below. (Figure 1)

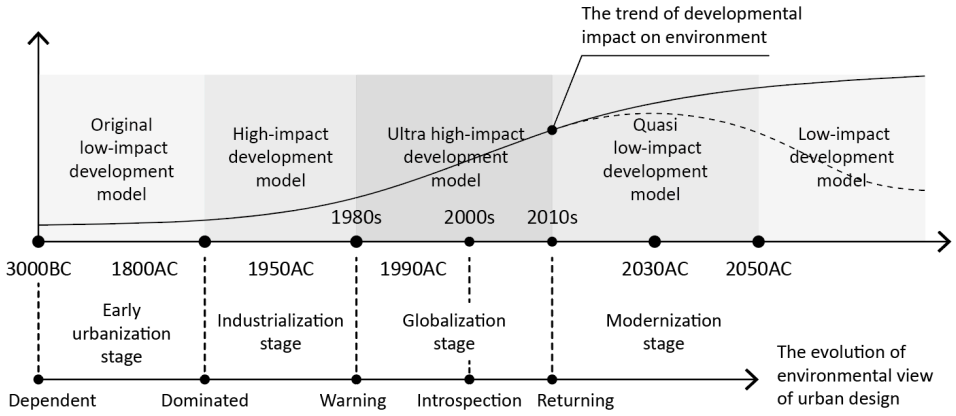


Figure 1 The evolution process of environmental value of urban design

It can be seen from the figure that the environmental view of urban design has gone through four stages: original low-impact development model, high-impact development model, ultrahigh-impact development model and quasi low-impact development model. In the early urbanization stage, the city adopted a simple and primitive low-impact development mode, which was under the control of social productivity. Subsequently, the rapid development of industrialization led to the high-impact urban development mode. At this stage, the environmental view was mainly manifested as the dominant use of natural environment and resources. At this time, the theoretical circle had begun to sound warnings about the adverse impact of urban development on the natural environment. After the city into the

stage of globalization, as a result of the social productive forces rapid ascension, urban development impact on natural environment reached unprecedented heights, the emergence of a large number of urban problems prompted scholars and urban managers a reflection, exploration eco-friendly concept of urban development and urban design theory is urgently needed. At the beginning of the 20th century, the urban development mode represented by low-impact development has been recognized globally. Specifically, the impact curve of urban development on the natural environment has been moderated and decreased, providing a good expectation for the ultimate realization of low-impact urban development mode.

1.2. The definition of low-impact urban design in China

In the past 30 years, China has experienced an unprecedented process of rapid urbanization, realizing the development achievements of developed countries that took nearly a century to achieve. On the one hand, rapid urbanization has greatly improved China's social economy and people's living standards. On the other hand, the high-impact development mode represented by serious irreversible damage to the natural environment is also constantly interrogating the conscience of urban managers. Therefore, in recent years, the low-impact urban design concept represented by green urban design and eco-oriented urban design has been widely recognized and applied in China, and has accumulated considerable theoretical and practical experience.

Low-impact urban design is a new urban design concept with green urban development theory as the background, natural ecological system as the support, human behaviour as the leading, spatial form design as the means, advanced technology as the support, implementation and evaluation as the guarantee, and spatiotemporal continuation as the purpose.

Specifically, low-impact urban design is under the background of global climate change, and to the environment, energy, ecology and other related disciplines theory as a guide, in-depth study of urban space environment and the internal interaction between urban construction activities, and in view of the urban form evolution and low impact development issues, the relationship between dimensional specified in the theoretical basis and practical level of strategies, methods and evaluation system. So as to promote the formation of ideal low-impact urban development mode, and creates a social practice process of urban space environment in harmony with the climate environment protection, ecological system growth and high-quality public life.

2. The connotation interpretation of low-impact urban design

2.1. The framework of low-impact urban design

"The interaction between human and environment" has always been the focus of urban design and the practical basis of low-impact urban design. The so-called "environment" refers to the overall space of people and various natural and social factors that can directly and indirectly affect human life and development. As a realistic system and basic framework of citizen life, urban physical space environment should include artificial environment, natural environment and the interaction between the two parts.

Low-impact urban design is based on the understanding that urban space environment can support and guide human behaviour. "Natural environment -- human activities – artificial environment" has also become the main line of methodological framework to exert the values of low-impact urban design. It should be noted that since city is a complex giant system, the structural mitigation effect of urban design on the impact of urban construction on the natural environment is often difficult to be quantified and ignored as an indirect path. But in fact, urban design can achieve the goal of comprehensively reducing the impact of urban development on the natural ecology from the perspective of reducing the overall space energy consumption demand, improving the overall space ecological quality, and promoting the human activities efficiency.

Therefore, follow the main line, low impact urban design research should further to the relationship among human, artificial and natural elements under the background of climate change. (Figure 2) As well as its mechanism of integrated influence on urban system.

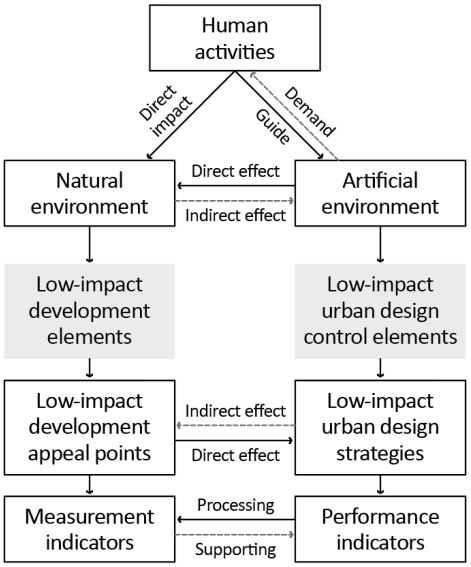


Figure 2 The evolution process of environmental value of urban design

2.2. The objectives of low-impact urban design

The establishment of the objective framework of low-impact urban design plays an important guiding role in the practice process and is the internal power throughout the whole process of urban design. The following will be discussed on the strategic level of the goal composition.

The strategic level goal of low-impact urban design is to help mitigate climate change and promote sustainable development of human settlements. Sub-goals are decomposed into three aspects:

(1) Promote the development of low-impact economic structure: urban design can combine new economic structure, logic of green development, ecological security pattern, energy-saving building technology, clean and efficient energy to create opportunities for new growth points of low-impact economy.

(2) Promote the formation of low-impact social order: urban design can create an environment and opportunities for residents to change their lifestyle through form design

and public participation, so as to facilitate the formation of a low-impact economy-oriented consumer society.

(3) Promote the coexistence of human and nature: urban design can protect natural resources and environment by exploring the development of settlements with the lowest energy intensive lifestyle.

2.3. The basic characteristics of low-impact urban design

Low-impact urban design is built on the basis of ecological civilization. Its essence is to integrate various natural elements and urban system components into the overall environmental system, and discuss how to achieve the liveability of urban environment and the efficiency of urban operation under different resource endowment conditions. Its basic characteristics mainly include four aspects as following.

(1) Systematic features Low-impact urban design advocates to re-examine the traditional linear planning mode, pay equal attention to the material and non-material attributes of the environment, and grasp the overall relationship of the system from the mutual connection of various components. The integral control of urban design on spatial form is not a simple superposition of various low-impact design elements. Instead, it aims to improve the operation efficiency of urban systems, reduce urban internal consumption and environmental damage, and ultimately achieve the symbiosis between human and nature.

(2) Operational features Low impact urban design has stronger target orientation and operability, and the related concepts are easier to be implemented and put into place. It has high operability that can be copied and promoted. The concept of "low impact" is permeated into various spatial scales and operational levels to test the effectiveness of the design results. Specific performance for the stage development expectations, measurable technical indicators, verifiable evaluation system.

(**3) High efficiency features** Low energy consumption, low pollution, low emissions and high performance, high efficiency and high benefit are the characteristics and direction of urban development in China, the Chinese academy of sciences points out in its China's sustainable development strategy report. To some extent, low-impact urban design is essentially a kind of "high-efficiency urban design", which follows the principle of minimum loss and minimum impact, improves the urban physical environment through natural regulation, pays attention to the climate protection effect of the ecosystem, and reduces the negative impact of human activities on the environment as much as possible. In short, one of the important features of low-impact urban design is to attach importance to the rationality of resource utilization, and to obtain the maximum economic, social and environmental benefits with the minimum input.

(4) Circularity features Circularity is the internal mechanism of natural ecosystem with strong vitality. Low-impact urban design should also combine the "circulation law" of the ecosystem to establish the feedback mechanism and material exchange mode between urban space and environment, so as to reduce the impact of construction activities on the natural environment to the smallest extent possible. It includes reduction of resource input, reuse of process maintenance and recycling of resource output. It can be seen that the focus of low-impact urban design should shift from functional design to resource-oriented design to reduce the adverse impact of urban activities on the natural environment and improve the self-sufficiency of the city.

3. The strategies of low-impact urban design

3.1. Compilation process in line with the statutory planning system

In the relationship between low-impact urban design and statutory urban planning, urban planning focuses on studying the functional combination of urban land use, comprehensively coordinating the development of economy, society and engineering technology, and seeking the comprehensive balance of social, economic and environmental benefits. The research field of low-impact urban design focuses on the interaction effect between urban natural environment and artificial environment, mainly to solve the disturbance of urban physical space and human activities on the natural environment, and its core content is to use the theoretical methods of related disciplines to create an efficient and high-quality urban environmental space.

Low impact urban design because of its lack of legal status, cannot be directly used to guide the implementation and planning management work, but as a research method and analysis process can also be throughout the whole process of urban planning. (Figure 3) It is coordinated with all levels of planning in time axis and space scale, which provides a model foundation for constructing a collaborative platform. Judging from the revision process of urban and rural planning laws and regulations in China and the implementation of local regulations, it is difficult to solve the demand of urban design legal status and regulatory effectiveness in a short term by means of legislative approach. Therefore, it is a reasonable choice to translate low-impact urban design achievements into legal planning system by means of "planning translation". By compiling multi-level urban design results to comply with the statutory planning system. The core control elements in the design results are reflected in the planning provisions, restrictive descriptions, prescriptive or guiding indicators at the certain level and taken as the basic conditions for the preparation of the sub-level, so as to strengthen the guiding and regulating role of urban design in the city construction project.

3.2. Establish low-impact urban design control elements framework

The element is the essential factor that makes up the thing, also is the basic unit that makes up the system. Combining with the low-impact urban design factors affect the mechanism of decomposition is analysed and related reference, this paper presents the "low-impact urban design control elements 5 layers framework" composed of the ecological impact layer, space impact layer, demand impact layer, economic impact layer and the aesthetic impact layer. It should be noted that the control elements of low-impact urban design are the selection and reconstruction of traditional urban design elements from the perspective of promoting urban operation efficiency in the context of climate change. Irrelevant or weakly correlated elements are not considered in this paper. (Figure 4)

(1) Ecological impact layer The impact of urban construction and human activities on the natural environment and natural resources was emphasized, and more attention was paid to the content of low impact on the macro-ecological security system and the original structural characteristics.

(2) Space impact layer This layer focuses on the physical form and spatial quality of urban physical space, and how to reduce the impact on urban operation state under the premise of developing corresponding contents, including urban infrastructure sub-layer, road traffic network sub-layer, urban block and open space sub-layer.

(3) Demand impact layer As the decision-maker and executor of urban construction behaviour, human is the ultimate decisive force of low-impact development. How to realize the vision of low-impact urban design under the premise of meeting the usage demand and spiritual demand of the citizen is the focus of this layer.

(4) Economic impact layer Economic development is one of the fundamental missions of cities, and low-impact urban design also needs to pay attention to this aspect. It includes the adjustment of urban economic structure, the improvement of comprehensive land value and the improvement of urban operation efficiency, and the supply of resources and services.

(5) Aesthetic impact layer The aesthetic demand of city is an inevitable product of urban development to a specific stage. As a new urban development concept, low-impact urban design inevitably contains the content of aesthetic thinking, which also proves from the side that the spiritual appeal of urban activity participants is one of the fundamental driving forces of urban evolution.

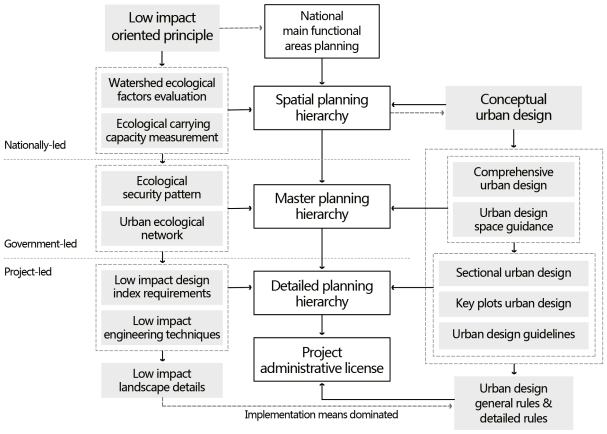


Figure 3 Coordination mechanism between low-impact urban design with statutory planning

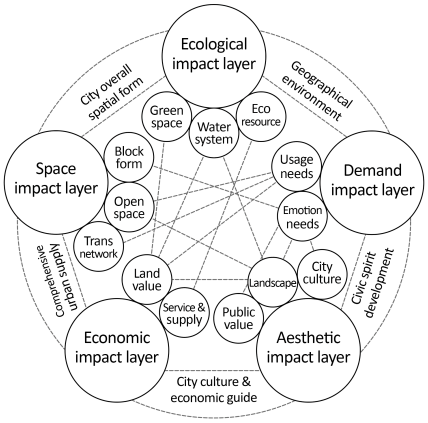


Figure 4 Low-impact urban design control elements framework

Specifically, in order to ensure the integrity and effectiveness of the proposed framework structure, it should have the following characteristics.

(1) Hierarchy The framework of low-impact assessment elements deconstructs the influencing elements according to the progressive collection of elements, and each layer is composed of its own sub-elements to form a hierarchical element system framework.

(2) Structural Refers to the system independent of each other in proportion to a certain structure, and to a large extent determine the nature of the system. The levels of low-impact elements are complete and independent. After superimposed, the links among subsystems are emphasized to form a tower-like element correlation structure together with human activities, which determines the comprehensive performance of low-impact urban design as a whole.

(3) Heterogeneity Refers to the different status and function of the same element in different subsystems. Each level of the low-impact evaluation system has its own emphasis on the impact of the city, and the evaluation period is also different. The layered setting is convenient to discuss the effect and potential of each level more clearly, and also helpful to provide reference basis for the design organization, management and maintenance.

3.3. Dynamic evaluation mechanism of low-impact urban design

City itself come from the continuous accumulation of urban design implementation. The results of implementation at this time must be updated at a future point by the ongoing impact of human activities. However, the results accumulated through the passage of time will gradually accumulate into the urban design gene of the city, which will lead the iteration of the city development for a long time. In addition, the mutual attraction and consciousness between people and cities can be established by this gene, and eventually become part of the public values of the city.

The practice of low-impact urban design in China has long been focused on design but neglected implementation. This static urban design system is unable to timely and effectively foresee and adjust the unreasonable aspects in the design results due to the characteristics that its action factors are difficult to be separated. After its implementation and operation in the physical space, it will be modified postemptively and passively, resulting in multiple wastes of planning resources, construction resources and development time.

The logic of circular evaluation of low-impact urban design refers to by the whole cycle process is decomposed into preparation sub circulation as decision-making, implementation, evaluation, adjustment. Then the connotation behaviour of each sub circulation is logically disassembled, and the implementation effect of the sub-cycle is continuously evaluated and monitored. The obtained results are injected into the starting point of each sub-cycle to determine whether there is an update or adjustment demand, so as to realize the dynamic optimization goal of the whole process of low-impact urban design results. (Figure 5)

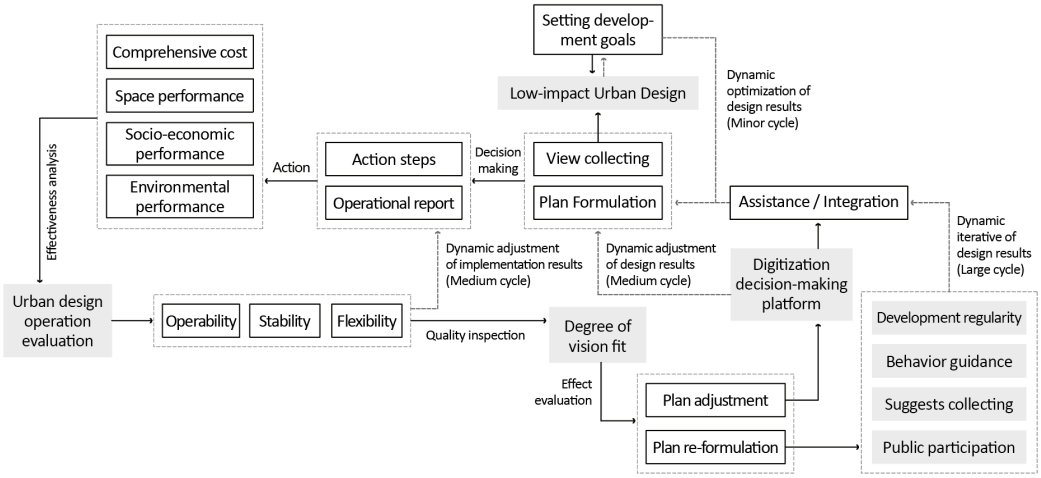


Figure 5 Dynamic evaluation mechanism of low-impact urban design

From a neutral perspective, resource effectiveness, internal and external effectiveness and ecological effectiveness are the evaluation conditions of the implementation vision of low-impact urban design. In addition, it tries to reach a relative consensus under the background of multi-value subjects of the government, the market and the people, so as to guide and adjust the action plan and connotation of urban design, generate sensible spatial results, and conclude the "reincarnation way" of low-impact urban design through deduction.

4. Exploration on low-impact urban design application

4.1. Introduction of Beijing waterfront space

As a world-famous ancient cultural capital, Beijing has a history of over 3,000 years, the water conservancy construction in Beijing is closely related to urban construction. And its waterfront urban design research is also an important part of the implementation of Beijing's overall low-impact urban design, which has a high research value.

Beijing water system was constructed in the Jin Dynasty and then completed in the Yuan Dynasty. After the utilization and development of Ming and Qing dynasties, a complete system and complete function water network was formed. Since the founding of the People's Republic of China, the urban functions of Beijing water system has gradually degraded in the context of large-scale city expansion. A large number of water system has lost their original functions of grain transport, irrigation and defence, and even the royal river channels supplying water for imperial gardens were not entitled to special status any more. Many natural river channels and ponds were straightened with curves cut off, and thus formed into artificial drainage river channels during this period. (Figure 6, 7)

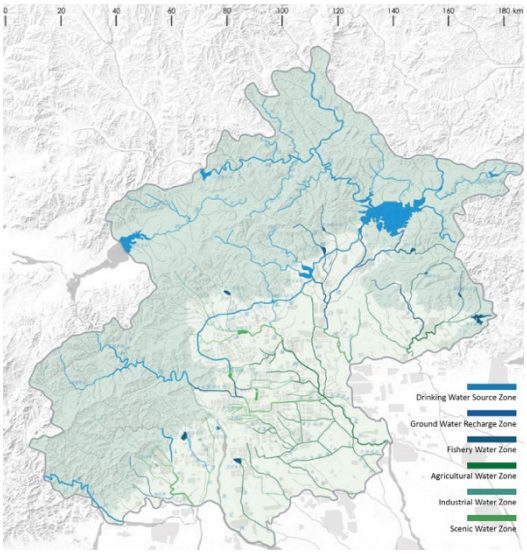


Figure 6 Water function layout plan of Beijing waterfront space

Figure 7 Satellite data of Beijing central city waterfront network

It can be seen that the development course of Beijing water system in recent years is not in line with the concept of low-impact urban development. Excessive intervention of artificial behaviour has greatly damaged and weakened the original form and natural properties of urban water body, which remains to be solved. Therefore, the research on low-impact urban design of Beijing waterfront area is helpful to restore the natural properties and functions of water bodies to some extent, alleviate various problems caused by urban construction activities, and improve the ecological elasticity of space and the value of natural supply.

4.2. Evaluation of Beijing waterfront space

The core objective of Beijing waterfront space urban design is, based on the relationship of city and river, to analyse how water impacts ecological environment, urban space and public life in the circular and metabolic process. The project will be developed from the following research perspectives and evaluation framework with synthetic weight. (Table 1)

(1) Landscape pattern perspective Geographical position and topography precipitation in Beijing is characterized by uneven space-time distribution, and dry and wet seasonal alternation. Given hydrological features and distribution of hydraulic facilities, an ecological design principle of regulating the dry and wet season is provided to guide the low-impact oriented waterfront space design.

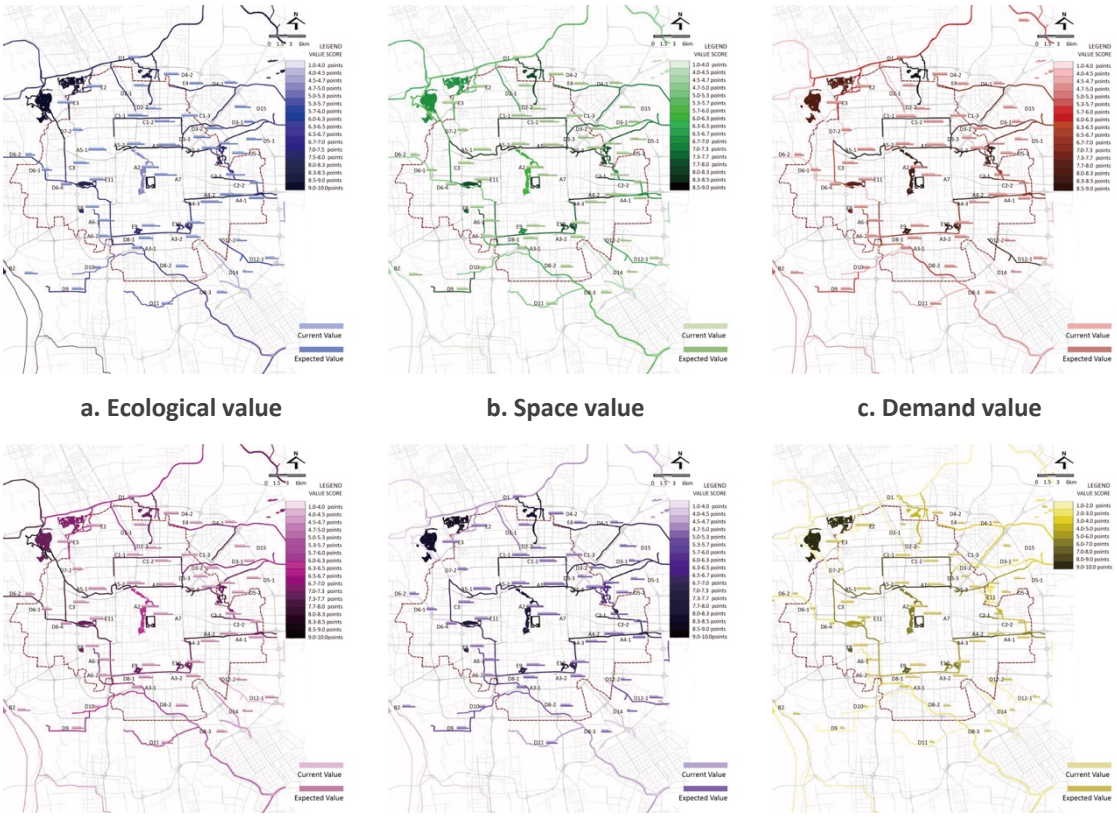
(2) Behavioural requirements perspective Due to the water supply security as the main function of the water network in Beijing, there is little room for public activities within the river channels. According to people's utilization requirements of the waterfront space in different seasons, space for urban water utilization and public activity is integrated, and regulation suggestions are proposed in order to improve environmental quality of waterfront space.

(3) Administrative implementation perspective According to impacts of city evolution on the water system distribution in modern times, multi-department coordination and management mechanism and pertinent design guideline are proposed based on the duty of each relevant urban administrative and institutional body.

Table 1 Evaluation elements and synthetic weight of Beijing waterfront urban design

FIRST CLASS	SECOND CLASS	SYNTHETIC WEIGHT	INDEX LEVEL	WEIGHT
ECOLOGICAL IMPACT LAYER	WATER	0.368	WATER QUAILTY	0.318
			WATER QUANTITY	0.417
			GROUNDWATER	0.285
	GREEN	0.510	CATEGORY	0.059
			RATIO OF GREEN SPACE	0.392
			CORRIDOR WIDTH	0.305
			DEGREE OF FRAGMENTATION	0.124
			RATIO OF WATER TO GREEN	0.120
	CREATURE	0.120	DIVERSITY	0.580
			HABITAT	0.419
SPACE IMPACT LAYER	INTERFACE	0.490	WATER QUAILTY	0.130
			BUILDING FACADE	0.130
			BUILDING SCALE	0.155
			WATER FRONT	0.280
			OPEN SPACE	0.307
	WATER FRONT	0.282	STYLE OF WATER	0.331
			GRADIENT OF WATER FRONT	0.136
			MATERIAL OF WATER FRONT	0.531
	TRANSPORTATION	0.286	EXTERNAL TRANSPORT	0.410
			INTERNAL TRANSPORT	0.427
			WATER TRANSPORT	0.161
DEMAND IMPACT LAYER	USAGE NEEDS	0.547	ACCESSIBILITY	0.220
			INVOLVEMENT	0.160
			BEARING CAPACITY	0.280
			RICHNESS	0.161
			CONVENIENCE	0.180
	EMOTIONAL NEEDS	0.450	SENSE OF SECURITY	0.250
			BELONGING	0.348
			PRIVACY	0.140
			SENSE OF PLACE	0.270
	HISTORY VALUE	0.120	HISTORY	0.120
ECONOMIC IMPACT LAYER	SUPPLY	0.343	INDUSTRY WATER SUPPLY	0.280
			DOMESTIC WATER	0.430
			AGRICULTURE WATER	0.318
	SERVICE	0.288	STORE FLOODWATER	0.427
			PURIFY	0.573
	ADDITION	0.370	LAND PRICE	0.170
			BUILDING DENSITY	0.340
			COLLOCATED FUNCTION	0.380
			LABOR	0.110
AESTHETIC IMPACT LAYER	CULTURE	0.580	GEOGRAPHICAL FEATURE	0.384
			HISTORICAL MEMORY	0.289
			SYMBOL	0.237
	NIGHTSCAPE	0.120	SYSTEMATIC	0.453
			IDENTIFICATION	0.550
	LANDSCAPE	0.318	OPTIC CENTER	0.399
			COLOR MATCHING	0.240
			FACILITY CHARACTERISTIC	0.380

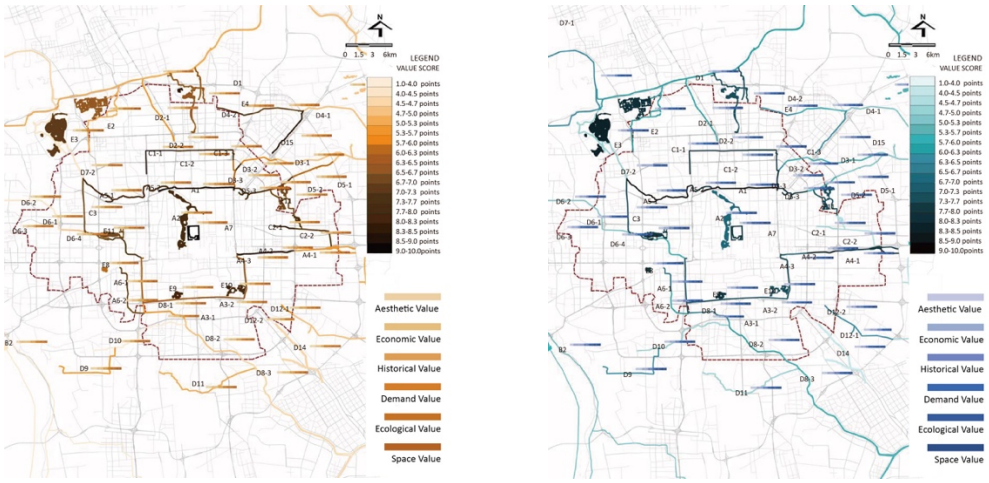
Combine the related survey data with the low-impact design vision, at the same time, based on the evaluation layer system and weight factors listed in table 1. The ecological value, space value, demand value, economic value, aesthetic value, historical value of Beijing waterfront space urban design has carried on the quantitative analysis, the result is shown in figure 8 and figure 9. The information shown in the figure relatively objectively shows the current situation, characteristics, needs and other content characteristics of Beijing waterfront space, and can effectively guide the following low-impact urban design work.



a. Ecological value b. Space value c. Demand value

d. Economic value e. Aesthetic value f. Historical value

Figure 8 Evaluation of sub-layer of Beijing waterfront space



a. Current comprehensive value b. Expected comprehensive value

Figure 9 Current and expected comprehensive value of Beijing waterfront space

5. Conclusion

In the development process of low-impact urban design, the interactive extension of ideas, entities, time and people makes the city in constant evolution, showing colourful vitality in a flexible way. Admittedly, this direction is still in the exploratory stage in China, and a set of universal experience and methods have not been summarized yet. Although the multi-dimensional integration concept and mode framework described in this paper does not become a common value orientation and criterion in the field of low-impact urban design, it can also be regarded as a positive attempt.

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