Study on the Framework of Water Environment Layer in Urban Layer System

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Abstract
Many city issues have emerged during city development and environmental changes, which mostly are due to the weak organization among city elements, therefore affecting the city physical spatial morphology. Urban design therefore should comb the relationship among city elements. The contemporary urban design has additionally had the research in elements in recessive ecology, culture and civilization while the traditional urban design focuses on the external elements of city physical space. The era of big data, meanwhile, provides a large amount of data information about them. Urban design, as a kind of graphic language, should combine the graphic information with data information. In this paper, the concept of urban layer is proposed to determine its characteristics and content with an attempt to comb and integrate city elements using urban layer system. And the superposition of urban layers is also applied to analyze how urban elements affect city spatial morphology .
The key of this paper lies in the urban water environment layer in urban layer system with the structure of urban water environment layer. Based on the comb and summary of the existing urban design theories related to urban geography and water, the relevant elements and urban maps, which affect urban design, are selected, extracted and integrated to establish the framework of urban water environment layer and its content and elements.
Beijing, as the capital of China, has drawn worldwide attention in its construction. In this paper, environment layer in urban layer system is initially applied in general urban design projects of Beijing waterfront. The author has tried to guide urban spatial morphology and urban design project of Beijing waterfront through the analysis, comb, superposition and research of waters and waterfront water environment within Beijing downtown area.

Keyword
urban design; urban layer; urban water environment layer; Beijing City; waterfront urban design

1. Introduction

1.1 The focused research of urban connotation in contemporary urban design

The traditional urban design theory focuses on studying the urban spatial form. However, contemporary urban design is not only a study on the dominant urban physical space, and also studies the recessive urban ecological environment, urban cultural connotation and human needs. So that, it can make urban design more comprehensive.
City internal recessive attributes directly or indirectly affect the external urban spatial morphology. Urban design therefore should comprehensively consider the elements in each level, which affects urban development, with the analysis, research and integration. urban layer research framework of urban design is established to clearly comb each level, elements and their inner relationship ,which affect urban design.

1.2 Problems of relationship organization among urban elements

As city develops and environment changes, many city issues and contradictions have appeared. For instance, city construction has led to water depletion and urban ecological environment deterioration has caused microclimate issues. Many city issues are mostly due

to the weak organization among city elements, therefore affecting the city physical spatial morphology. Urban design therefore should comb the relationship among city elements. Urban layer system framework is therefore established to analyze the specific content of elements, affecting urban design, and the dominant and recessive relationship between them, as well as the influence on urban physical space from urban elements, single superposition or superposition of multiple layers.

1.3 Combination of graphic and data urban design

As a graphic language, urban design is expressed and controlled through different types levels of diagrams. Because of the era of big data, many scholars from different areas have studied various urban maps by using data and urban geographic map, such as, urban climate map, urban block map, citizen ideology map, urban noise map, and so on. urban layer system is established to integrate all urban data, maps, elements, and layers so that data, information and graphic language can be more used systematically in urban design.

2. Urban design and urban layer system

2.1 urban layer and urban layer system

Urban layer refers to the elements and relationship among them in the city, such as physical space, ecology, economy and humanity. It includes the visual dominant information and hidden information of each urban element, a dynamic information carrier. Each urban layer is composed by certain elements. These layers constitute the entire urban layer system through the superposition. Each layer in layer system is a certain relatively independent variable, which may be relevant to other variables and can be shown in layer groups according to different requirements.

Urban layer system covers all kinds of elements which affect urban spatial morphology, which is controlled by each element of the city through the superposition of layers. In urban design, it's can be found how single urban layer or multiple urban layers affect urban physical space. The influence of urban layers on urban design can be single or overlapped.

2.2 Urban layer and urban subject map

Urban subject map is a graphic language which can perfectly display one or several urban natural or social elements, an map with specific content, such as urban functional zoning map and map of urban underground pipes. In urban design, urban subject map is a visualized urban element or geographical information carrier of a group elements, which express the instantaneous information, static information and visible relationship of this element or groups. It is the geographical identification of this element or groups in urban layer. In additional to the visible relationship from the urban subject map, urban layer also includes the hidden recessive relationship within or among elements, indicating the collection of urban subject map and internal relationship.

Urban subject map, as a collection of one or a group of elements of urban layer, is the graphic expression of its information relationship, which is usually show in urban geographical map for the convenient of analysis, superposition of layers and guidance for urban design project. Urban subject map may be specific only for one certain urban layers, not all urban layers.

2.3 Urban layer system and urban subject atlas

Urban subject atlas, as a kind of information evaluation tool, integrates geographical distribution, analysis and planning recommendation of one urban subject element. The conditions and relevant issues of one urban element are shown on two dimensional map, visualizing urban element information. Urban planners can easily obtain relevant urban element information through urban subject atlas and make right evaluation together with city land use and city development trend. Ultimately urban subject atlas could provide guidance for the practice of urban planning.

Comparing with the existing urban subject maps, urban subject atlas also include the analyzed map and planning recommendation map of the elements. Such as, the existing urban climate atlas contains urban maps of elements related to urban climate, urban climate analysis map, urban climate planning recommendation map. All maps are drawn on the basis of urban geographical maps.

Urban layer system include several urban subject atlas as well as the recessive relationship and dynamic changes among all the urban subject atlas. It's more complex in dimensions and relationships than two dimensional urban subject atlas. Figure 1 shows the relationship among urban elements, urban subject map, urban subject atlas, urban layer and urban layer system.

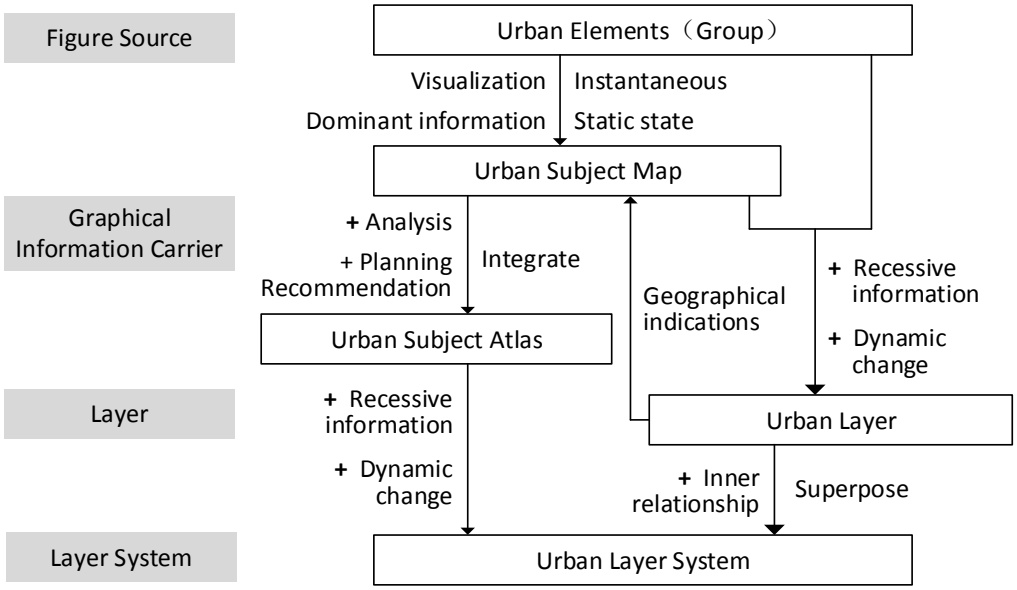

Figure 1: The relationship among urban elements, urban subject map, urban subject atlas, urban layer and urban layer system

Figure sources: drawn by author.

3. Multiple dimensional urban layer system

Most of the urban designs in China are vertically spatial planning and design. The temporal dimension usually takes into account of the construction order, namely phase planning of the future development and construction. But urban design should include more dimensions and contents. Urban layer system firstly should include the visible vertical space, which belongs to horizontal dimension and longitudinal dimension. Additionally, some recessive dimension and content should also be concluded. In temporal dimension, urban layer also should consists of the historical evolution rules except for the future development order. Urban space affords citizen life and spiritual demands, which also should include spatial symbolic dimension. So that, urban layer system should be a four-dimensional system. It contains horizontal dimension and longitudinal dimension, which are dominant. And also contains recessive temporal dimension and symbolic dimension, which are recessive (Figure 2).

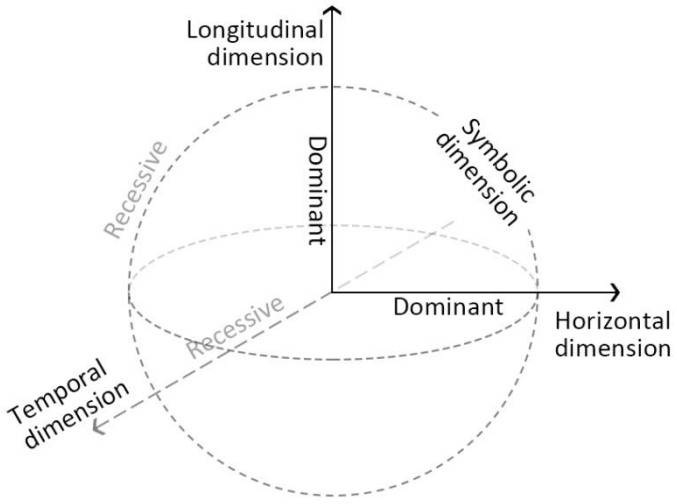

Figure 2: Four-dimensional analysis of urban layer system

Figure sources: drawn by author.

3.1 Horizontal dimension

Urban layer system should corresponds to all kinds of practical urban design projects. In China, urban design is generally divided into 4 levels: comprehensive urban design, district urban design, plot urban design and subject urban design. Urban layer system should consider the macro level, meso level and micro level, so that it can be able to cover all different scales of urban design projects (Figure 3). For different scales of urban design, urban layers and elements are different. Each level of urban layer and elements should have a certain degree of independence, so that they can adapt to the changes of urban design at this level. At the same time, in addition to considering the content of each level separately, it is necessary to link different scales. The layers of each level contain the elements and layers of the next scale, and the layer itself is integrated into a higher level of urban layer system as an element or layer. Urban layer system must be suitable for all types of urban design projects, such as, urban renewal, new district construction, subject urban design and comprehensive urban design, and so on. Every type of urban design project should has targeted selection of urban layers and elements, and they should be selected based on system relationships.

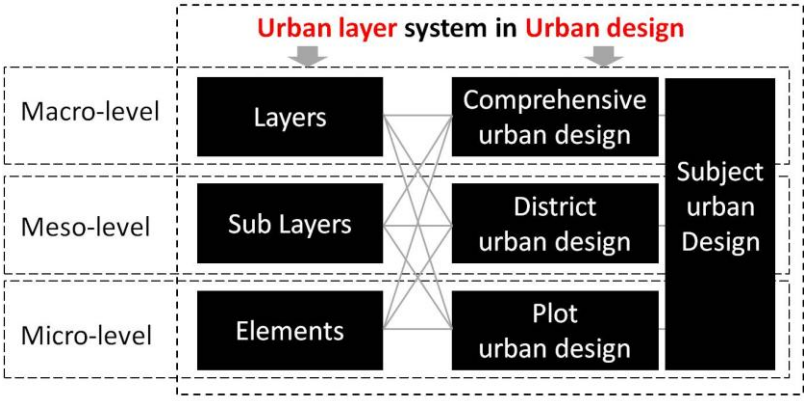

Figure 3: The relationship between urban layer and urban design levels in China
Figure sources: drawn by author.

3.2 Longitudinal dimension

Natural geographical environment of the city is the key aspect to affect urban design, therefore urban layer should consider each longitudinal geosphere, which affects urban design. Within geosphere, earth's crust is mostly close to urban design, which affects urban design through geology, geomorphology, topography, underground resources and geological hazards. Outside geosphere, the close elements include hydrosphere, biosphere and atmosphere (Figure 4). urban layer should consider the relationship between each longitudinal geosphere and urban spatial morphology. In urban layer, hydrosphere should focus on water environment. Biosphere affects urban design through different biological activities. It's emphasized that people's activities are also considered in biosphere in urban layer. The atmosphere should pays attention to the climate conditions in urban layer.

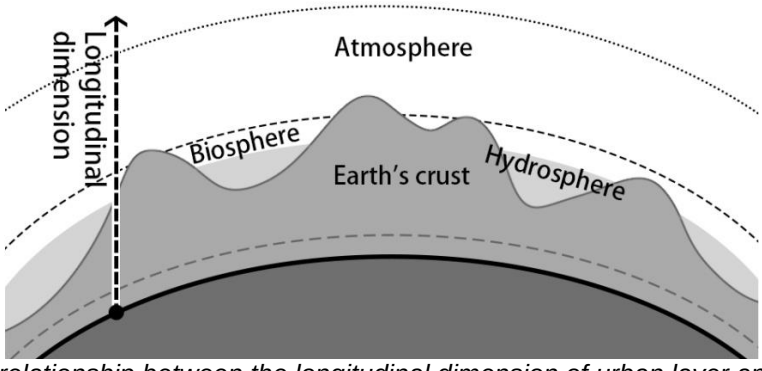

Figure 4: The relationship between the longitudinal dimension of urban layer and geosphere
Figure sources: drawn by author.

3.3 Temporal dimension

City develops gradually and urban layer should be dynamic, which is significantly different from other graphic language of urban design. Without a review to the past, it is impossible to recognize the future. Therefore urban layer should corresponds to the time changes as much as possible. Based on city history, the development rules of the city is combed and analyzed to find out the urban elements and layers with maximized influence on urban physical space as well as determine the dynamic elements. The relationship between single urban layer or element and time changes is discussed. Within several related layers, the changing trend of each layer and changes between layers are also discussed as time changes.

3.4 Symbolic dimension

Urban layer should also consider symbolic dimension besides the common urban physical space, buildings, ecological environment, infrastructure and other entity dimension. The essence of the layer is to express the symbolic information more conveniently through the signs and graphic information. Urban symbolic dimension mainly include sites, citizen's activities and their psychological assessment. Site doesn't develops through city while the city grows up through the site. Site, as meaning space of a city, constitutes most of external space with urban network. Urban layer system physically therefore requires to consider the physical relationship and symbolic connotation of urban sites. Urban design work should include the participants of all the city construction activities beyond the professionals and management staff. Urban design, based on urban geographical images, could express citizen' activities and their psychological assessment more simply, which is convenient to make suggestions to urban design.

4. Establishment of research framework for urban water environment layer

4.1 Idea to build the framework of urban water environment layer

From ancient to modern times, city construction and water are mutually influenced and constrained. Along the timeline of city construction, water is mutually coupled to city siting, development, spatial morphology and function. Urban water environment layer is thus gradually emerged and continuously upgrading as city develops. In urban design, urban water environment layer should be constructed based on the relationship between city and water from ancient to modern times during the city construction period (Figure 5). This paper will starts from city siting, construction and citizen's use and refines corresponding elements. The logic relationship of urban design is applied to integrate urban water environment layers in each period. Beijing waterfront space is taken as an example to further explain urban water environment layer.

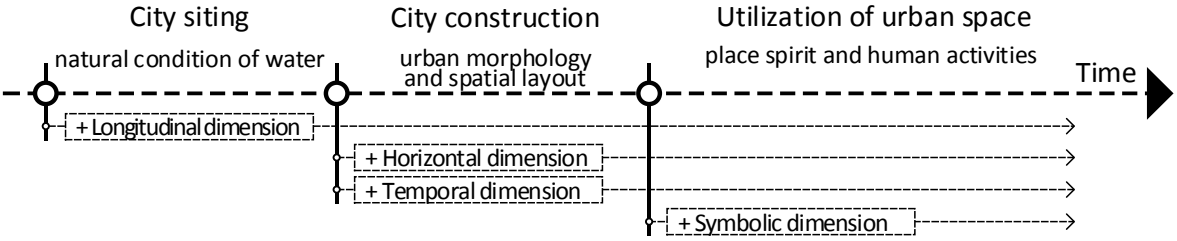

Figure 5: The relationship between urban water layer development and time
Figure sources: drawn by author.

4.2 Water environment layer during city siting period

Water source was undoubtedly the initial consideration when the ancestors decided where to live. Ancient cities almost were built along the water system to use the water conveniently. Water system functions as water source, materials' transportation, farmland irrigation and military defence while also bringing flood disaster and deposition of rivers and lakes. As said in a prose, "Guanzi Chengma", the relationship between water environment and city location is narrated. The capital of a country must be on top of mountain instead of at the foot of it. When living far away from the hills on the high terrain, there is sufficient water and when living far away from the water on the low terrain, there is no need to construct dykes. People

should take advantage of the existing environment and nature, without having to stick to the rules, to further create their own roads. Since humankind's settlement modes and location are related to water source, most of the ancient cities emerged from the water. Water condition will be considered for city siting, which promotes the longitudinal dimension in urban layer (Table 1).

Sphere	**Urban water environment layer**	**Urban design elements**
Earth's crust	Geological conditions	Flood, deposition, freeze and thaw, geological condition for suitable construction
	Terrain and landform	Embankment slope, height, block undulations
Biosphere	Flora and fauna	Vegetation, animals
	People's activities	Water and activities
hydrosphere	Underground water	Location and source of underground water
	Surface water	Water source site, underground basin, flowing direction and water yield
Atmosphere	Water and climate	Temperature, humidity and precipitation

Table 1: Urban water environment layer during the period of city siting
Table sources: drawn by author.

The earliest site for Beijing is Xi, which is the capital of Yan Country (337-370) during the Warring States period. The siting of Beijing City was located on the northwest of the Great Plains of North China, surrounding by mountains on three sides. It's Chexiang River to north and Leishui River to the south, forming a small plains adjacent to the water. Gaoliang River also flowed through the city. This siting mode just accords with the of one water with three mountains in ancient Chinese Fengshui (Figure 6). From the climate environment, Beijing city is one of the areas with most precipitation in North China also with suitable temperature and humidity. In sight of water environment, the underground water reserve of Beijing City is abundant . Water was accessible for digging wells, convenient. The surface water originated from the nearby Yongding River and more distant Chaobai River. All these have affected urban design elements and water environment layer of Beijing City siting.

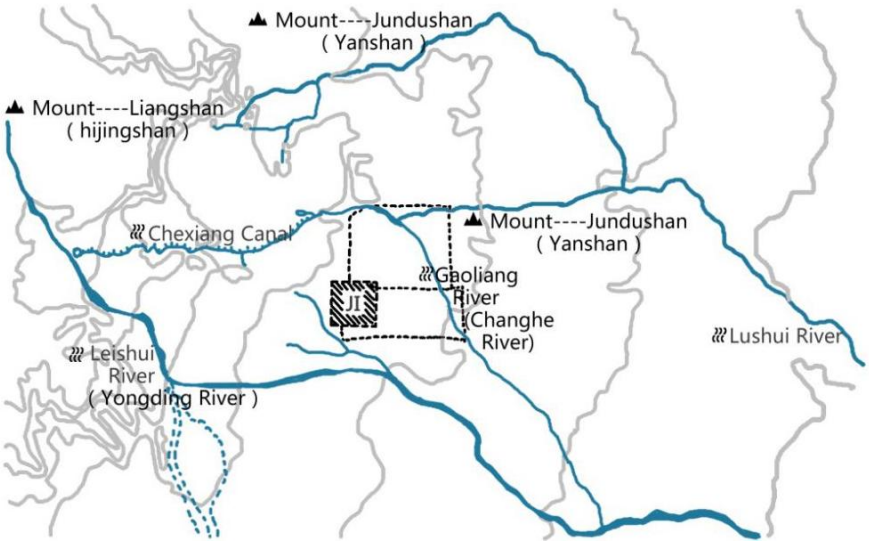

Figure 6: The relationship between Beijing city sitting and urban water layer
Figure sources: drawn by author.

4.3 Water environment layer during city construction period

Comparing with the city siting period, urban water environment has more influence on urban space during the city construction, during which urban water environment layers are mostly related to urban space. In early period, namely the construction process after siting, the influence on urban design from water environment are mainly shown in following aspects. The overall urban pattern is affected from the location of water source, the basin, flowing direction and morphology of the surface water at a macro level. Since urban waters in

different areas function distinctively in the city, the function and morphology layout of urban space surrounding the waters are relatively different as well on the meso level. The morphology pattern of waters and shoreline have affection o the spatial mode and blocks' structure within a certain distance from the waters. Therefore in the urban design of this period, horizontal dimensional urban water environment layers are added.
After city construction, city requirements continuously changes as time proceeds. City will be faced rounds of planning and design and urban renovation. During this long period of urban development, urban water environment will be endowed with corresponding time meaning and historical connotation, namely temporal dimension of urban layer. Therefore urban water system evolution layers and other water environment layers are included in urban design (Table 2).

Dimension	**Urban water environment layers**	**Urban design elements**
Horizontal dimension	General urban design The overall urban water pattern	Ecological security pattern of urban water environment , urban surface water basin, urban groundwater distribution, urban water function
	Zoning urban design level Waters and urban space	Water and urban space layout, water and urban ecological landscape space , water and sight
	Plot urban design level Waters and spatial structure	Block's pattern, waterfront space, shoreline and skyline surrounding water
Temporal dimension	Urban water evolution	Urban water function evolution, groundwater distribution evolution, underground water distribution evolution

Table 2: Urban water environment layers during city construction period
Table sources: drawn by author.

Jin Dynasty (1115-1234) moved the capital to now Beijing City from Chang'an City, which is the capital during Tang Dynasty, becoming Jinzhongdu. Starting from Jin Dynasty (618-907), Beijing City began its city construction. During Jin Dynasty, waters in Beijing City functioned as water supply, flood transportation and flood discharge. The water system pattern was set up for Yongding River and Gaoliang River. With the subsequent construction during each periods, the whole urban water pattern was relatively solid during Ming (1368-1644) and Qing Dynasty (1636-1912) for Beijing City, similar to the that of the current Beijing City.
During city construction, Beijing's waterways also have had certain influence on the whole spatial layout and blocks' spatial structure. The most characteristic of planning of imperial palace is that the water surface was taken as the center to determine urban pattern. The following urban planning for Ming and Qing Dynasty also continued this concept that water is taken to determine the city. Therefore Beijing' central axis and natural waters were complemented during Yuan (1271-1368), Ming (1368-1644) and Qing Dynasty (1636-1912), indicating the integration between urban planning and natural water as well as the urban layout with city adapting to the topography (Figure 7).

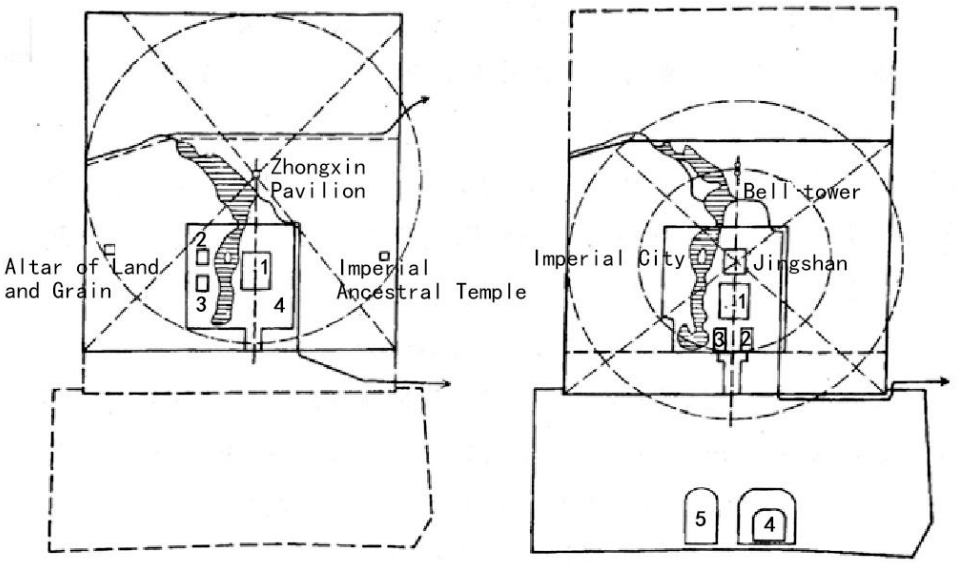

Figure 7: The relationship between the overall spatial layout of Beijing and the water in the Yuan Dynasty and the Ming(1368-1644) and Qing Dynasty (1636-1912)
Figure sources: drawn by author.

The blocks' layout of Beijing City is mostly rectangular in the north-south direction. But to in accordance with shoreline and topography, there are many inclined street in waterfront areas. It's can been the influence of water on urban spatial layout during city construction period (Figure 8). urban water environmental layers for Beijing City have taken urban layout and spatial structure into account.

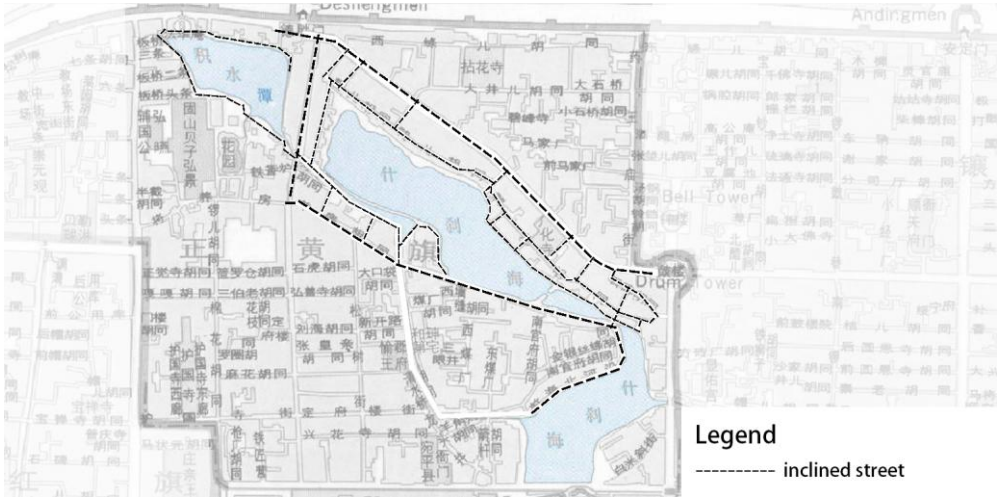

Figure 8: The inclined street of Shichahai area in Qing Dynasty (1636-1912)
Figure sources: drawn by author.

4.4 Water environment layer during utilization of urban space

After city construction completion, urban space begins to be used by citizens. people and urban water environment interact through citizens' a series of activities in urban water and waterfront space. Then citizen's utilization has endowed urban water environment and its surrounding space with certain meaning of the place. Urban design begins to think out human activities and the spirit of the place in urban water environment. Urban water environmental layer begins to form the symbolic dimension. From the point of human activities, the urban water environmental layer should include urban design elements, such

as waterfront activities, activities' facilities and space, service radius of activity space, and so on. The place spirit includes urban design elements, such as urban cultural connotation, historical significance, neighborhood relationship and so on (Table 3).

Urban water environment layer	**Urban design elements**
Human activities	Waterfront activities, activity facilities and space, service radius of activity space
Place spirit	Urban cultural connotation, historical significance, neighborhood relationship

Table 3: Urban water environment layer during utilization of urban space
Table sources: drawn by author.

The initial functions of Beijing's waters were irrigation, water supply and shipping with less activities between people and water. People's activities began to increase after the solid water pattern during Ming (1368-1644) and Qing Dynasty (1636-1912). From the Republic of China, citizens would use frozen rivers to access and make outdoor recreation. As Beijing's waterfront transformation, waterfront space has begun to have the spirit of place with increasing citizen' activities, such as fishing, running and visiting. The current waterfront areas of Beijing can afford the functions of urban cultural connotation, historical significance and neighborhood relationship (Figure 9).

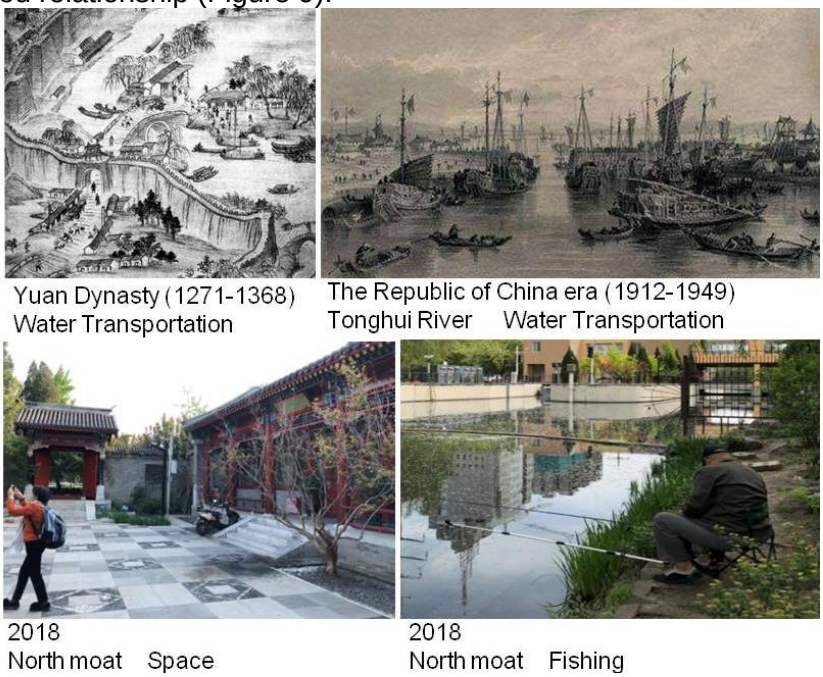

Figure 9: The use of Beijing waterfront in different periods
Figure sources: shoot by author.

5. Conclusion

In this paper, urban layer system is proposed to be set up in urban design, following by the concept interpretation of urban layer, urban layer system, the existing urban subject map, urban subject atlas and others. Meanwhile, the concept of urban layer is explored out from four dimensions: horizontal dimension, longitudinal dimension, temporal dimension and symbolic dimension. Ultimately, the author has attempted to establish the framework of urban water environment layer and Beijing waterfront urban design project is taken as an example to further illustrate the application of urban layer system and water environment layer in urban design from the practice perspective.

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