STUDY ON COMPREHENSIVE LANDSCAPE APPROACH FOR THE RIVERFRONT IN THE CENTER CITY OF CHONGQING

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Abstract- The riverfront hydro-fluctuation belt (HFB) formed after impounded by the three gorges reservoir is the crucible to us, but also the opportunity for the riverfront cities in the three gorges reservoir. The aim is to find a Comprehensive Landscape Approach adjusted to the hydro-fluctuation belt phenomenon, and integrate multi-value and multi-technology for the environment changes and human development. The study is based on five case studies that selected from the systematic long-term investigation to the riverfront in the center city of Chongqing. The Analytic Hierarchy Process (AHP) method was used to analysis samples on ecology, landscape shape and humanization. In our study, we attempt to research a comprehensive landscape approach which adapted to the environment phenomenon and human activity, build a integrate technology system which aim to guide the riverfront development in the future.

Key words- Comprehensive Landscape; Hydro-Fluctuation Belt; Riverfront landscape; Three Gorges Reservoir

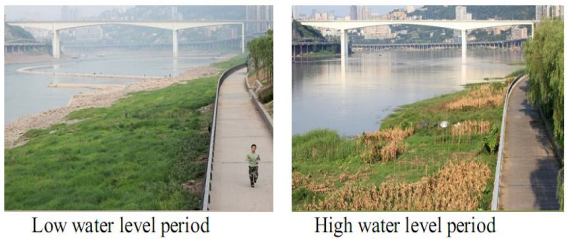
I. INTRODUCTION

The Three Gorges Dam is so far the largest water-control project in the world, and it played an important role in flood control, power generation, navigation, water diversion [1]. But the hydro-fluctuation belt phenomenon formed after the impoundment by the three gorges reservoir has become one of the biggest urban construction and environment protection problems in cities along the riverfront areas [2, 3].

Because of the demands such as flood control, desilting and shipping, three gorges dam store the clear water in winter and discharge the muddy water in summer, the lowest water level is 145 m in summer, and the highest water level is 175m [2].

Therefore, it forms the hydro-fluctuation belt zone with the elevation difference of 30 m (145 ~ 175 m), which is contrary to seasonal fluctuation law of rivers in nature above all,30m fluctuation is rare in the world.

Chongqing is one of the biggest cities which are influenced by the three gorges reservoir in the upper Yangtze river, according to the statistics, 445.5 km^2 area of land are flooded in the three gorges reservoir area (Chongqing section), among them 291.1 km^2 areas are the hydro-fluctuation belt zone which elevation is between 145~175m [2, 4]. Hydro-fluctuation belt area's proportion accounted for more than 65% of total flooded area (Fig.1).



Low water level period High water level period

Fig.1. Different water level periods in the riverbank

At the same time, Chongqing is one of the most typical mountainous riverside cities in the world, healthy and sustainable development in the riverfront of center city is the key to smart growth in the period of "inventory optimization", and the riverfront landscape optimization is the important part to improving urban image and promoting the quality of urban public space. It is not only the crucible to us, but also the environmental opportunity [1].

The theories and methods at present on urban waterfront landscape planning and design are more and more abundant complete, Included the land use and function orientation [5, 6] in the waterfront district, the public space environment in waterfront, the waterfront accessibility of urban traffic system, the waterfront regeneration based on the social effects[8, 9], urban waterfront landscape function based on ecosystem services[6, 10], culture-led regeneration of waterfront[11], study on urban waterfront design to rise the city image.

However research for the riverfront hydro-fluctuation belt landscape in the city is still at the fledgling stage. The current studies of the riverfront hydro-fluctuation belt mainly focused on the land use patterns [4], biodiversity conservation[2, 12], environmental governance[3], ecological restoration and reconstruction[13], flooding-tolerant species' selection[14], water pollution and environmental protection([15]), some inaccessible natural regions or city suburbs are chosen as research objects.

Obviously, it is observed that the emphasis of research focused on the flooding-tolerant species selection and the ecological technology in the hydro-fluctuation belt to response to water level changes, it is actually true that they are the one of the most pivotal point, but lack of overall consideration to the landscape system lead to the disappointing results when implemented,

particularly in the center city where the contradiction between human and land is quite obvious.

Overall, the gap of the past research is that there is no a unified theoretical framework, mostly emphasize on a single value or a single approach, for instance, ecological, aesthetical, engineering, and the research institutions are form single disciplinary field .So it's unavoidable to cause some conflicts among the different landscape values and discipline foundation [16], and it is almost inevitable that the practical applications are difficult to implement efficiently.

The research purpose is to find a Comprehensive Landscape Approach adjusted to the seasonal water level fluctuation, and integrating multi-value and multi-technology for the environment changes and human activities. The aim is to optimize the public space in the riverside landscape and guide urban environmental construction in the future.

II. METHOD

A. The study area

Chongqing originated in the confluence of two rivers; it is famous for mountain and river, since ancient times. The bank of Yangtze River and Jialing River as the city's water transport, industry cluster of aggregation, waterfront public space, is the important development area in Chongqing.

The research area in this article is the center city of Chongqing, involved the banks of Yangtze River and Jialing River, one of which is from Shuangbei Bridge to ChaoTianMen (about 14.9 km),the other one of which is from Egongyan Bridge to Dafoushi Yangtze river bridge (about 13.7 km). Rivers connect urban green areas, commercial entertainment areas, residential areas, heritage protection areas, freight traffic areas and industrial areas of Chongqing, which reflected the traditional and modern style and features. According To Statistics, the commercial entertainment areas, residential areas and urban green areas, accounted for the largest proportion among the total land of riverside, they accounted for 88% of the total land in the construction area of Chongqing.

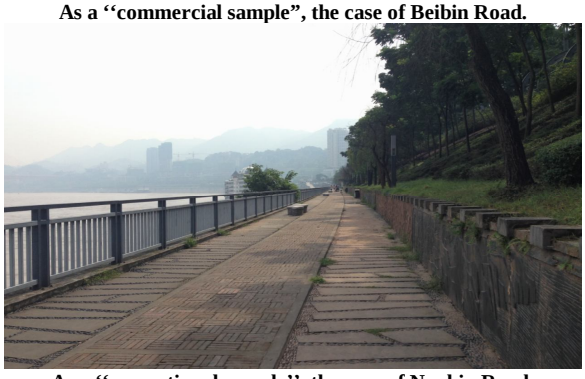
The study area is a multidimensional complex, urban construction is the most concentrated, city function is diverse, the traffic system is the most complicated, the social relations are mixed, at the same time the hydro-fluctuation phenomenon is the most obvious. The riverside space of Chongqing is an important interface between land and water, man-made and natural, also the ecological and landscape interface. Therefore, we must put it on an integrated value system as a landscape complex to solve the practical problems.

B. Samples specification

Cases were carefully chosen, in order to present to the riverside landscape in the center Chongqing. The criteria for the evaluation of the possible case studies were obvious in the seasonal water-level changing sites, typical in the functions of each district, located in built-up area in Chongqing center city. Accordingly, adding the observation and investigation to Chongqing riverside for a long-term, following five samples were chosen and presented to the Chongqing riverfront landscape:



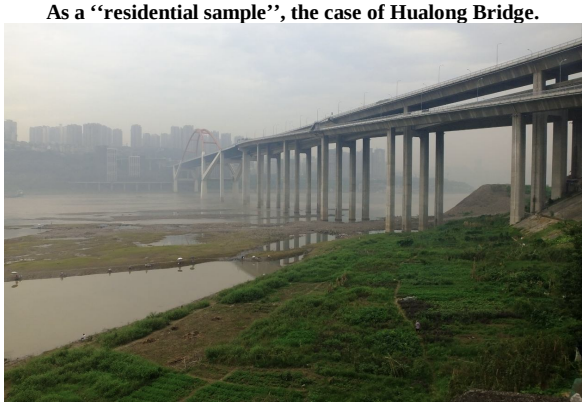
As a ''commercial sample'', the case of Beibin Road.



As a ''recreational sample'', the case of Nanbin Road.



As a ''residential sample'', the case of Hualong Bridge.



As an ''environmental sample'', the case of Shahuba.



As a ‘‘historic sample’’, the case of Chiqikou.

C. Samples specification

We used Analytic Hierarchy Process (AHP) method to analysis samples, made a landscape suitability evaluation based on three items, including ecology, landscape shape and humanization, and there are different principles and detailed criterions supporting to each items. The aim of the evaluation is to judge whether the samples adapt to the environmental changing and human’s activities on the three dimensions of ecology, landscape shape and humanization (Table 1).

Table 1. Landscape appraisal index system

items	principles	criterion
Ecology	primariness	degree of respect for the original terrain
		degree of retaining the original vegetation
	river continuity	continuity of the waterway/river bank
		continuity of the vegetation
		width of the riparian buffer zone
	biodiversity	animal diversity
		vegetation diversity
		native species proportion
	habitat quality	vegetation coverage
		proportion of natural and artificial
		diversity of habitat
		degree of pollution of the environment
Shape	degree of beauty	period of high water level
		period of low water level
	functionality	traffic accessibility and convenience
		adaptability of public facilities
		landscape facilities is easy to clean
		permeability of pavement materials
	safety	robustness of landscape facilities
		Is there a safety emergency facilities (such as a life buoy, rescue boats, etc.)
Humanity	participation	diversity of activities
		hydrophilic activities
	sense of identity	period of high water level
		period of low water level
	based on the historical culture	site under national protection
		historical memory
		Intangible cultural heritage projects

In addition to use statistical tools in this study, combining quantitative and qualitative research, the most important research work is still the continuous monitoring and regular recording to the hydrology, vegetation, sites, used by the crowd and the city construction with the fixed time and location for a long-term.

III. RESULTS

A. Inadaptable symptom

It turned out that inadaptable symptom indeed exists in the riverfront of Chongqing. To sum up, the inadaptable symptoms appeared in the following three aspects.

1.Fragmented interface

After the formal operation of Three Georges Reservoir, there would be a vertical drop of nearly 25 m water level fluctuation in Chongqing riverside [17]. Because of the high density construction and development and the rough and huge municipal facilities (such as flood control facilities, transportation facilities, box culverts and pipelines, etc.), it made the riverfront visual landscape terrible when the low water level period (from February to June each year). The most important influence is the lack of relations and lack of integrity in the riverside landscape made a great crack formed between cities and the rivers interface. It caused the ecological energy exchange unable to operate and human’s activities in the urban public space far away from the river bank. Therefore, it can't really present the characteristic view of the natural mountains and rivers in Chongqing.

2.Predicament of landscape ecological system

As greatly high water drop and off-seasonal fluctuation phenomenon in the three gorges reservoir each year, it leaded to a series of ecological environment problems such as the geological environmental instability of reservoir, the destruction of vegetation, soil erosion, frequent natural disaster etc. [18, 19]. Fluctuation zone area aquatic ecosystem cannot adapt to 4-month land period while terrestrial ecosystem can hardly survive in at least 1-month flooding period, causing gradual death of aquatic and terrestrial plant as well as damage to the soil structure [18]. Therefore, universal soil erosion has come out. Washed over by the wind and ships, the bank continually erodes, which causes mountain and bank landslide and collapse with other frequent geological disasters in the rainy season and flood season [20, 21].Meanwhile, expressway, viaduct, retaining wall, embankment and other concrete facilities occupy the natural shoreline and river course, cutting off exchange and transmission among nutrient, biomass and energy, destroying the migration corridor and the habitat environment for birds and waterfront animals,

leading to extinction of common waterfront species [22].

3.Lack of human scale place

At present, Chongqing is under the stage of rapid urbanization. Resident population and rate of urban population grew from 29.5% to 53% from 1996 to 2010(Chongqing 2011).Growing public demand for residence, transportation, recreation and so on produced enormous pressure on municipal facilities, and the complicated terrain structure of mountainous city caused the difficult organization for municipal function.

Particularly, monotonous and rough riverside roads increasingly, although to a certain extent, taking a part of the traffic pressure in the city center, but cut off the relations between people and rivers. Because of lack of human scale place and hydrophilic landscape design, citizens can only enjoy water on the levees, or reach river banks in extremely unsafe way. The chaos of the riverside landscape, enormous rough municipal facilities and unsafe leisure ways for people, it revealed inadaptable riverfront landscape that was out of control.

B. Prototype

According to characteristics of the dynamic change of water level in the urban riverfront and the relationship between the riverside and urban space, the landscape prototype in the city riverfront includes three parts: the water level changing area, the buffer area, the transition area (Fig.3).

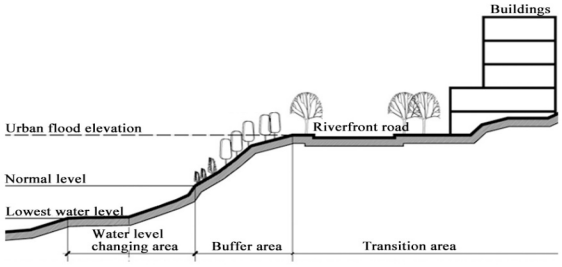


Fig.3. The prototype of riverfront landscape

1.Water level changing area

According to the three gorges reservoir operation plan, water level area changes from the 160m (the lowest level) to 179m (normal water level in the three gorges dam) every year. The stability of the topography, the continuity of the rivers or riverbank, the diversity of species and the quality of habitats would exert an influence on the water level changing area.

2.Buffer area

Buffer area is the zone between the normal water level and the urban flood elevation. Affected by the river environment as well as urban, the adaptable buffer area could promote natural release and transfer for the environment, meanwhile it can provide people with a practical and safe waterfront places. Therefore, whether the allocation of the public facilities is rationality and adaptability riverside, the security of the landscape facilities and the permeability of pavement material etc., would impact deeply on regional adaptable riverfront landscape in buffer area.

3.Transition area

Transition area is the riverfront landscape zone within the affected by river in inland built urban area. Although most of the transition area has not directly be affected by water level changes, however the quality of the riverfront landscape would largely affect people's cognition and perception, the accessibility to the riverfront could influence people's use. Not only can city image be affected, lack of contact in public space in the waterfront space lead to lack of vitality, more important thing is that, it could lead to people make a wrong judgment and decision, and then a vicious cycle is formed.

IV. DISCUSSION

A. Adaptive landscape design strategies

1.Build multi-scale network system

The establishment of comprehensive city landscape infrastructure must integrate environment, ecology, social and economic driving force within a related standard, so as to avoid resilient damages caused by excessive efficiency improvement and structure optimization(Walker and Salt 2006). The formed function system can adapt to water level changes of the fluctuation zone and demands for city functions.

Build a multi-scale network system, which integrated green & blue corridors, transport system, ecosystem and city cultural system, as the landscape infrastructures on the basis of adaptation to changes of water level.

2.Optimize landscape for resilience

The core of resilience theory is the system adaptive cycle, which describes how multiple components in a system change with time, and how the system resilience changes according to particular stage of system(Walker and Salt 2006). The stability of ecosystem depends on the space-time scale and spatial heterogeneity(Peterson et al 1998, Vannes and Scheffer 2005). Building an adaptive landscape infrastructure needs to consider the link among the land, land-water ecotone and water in population flow, ecological corridor and landscape view, to do layering according to the ecological sensitivity in slope slow area, and to build the horizontal ecological corridor paralleled to river according to the topography, slope and regional water trends and build the longitudinal ecological corridor connecting the water, the floodplain, the creek, the hillside and the ridge together so as to protect the animal and plant migration channel and biodiversity. It is needed to

consider the connection between the city development path with the water cycle of waterfront fluctuation zone and city patterns, historical texture, characteristic construction in the view of time.

According to the waterfront ecological protection and landscape view, combined with the topography and water level changes, establish the walking system of resilient waterfront in public space, including the floating water affinity platform which can adapt to water level changes and terrain height differences, the water-permeable waterfront pathway, temporary service facilities and identification systems and so on.

3.Foster landscape in context

Pay attention to the platform of Chongqing riverside combining with the hydrological conditions; build human scale riverside places by multi-step to ensure hydrophobicity for different water level. Shape the human scale landscape space, and protect the historical cultural elements and structures along the Yangtze River such as historic buildings, ports, boats, stone inscriptions, even the historic stories. It's a viable option to use modern technology to remolding Historic landscape [23]. Design with the local culture connotation and characteristics of riverside landscape; promote "place spirit" formed.

B. Technology Integration

1.Ecological technology

- Multi-buffer systems: Plant flooding-tolerant trees, shrubs, wetland meadow, according to the landform and water level variation.
- Selection of adaptable vegetation: In the waterfront fluctuation zone, the vegetation need adapt to water level change. Selecting the plant species, planting density and communities which are adaptable to the change of water level is the most important factor for the ecosystem stability.
- Micro-topography reconstruction: Micro-topography reconstruction can offer the adaptive habitats for the fish and other animals in the river through rebuilding the microhabitat on the river bank, bend and beaches.

2.Landscape Engineering and Technology

- Seasonal hydrophilic landscape facilities;
- Ecological landscaping dam technology;
- Engineering technology under the bridge.

C. Integration & conflict

With the meaning of landscape tend to be more and more complete because of human's cognitive, the research dynamic has showed that the contents of landscape evaluation has been gradually from the aesthetics as a single perspective shift of a entirety of aesthetics, ecology, culture, etc. Through the comprehensive landscape is widely thought to be better and more integrate, but a simple combination could cause contradictions and conflicts among different landscape evaluations [16, 24]. Perhaps adaptability could be an effect index to evaluate in the landscape, but there are still many of the key research and practice need to work on.

CONCLUSIONS

The result of this study confirmed that the changed environmental phenomenon is not only the crucible to us after Three Gorges Project, but also the environmental opportunity.

The prototype of the center city's riverfront landscape includes 3areas: water level changing area, buffer area and transition area. Comprehensive Landscape approach (CLA) is based on the model of human–environmental Interactions in the landscape includes building multi-scale network system, optimizing landscape for resilience and fostering landscape in the context as the riverfront landscape optimization strategies for the seasonal changing phenomenon. The technology approach integrates ecological technology for changing water environment and landscape engineering technology for the human activities.

In predicting the future, Comprehensive landscape approach (CLA) can cope better with the current situation of urban development; it may be a good way to solve the other landscape environment projects.

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