Research on the goal of urban water system governance system construction-Taking Jinan sponge city as an example

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Abstract. With the accelerating process of urbanization in China, the traditional urban water system governance system is facing the challenges of flood and waterlogging, river ecosystem deterioration, water pollution and urban water shortage. Therefore, it is necessary to introduce a new urban water system governance system that respects nature and complies with nature. Taking Jinan sponge city construction as an example, the paper analyzes the existing problems in the pilot area, putting forward the overall goals of sponge city construction, total annual runoff control rate, waterlogging standards, flood control standards and build ways. The works can provide direct guidance for the construction of sponge cities in Jinan city. On the other hand, they may be able to accumulate experience for the research on urban water system construction in China, gradually boosting the application and development of sponge city theory in practice.

1. Introduction

With the rapid urbanization of China, the construction of water system governance system in urban areas has attached great attention. The so-called urban water system governance system refers to a new type of management system that is more flexible and emphasizes multi-agent participation than traditional water system management. Urbanization is an important manifestation of the economic development of a country. However, human beings have brought about a series of problems in the construction of traditional cities due to the change of natural ecology. Urban streets, houses, public plazas use more rocks, cement, asphalt and other impervious materials, resulting in surface hardening, and rapid spread of the impervious surface with the urbanization process [1]. As a result, the crisis of water ecological governance in Chinese cities is caused [2]. Among them, the city's floods and water shortage problems are more distinct [3]. In this context, Chinese scholars proposed the "sponge city" theory based on the research of foreign Low Impact Development (LID) [4] and Sustainable Urban Drainage Systems (SUDS) [5].

2. Methods

The paper mainly adopts literature research method, field surveys and case study method. At first, this paper summarizes the definition of sponge city and its foreign construction experience through literature research methods. Secondly, this paper takes the construction of the sponge city in Jinan as an example and conducts a case analysis. At last, the authors conducted field surveys in pilot areas and obtained direct data. During the investigation, the research team collected data through interviews and

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on-site observations. And during the interview, some popular opinions were obtained from the residents. From the perspective of democratic decision-making, such fieldwork can fully reflect public opinion and enable the construction of a sponge city to base it on a humanistic care. After data acquisition, academic team members processed the data through quantitative analysis.

Then, based on the data analysis, the goal of the construction of the Sponge City was decomposed by the target decomposition method. Feasibility standards were formulated for the existing problems in the pilot areas, and standards were used as the norm to seek specific measures to achieve the goals. Specifically speaking, the ultimate goal of building a sponge city is to realize the sustainable development of water system governance and ensure that people and the urban water environment live in harmony. Specific problems in Jinan include flood risk, water pollution, and spring protection. Solving these problems is an inherent requirement for the construction of a sponge city in Jinan City. Taking the specific issue as a clue, we can easily construct the goals for the construction of the Sponge City and eventually provide experience for the construction of the urban water system governance system.

3. Sponge city

Sponge city construction is an important part of urban water system governance. It can be said that the sponge city is an effective strategy to achieve the effectiveness of urban water system governance. The paper aims to build on the foundation of Sponge City and provide experience for urban water system governance. Therefore, this section will explain and define the concept of a sponge city. In addition, summing up and drawing lessons from the advanced international experience in the construction of Sponge City is also an important part of this section.

3.1. Sponge city concept and connotation

The concept of Sponge City was first proposed by Australian research scholars. It is used to describe the city's absorption effect on the surrounding rural population [6]. In recent years, many scholars have begun to use the concept of sponge city to describe the relationship between urban and hydrological studies. At present, in the urban water system governance, sponge city refers to the city as a sponge, having good flexibility in adapting to environmental changes and dealing with natural disasters. When it rains, it can absorb water, store water and purify water, and when needed, the stored water can be released and used. This definition highlights the important role sponge city plays in urban water system governance. In fact, sponge city theory draws on the best management practices in western countries, low impact development, green infrastructure theory [7], and emphasizes that urban construction and development should minimize the damage and impact on the natural ecology. By building a green infrastructure, natural resources are included as the main body of change in urban construction and management [8]. Former Deputy Minister of Housing and Urban-Rural Development Qiu pointed out that the essence of the sponge city is to solve the harmony between urbanization and resources and the environment. Its goal is to make cities "resilient" to environmental changes and natural disasters [9]. In the author's opinion, the connotation of sponge city is not only the way to solve specific problems in urban construction such as rainstorm, drought and water pollution. In a broader sense, the sponge city is an important node in the transformation of China's urbanization concept. It not only inherits the essence of the thought of "harmony between man and nature" in ancient China, but also draws on the ecological concept of harmonious coexistence between man and nature in various countries in the world. This is of great importance to global ecological governance.

3.2. Sponge city construction experience

How to build a sponge city? At present, the United States, Germany, Switzerland and other developed countries have formed a relatively perfect sponge city construction system [10]. In the 1990s, Prince George's County of Maryland, USA, has proposed the concept of LID. By adopting rainwater gardens, green roofs and other measures, the cost of rainwater drainage projects and management and operation costs are greatly reduced. Germany tends to adopt legal regulations. For example, the German

government implements a "rain drain charge" system. Users who discharge rainwater directly to the rainwater pipe network need to pay the relevant fees according to the impervious area. The New Zealand Government excels in the supervision and management of urban water environment. These examples suggest their construction focuses on how to deal with the problem of waterlogging in cities. The tactics adopted in various countries are mainly LID, urban sustainable drainage system and water-sensitive urban design etc [11,12]. And with the further development of the sponge city construction, the goal of these countries has gradually shifted from urban stormwater management to the sustainable utilization of rainwater resources, which has further embodied the ecological concept of the sponge city in practice.

There are already many successful pilot areas for China's construction of a sponge city. In 2003, Professor Yu Kongjian from Peking University first used the concept of "sponge" to describe the storage capacity of natural wetlands and rivers in urban droughts and floods [13]. At the same time, his team has created many successful practice cases of stormwater management from Tianjin Bridge Park in 2008 to Qunli Rainstorm Park in Harbin in 2010. Generally speaking, the research on "sponge city" in China is basically comprehensive and absorbs the advanced experience of all countries. However, the practical application in the process of urbanization in China needs to be further improved.

4. Jinan sponge city construction

We chose the construction of a sponge city in Jinan as a case. Jinan is the capital of China's Shandong Province in the east of the country (figure 1). As a provincial capital, Jinan is highly representative of both the geographic features of the area and the government's policy support. At the present, the construction of the sponge city in Jinan is taking places, which means the construction process can be tracked in real time. This section will describe the geomorphological features of Jinan City. And we will also describe the state of the sponge city construction in Jinan.

Figure 1. Geographic location of Jinan City.

4.1. Pilot area overview

4.1.1. Pilot Area Representative Analysis. First of all, the issue of road flood in the area is outstanding. It is also a high-risk area for floods in Jinan City. The pilot area is in the upper reaches of southern Jinan, with a large number of hillside slopes. Due to the rapid development of the city, the hardened

area of the underlying surface has been greatly increased, the ecological environment of the mountain has been degraded, and there is a lack of storage facilities in the area. Therefore, when it rains, the confluence time is fast; the peak flow rate is high; the peak time is greatly advanced. Jinan City downtown flood disaster happened to be located in the pilot area downstream. Waterlogging in the downtown area was mainly due to the flood release in the pilot area. At the same time, the pilot area is also an important channel for mountain floods to flow to the lower reaches of the plains.

Second, the pilot area is located in an important area where water supply and groundwater recharge in Jinan City is carried out. The pilot area is located at the source of many springs such as Daming Lake and central urban area. There are many seepage zones in the area, which are the sources of seepage and recharge of groundwater and ensure the continuous flow of downstream spring water all the year round.

4.1.2. Pilot area underlying surface composition. Xinglong District of Daming Lake, Jinan City was chosen as a pilot area as an example of a sponge city being built at the moment. The current elevation of Xinglong District is between 44.1 m-459.9 m, being high in the south, low in the north, high in the east and low in the west. East and south are hills, the middle is a small hill, the ground slope up to 23 ‰. The status of built-up area is mainly in the hilly slopes and flat areas, with an elevation of 44.1-163.0 m. The area has both concentrated areas of infiltration, but also large areas of high-density building area. The present status of permeable ground area ratio is about 41.2%; the total area of pilot area is 39 km^2, of which mountainous area is 16.7 km^2, and development and construction area are 22.2 km^2. The current population is about 320,000. Development and construction of land types is shown in table 1.

Table 1. Development and construction of regional land use type table.

Serial Number	Category	Area (km^2)	Land Ratio
1	Building	13.6	61.3%
2	Water Surface	0.6	2.7%
3	Green Space	4.3	19.5%
4	Road	3.7	16.6%
Total		22.2	100%

4.2. Analysis of the pilot area

After analyzing the representativeness of the pilot area, we need to conduct research and analysis on the existing risks in the area. The ultimate goal of an urban water system governance system is to shape an ecosystem in which people and the environment coexist harmoniously. But after this goal is specific to a certain actual area, it needs to be decomposed into several feasible goals. This decomposition process is based on the water environment risks that need to be overcome in the area. Therefore, this section will specifically analyze the comparatively prominent risks in the pilot area.

4.2.1. Flood risk analysis. After processing the data of the pilot area, a rainwater system model of the pilot area was established by info works simulation software According to the rainstorm intensity formula of Jinan city, the rainfall process in Jinan was calculated for 2 hours. In the study, the 10-year and 20-year events were selected to analyze the flood risk in the pilot area. Specific simulation results are as follows.

According to the simulation results, it can be found that the high-risk areas of water once every 10 years are mainly distributed along the road. By comparing the results of the 20-year-old rainfall scenario and the 10-year-old rainfall scenario in the pilot area, we found that the former has a greater risk of flooding. And the risk of flooding in the mountains is even more pronounced (table 2).

Table 2. Flood risk analysis results of pilot areas.

Simulation scenarios	Water area (m^2)	Water volume (m^3)	Water risk	Average water depth (m)
The status quo once every 10 years	3623306	3259205	6949	0.91
The status quo once every 20 years	4528512	4322110	9305	0.96

Note: water risk comes from expert rating, so there is no physical unit.

4.2.2. Rainfall runoff is seriously polluted, and the water quality of surface water bodies is poor. In the pilot areas, the development and construction areas have a greater intensity of development. The current comprehensive runoff coefficient is 0.67. Refer to Shandong Jianzhu University's water quality inspection data of different underlying surface runoff in Jinan City from 2010 to 2013 (average rainfall of SS event is about 243 mg/L), and the preliminary estimate of SS annual average emission in pilot areas is 4,204 tons. Among them, the overflow pollution of the combined drainage system and the initial rainwater pollution load of the diversion drainage system are higher. The pollution load caused by stormwater runoff in receiving water exceeds 36.7% of its total amount.

4.2.3. Seasonal water shortages, the problem of protection for the spring waits to be solved. The water rate in the pilot area is decreasing year by year, and the temporal and spatial distribution of precipitation is not uniform. The downstream spring recharge mainly depends on the strong seepage zone in the south near the mountain. Due to the large slope of the ground, large flow of rainwater, rapid convergence, and insufficient storage capacity, the groundwater cannot be effectively infiltrated.

5. Jinan sponge city construction overall goal

For the existing risks in the pilot area, we obtained control indicators through data analysis and calculation. Then put forward the feasibility measures to achieve the indicators.

5.1. Annual runoff total control rate

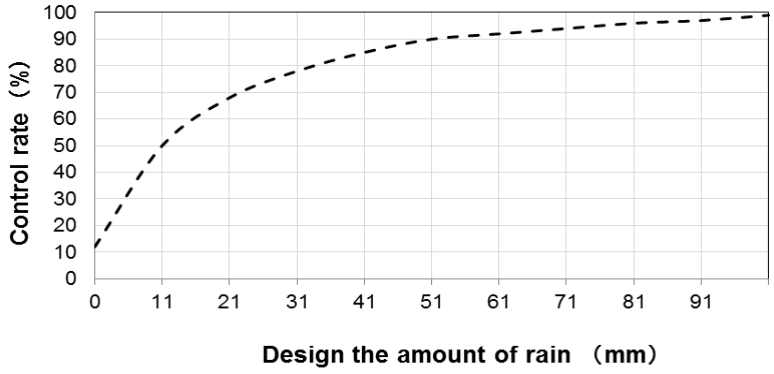

Figure 2. Relationship between total runoff control rate and designed rainfall in Jinan City.

According to the Technical Guide for Sponge City Construction, the total amount of annual runoff in mainland China is controlled by zoning map. Jinan City is located in Zone IV in the sub-district with a control rate of 70% -85%. According to the daily precipitation data of weather stations in Jinan City in the past 30 years (excluding snowfall), statistical analysis shows that the relationship between total annual runoff control rate and design rainfall in Jinan is shown in figure 2. At the same time, the

annual rainfall total control rate corresponding to different design rainfall in Jinan City and the design rainfall corresponding to different annual runoff total control rate can be calculated. See table 3. Based on the above statistics, if the pilot area is to meet the required control rate of the guideline, then the corresponding design rainfall should be 23.1-24.1 mm.

Table 3. Jinan annual runoff total control rate corresponding to the design of rainfall.

Annual runoff total control rate (%)	60	65	70	75	80	85	90	95
Design rainfall (mm)	16.2-16.5	19.4-19.7	23.1-23.4	27.1-28.2	32.5-34.1	40.7-42.1	51.6-53.8	71.1-76.2

5.2. Jinan sponge city construction drainage waterlogging standards

Jinan Municipal Government issued a series of regulations for the drainage and waterlogging standards for the construction of sponge cities. The regulations require that the pilot area's drainage waterlogging standards should meet the following standards.

5.2.1. Drainage standards. In the pilot area drainage system, <1 year once accounted for 21%; 1-2 years once accounted for 5%; 2-5 years accounted for 40%; >5 years once accounted for 34%. Through the construction of sponge city, the drainage pipe and drainage system in normal area all reached a period of more than 3 years. The important areas have met the standard of once in a decade, and the underground passages and sunken plaza have reached the standard of 30 years.

5.2.2. Waterlogging standards. Waterlogging prevention and control standards in the pilot area are effective to withstand rainstorms not less than 50 years and to ensure that water does not enter the ground floor of residential buildings and industrial and commercial buildings. In addition, the depth of water in motor vehicle roads should not exceed 15 cm. The blocks located in the central urban area should gradually reach the standard of prevention and control of waterlogging in 50 years according to the plan of regional planning and reconstruction. When the local surface water does not meet the above requirements for prevention and control of waterlogging, measures should be taken such as infiltration, regulation and storage, setting of flood-releasing channels and river regulation. The design of waterlogging prevention and control in the pilot area should pay attention to the water boundary conditions at the downstream of the drainage system and connect with the flood control standards.

5.3. Flood control standards

The flood control standards for river courses in the pilot areas have reached more than 50 years, of which the flood control standards of Xingji River reach once every 100 years. The flood control standards of the Liyang River and Yuxiu River reach once in 50 years.

5.4. Construction of sponge city in Jinan City

At present, the construction of the sponge city in Jinan City is advancing. The municipal government and related departments have attached great importance and have also received strong support from the public. The specific construction approach is as follows.

At first, we can construct a set of low-impact source and development of rainwater systems. Specific measures include the use of permeable pavement, sunken green spaces, rain gardens, shallow groves, rainwater collection ponds, and other rainwater control and utilization facilities. Significantly improve the infiltration of rainwater recharge groundwater, irrigation and other green water collection and reuse of rainwater resources level, effective control of runoff pollution. To ensure that the regional annual runoff pollution load reduction rate is not less than 60% (in SS), slow peak hours, reduce the peak flow rate and reduce the total amount of rainwater runoff to achieve the average annual rainfall runoff control rate is not less than 75% Control objectives.

Second, through the improvement of drainage channels and drainage channels, it is necessary to

comprehensively enhance the closure, pollution control, transportation and discharge capacity of the canal system. Achieve a standard of 2 to 10 years for all urban drainage networks. Low-lying waterlogging and other areas of drainage waterlogging have reached the standard for 30 years. And through the construction of network information platform, comprehensively improve the regional drainage waterlogging warning, emergency response capacity and drainage waterlogging facilities maintenance and management.

Third, through such means as protection, restoration and reconstruction to broaden the rivers and lakes, dredging and ecological protection. We will comprehensively enhance the water storage, water supply, drainage and flood discharge capacity of river and lakes. The main flood section of the downtown area all reached 50 to 100 years once the standard. To gradually build a water network based on the ecological security pattern of the river basin to achieve grid management of "springs, lakes and rivers". So as to effectively alleviate the problems of "floods every rainstorm, drought after rainstorm" and the overall effectiveness of urban flood control and drainage and disaster reduction.

6. Discussion

Sponge City construction has just begun in China. Although some pilot regions have achieved relatively successful experiences, they have not established a standard construction model nationwide. Therefore, the paper's research on the construction of sponge city in Jinan City will help to accumulate sponge city construction experience. However, it should be pointed out that the construction of the sponge city in Jinan is in the process of construction. In the long run, whether its construction mode and experience is truly effective still needs further verification. In addition, the construction of the sponge city is only part of the construction of the urban water system governance system. The authors hope that the experience of sponge city construction in this paper can provide some possible experience for urban water system governance.

7. Conclusion

Taking Jinan sponge city construction as an example, this paper analyzes all the indicators and the process of the sponge city construction in the pilot area in detail. Need to point out, although the pilot area in Jinan is highly representative in sponge city construction, the construction of urban water governance system in any part of the country is a complicated project and must be consistent with the actual conditions in various regions. While thinking about the disadvantages of traditional urbanization, we must profoundly recognize the importance of urban stormwater management and urban ecosystem construction. The concept of traditional urban water governance in urbanization has been solidified in urban management in China. Promoting sponge city construction, reforming of urban water management system is still a long way to go.

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