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Challenges and Countermeasures of Urban Water Resources Planning and Management

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Abstract: *As a country with a large population, the distribution of water resources in China is very uneven, and the per capita water resources possession is lower than the world average. With the development of society and the acceleration of industrialization, people's waste and pollution of water resources have made China's water resources increasingly tense. This article aims to solve the current situation of scarcity of water resources in Chinese cities, and discusses the challenges and countermeasures of urban water resources planning and management. This article first introduces the planning and management of urban water resources in detail, so that readers can understand the necessity of urban water resources management, and finally proposes to use the construction of artificial wetlands to allocate water resources, and the effect is obvious(water allocation for Scenario 1 increased by 24.5%).*

Keywords: *Urban Water Resources Management, Imbalance between Supply and Demand, Low Utilization Rate, Challenges and Countermeasures*

1. Introduction

China has vast land and a huge population, but there is a serious regional imbalance in the distribution of water resources, and at the same time, the per capita water resources are much lower than the world average. In the process of urbanization, due to large-scale industrial development, a large amount of domestic and production wastewater has been produced, making the water resources that are not rich in nature even more scarce. However, since China's urbanization process is still in its infancy, the experience in the development and utilization of urban water resources is obviously not rich enough, which has caused a serious shortage of urban water resources. Severe shortage of water resources in local areas is not uncommon; drought and irrational groundwater development have resulted in large areas of decline funnels, as well as seawater intrusion. At present, many cities in China are facing the problem of water shortage in the process of economic development. Therefore, how to scientifically and rationally plan urban water resources is the key to urban development today.

For urban water resources planning and management, some scholars have conducted special research and investigation. SharafatmandradM mapped the spatial supply and demand of water and assessed drought conditions over 20 years (1994-2014) using the Standardized Precipitation Index (SPI). 23% of the catchment area has water supply and demand matching, mainly concentrated in cold regions. In dry years, water supply is reduced by up to 80%, and the matching ratio of water supply and demand in the catchment area drops to 5%. His findings suggested that the ratio of water supply to demand could be used as a proxy indicator of ecosystem health and water yield, providing good information for water resource managers to reduce the threat of water scarcity in arid and semi-arid regions [1]. GohilJ discussed how big data was affecting the field of water resource management and how important it was. He provided an in-depth look at several aspects of this field, noting its applicability to real-world situations. He examined and provided a comprehensive review of various applications currently deployed in the environmental and water resource management subfields [2]. Siirila-WoodburnER examined changes and trickle-down effects of snowpack reduction in the Western United States (WUS). He projected that snowwater equivalent across the western United States would decline by about 25% by 2050, a loss comparable to contemporary historical trends [3]. The applicability of the above research program is not strong, which is not conducive to promotion.

Water resources play a pivotal role in urban construction. To effectively solve China's water resource problems, it is necessary to continuously improve and strengthen the planning and management of water resources. At the same time, it must actively develop new water sources to ensure the balance of water supply and the sustainable development of the urban economy. This paper not only introduces the challenges and problems faced by water resources management in detail, but also proposes specific solutions.

2. Challenges and Countermeasures of Urban Water Resources Planning and Management

2.1. Current Situation of Water Resources Management

(1) Uneven supply and demand

Because of the current situation in China, the average person can only get 900mm3 of water resources, and the distribution is very uneven. Although China's water resources have increased from 443.7 billion square meters in 1980 to 596.5 billion square meters in 2009, there is still a gap of about 40 billion square meters due to water shortages. At present, there are more than 600 cities in China, 67% of which have water shortage problems, and this problem accounts for 18% of the total. Due to excessive mining, more than 70 cities in China have experienced surface subsidence to varying degrees, and the subsidence range has reached 64,000 kilometers. The balance of groundwater circulation in some areas of North China has been seriously damaged, and the quality of groundwater has also been seriously affected [4-5].

(2) The utilization rate of water resources is not high

At present, China consumes more than 380 billion cubic meters of water for farmland irrigation every year, accounting for almost 70% of the country's total water consumption. At present, the water efficiency of farmland irrigation in most parts of China is only 0.3-0.4. Developed countries have used water-saving irrigation since the 1940s and 1950s. Nowadays, many countries have realized anti-seepage and pipeline of water delivery channels, field sprinkler irrigation and drip irrigation, scientific and automatic irrigation, and the utilization coefficient of irrigation water has reached 0.7~0.8. The second is the waste of industrial water. At present, China's water consumption per 10,000 yuan of industrial production is about 80 cubic meters, which is 10-20 times higher than that of developed countries; compared with 75-85% in developed countries, China's water resource reuse accounts for only 40% [6].

(3) Excessive development and use

At present, the utilization rate of water resources in the country has reached 19%, three times the international average level, and even higher in some areas. It is generally believed that when it is more than 20%, the overdraft of water resources will have a greater impact on the ecological environment, and when it is more than 50%, the impact will be more serious. At present, the development and utilization degree of some areas exceeds 50% [7]. Due to the over-exploitation of groundwater, a series of environmental problems such as surface subsidence, seawater intrusion, and seawater backflow have been caused. Therefore, the development of various industries in China is currently affected by severe drought and water shortages [8].

2.2. Main Ways to Comprehensively Utilize Urban Water Resources

(1) Building a water-saving society and improve the efficiency of urban water use

Building a water-saving society system, assessment system and education system, carry out a water-saving society construction plan, strengthen people's awareness of conservation, and promote water-saving technologies, develop tertiary industries such as finance and logistics, promote the development of circular economy, build a clean and productive industrial park, and make it a zero-discharge wastewater [9].

(2) Building a sponge city to reduce non-point source pollution

While solving the problem of rainwater drainage, the construction of sponge city will also be of great significance to reduce the runoff of surface pollutants, increase the treatment capacity of urban domestic sewage, maintain the balance of urban groundwater resources, and reduce surface runoff caused by urban rainwater problems, etc.[10-11]. In the city, the function of the sponge wetland should be fully utilized to connect it with the water supply system and other supporting facilities. At the same time, it can also bring good landscape effects to the city and improve the quality of the city and living environment [12].

(3) Establishing an urban reclaimed water reuse system to increase the proportion of reused water resources

After domestic and industrial wastewater is treated and reaches the discharge standard, it will be recycled to form an urban reclaimed water reuse system. At present, the use of urban reclaimed water is expanding, and its treatment process can fully meet the needs of urban ecological water, garden water, cooling cycle water, and automobile urinal flushing water quality indicators [13].

(4) Regulating the price of water resources

Using economic means to improve the comprehensive utilization rate of water resources. Starting from December 1, 2017, nine provinces, including a certain region, have been included in the pilot scope of expanding water resources tax. The implementation of water tax reform will not increase the burden on residents' normal water consumption, but double taxation will be levied on water consumption exceeding the plan. Expanding the scope of the pilot and giving full play to the adjustment function of the tax lever will play a positive role in further curbing unreasonable water demand and promoting the protection and utilization of water resources [14].

(5) Establishment of water resources-economy-environmental management model

Under the background of "green economy", China should actively explore the management mode of water resources, economy and environment. Using the optimization method, the carrying capacity of urban water resources is calculated and allocated optimally, that is, to meet the maximum water demand required by the development of the national economy and urban society, and to carry out reasonable and feasible adjustments to the national urban economic development, and carry out environmental control and management, so that water resources can maximize their economic and environmental benefits, so as to achieve social green development [15].

(6) Improving the urban water resources information management platform

Cities should devote themselves to the integration of information platforms. This should include water supply data, water demand data, and quota-based industrial water use information, including water allocation for various industries, large-scale project water use, and other water use data, as well as user-level water use databases [16]. Trying to perfect the basic information of users, strengthen the management of users, implement household management, and reduce the gap between managers and users. In urban planning and management, strengthening information exchange is an important topic. At the same time, it is necessary to conduct specialized expert interpretation of relevant laws and regulations, and facility management assessment methods to ensure that managers can obtain the data and information needed for planning and management, thereby protecting the rights and interests of enterprises and institutions. At present, the Municipal Water Affairs Bureau has preliminarily built an information platform. At the same time, it can also learn from foreign experience to further improve the departmental water resources database, user identification method database, quota calculation index method database, expert knowledge base, decision support database, etc. [17].

2.3. Development Trend of Urban Water Resources Management

(1) Water resource simulation and modeling

In recent years, with the rapid development of computer technology and the continuous deepening of disciplines such as information science and system engineering, the state and performance simulation of water resource management systems has become an important research method. This paper establishes and improves a mathematical model combining certainty and uncertainty, and realizes the informational analysis of water resources. Water supply project planning is an important means of optimal management and planning of water supply systems, and is also an important content of optimal management and planning of water supply systems [18].

(2) Multi-objective analysis of water resources system

The variability and randomness of water resources, the multi-objective and multi-task development and utilization of water resources, the interaction between river runoff and groundwater, and the relationship between water quality and water quantity make the development and utilization of water resources face severe challenges [19]. This requires a comprehensive and systematic analysis of the

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water resource system, and the use of linear programming, dynamic programming and other methods to plan water resources. The purpose of system analysis theory is to obtain the optimal solution of the objective equation.

(3) Water resource information management system

In order to meet the analysis and management needs of the water resources system, a water resources data analysis and management system was preliminarily established, mainly including data query system, information library system, water resources situation assessment system, water resources management system and optimization planning system [20]. The establishment and operation of the water resources data management system has improved the level of water resources research, accelerated the rational development, utilization and scientific management of water resources, and has become an important technical pillar of water resources research and management.

(4) Advanced nature of water environment theory and technology

The continuous development of human society and economy has profoundly affected the status quo of the environment and the changes in ecology. Changes in ecological and natural conditions will inevitably lead to changes in water resources in nature, thus breaking the original rules of change. The research on the changing law of water resources is to find the inseparable relationship between this changing law and social development and economic construction, and the effective use of water resources, so that the environmental quality will benefit the immediate and long-term interests of human beings. At the same time, it is also necessary to save water resources and promote the recycling and reuse of sewage. In recent years, China has made great progress in the research of modern theories and technologies for water pollution control.

3. Specific Operational Experiments on Water Resources Management

Integrated water resources management planning should start from the demand for rainwater management, consider the ecological characteristics and functions of the watershed as a whole, and based on the hydrogeological conditions, climatic conditions and existing natural ecology of the watershed, to formulate specific, implementable and assessable quantitative planning objectives. On the basis of clear planning objectives, selecting the appropriate LID (Low Impact Development) solution, and use the model simulation method to examine and evaluate the planning scheme. Figure 1 is a technical roadmap for the planning method of integrated water resources management based on the concept of LID.

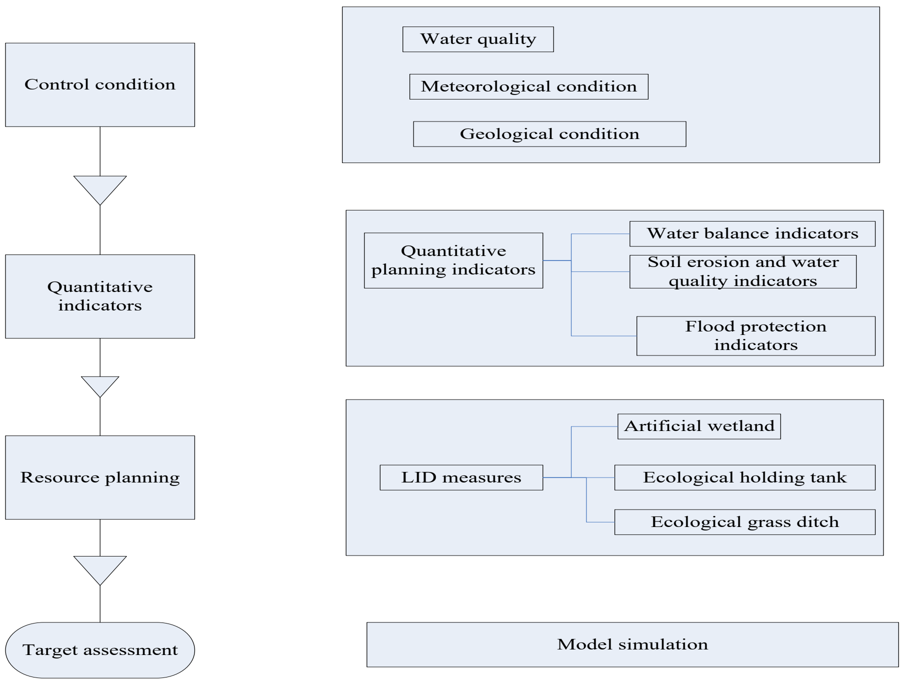

Figure 1: Technical roadmap of integrated water resources management planning method based on LID concept

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This paper evaluates the applicability of various LIDs in this area by analyzing the hydrogeological conditions, climatic conditions, and existing natural ecological foundations in the economic zone, in order to seek the implementable plan of integrated water resources management, and then explore the way to solve the sustainable development of the city.

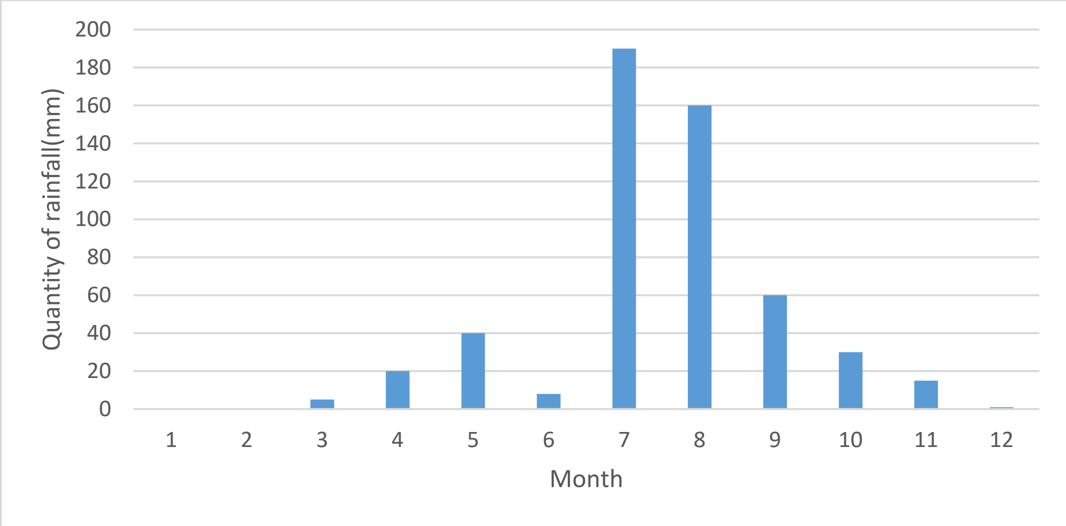

Figure 2: Monthly and multi-year average precipitation in the economic zone

The economic zone has a temperate semi-humid monsoon climate, with dry and windy spring, high temperature and high humidity in summer, and cold and dry winter. The rainfall is mainly concentrated in June to September, and the flood season occurs in July and August. The monthly and multi-year average precipitation in the economic zone is shown in Figure 2.

A 23km^2 urban watershed surrounded by the ring river in a certain economic zone is selected for simulation. The urban watershed is divided into 604 sub-catchments, and the average sub-catchment area is 3.8X10m^2. At the same time, 612 water collection wells, 615 pipelines, 4 rainwater pumping stations, the surrounding river and the East and West Lake systems were simulated. The study designed the operation of the water system under 7 working conditions (numbered 1-7) of the observed heavy rain on January 3, 2021 and July 24, August 15, and September 1, 2022.

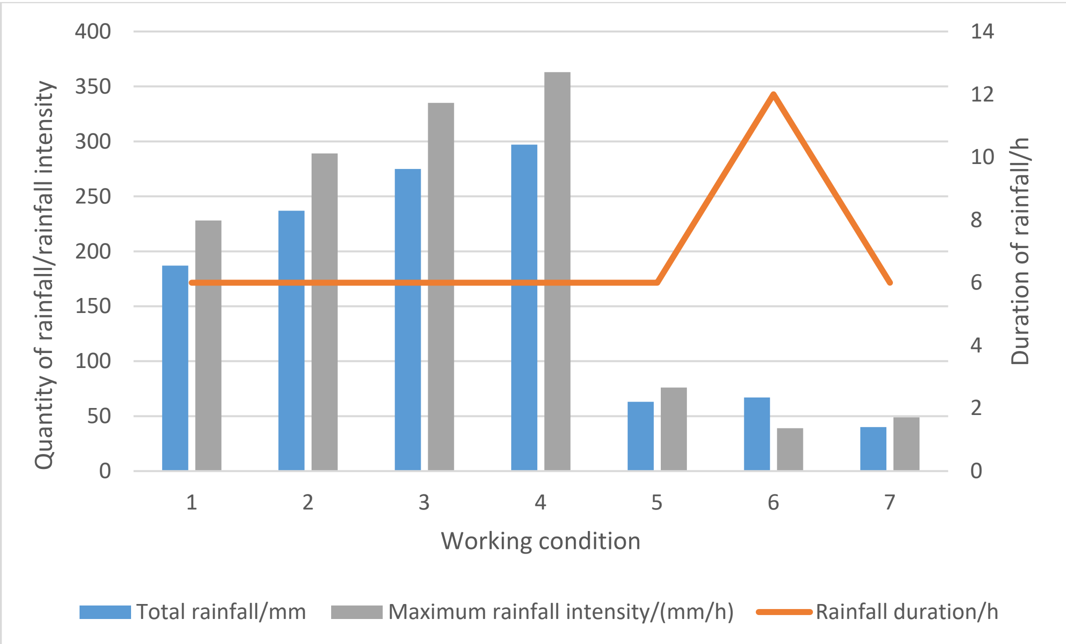

Figure 3: Rainfall under 7 working conditions

As shown in Figure 3, the total rainfall and the maximum rainfall continue to increase in the areas with working conditions numbered 1 to 4. However, the rainfall and rainfall intensity of working

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conditions 5 to 7 are relatively low. The duration of rainfall is 6 hours, and only the duration of rainfall in working condition 6 is 12 hours.

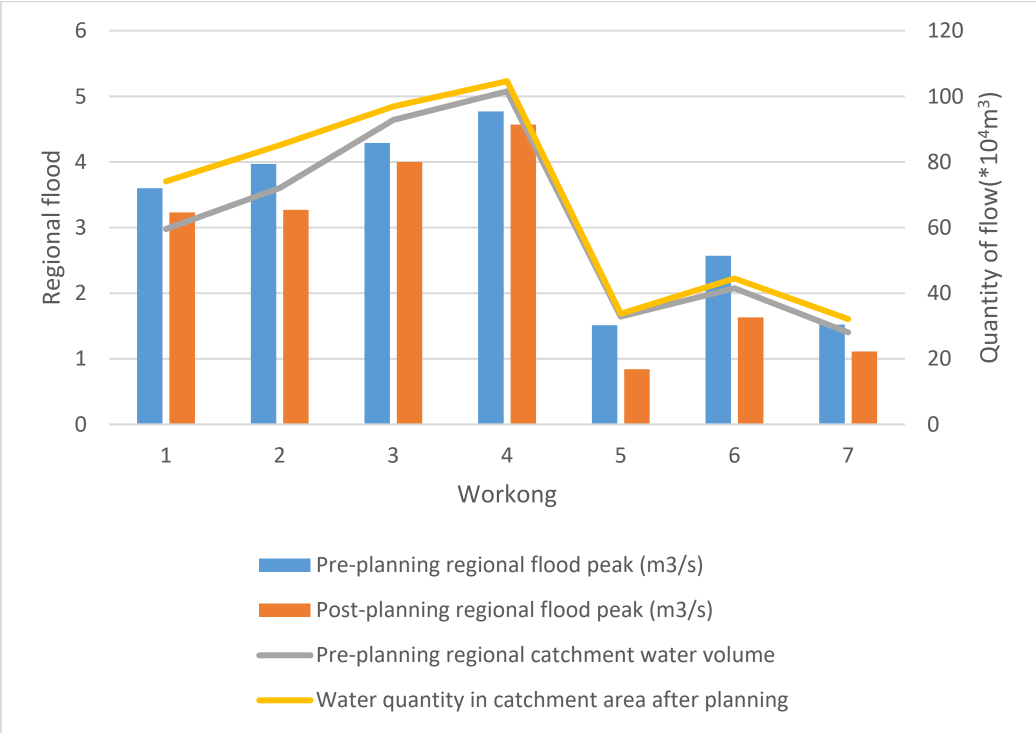

Figure 4: Regional water resources allocation under 7 working conditions

The distribution of regional water resources is shown in Figure 4. It can be seen from Figure 4 that for working condition 1, the water catchment after constructing the constructed wetland increases from the original 59.52X10^4m^3 to 74.08X10^4m^3, an increase of 24.5%. For the catchment area of $23km^2$ in the whole region, it can store 6.33mm more rainfall on average, which is of great significance to the stagnation and utilization of water resources. At the same time, through the local land use planning map and related data, it can be calculated that the impermeable area in the planned area accounts for about 63.4%, and intercepting 25mm of rainfall requires a storage space of 5.75X10'm^3, so the planned wetland can be completely controlled and eliminated water pollution due to initial scour.

4. Conclusion

In the process of urban development, the demand for water resources is increasing, but at the same time, it is also facing more and more serious water environmental problems. In the metropolis, how to effectively manage and protect water resources is a major issue to be solved in the future urban development. In recent years, Chinese cities have consciously implemented the principles of "water conservation priority, regional balance, systematic management, and two-pronged approach" into water resource management, so that water resources have been fully developed and utilized, protected and conserved, and water resources are allocated rationally, which has promoted the implementation of the most stringent water resources management system and promoted the full implementation of various tasks. This paper discusses the challenges and countermeasures of urban water resources planning and management, proposes detailed solutions, and verifies the feasibility of the solutions through experiments.

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