Research on the theoretical Framework of Integrated Urban Water System Planning Based on Water Cycle Theory

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Abstract: The city is a complex system, and the relationship between the city and the natural environment is very close, especially the interaction and relationship between water resources and water environment becomes more complicated in the city system. In recent years, there have been more and more researches on metabolism and recycling economy. This paper will use the concept of water cycle to carry out water system planning research. The study believes that the urban water system is an important part of the complex large-scale system of the city. It is the system of the natural circulation of water and the coupling of social circulation and urban space. According to the theory of water cycle, the final study divides the urban water system into rainfall, river system, water supply and water distribution system, urban water usage system, sewage treatment, water reuse, and rainwater discharge system. Based on the study of the relationship between traditional urban water-related planning and Integrated Urban Water System Planning(IUWSP), the theoretical framework structure of IUWSP(Integrated Urban Water System Planning[IUWSP]) is proposed.The planning system consists of the following modules: planning target determination method, standardized investigation content and method, and demand forecasting method, supply and demand analysis, comprehensive evaluation.

Keywords: water resources management, water cycle, water system planning method, theoretical system

1 What is the water cycle?

(1) Natural water circulation

The natural water cycle is the rainwater phase transition and the recurring process in the form of water vapor evaporation, water vapor transport, rainfall, runoff, and infiltration in the natural world, which Under the action of solar radiation and gravity.

As early as 1931, Horton studied the process mechanism of evaporation, condensation, sedimentation, runoff in natural water circulation (Horton, 1931).

The natural water cycle follows the law of conservation of mass, the change of water storage S0 = annual precipitation P0 - annual runoff R0 - annual evaporation F0

S0= S10+ S20+ S30+ S40

In this equation, S10—changes in soil water storage capacity; S20—changes in water storage in Tanggu; S30—changes in water storage capacity in rivers and lakes; S40—change in water storage capacity in wetlands

Runoff coefficient $\alpha 0=\frac{R0}{P0}$.

(2) Social water cycle

The social water cycle has emerged along with the development and utilization of water resources by human beings. It is a process of human "water intake – water supply – water drainage", and it is in the continuous flow of space and the process of recurrence.

In 1997, Merrett first introduced the concept of hydrosocial cycle, which was attached to the natural water cycle due to engineering activities and incorporated urban water and wastewater treatment services into the social water cycle(Merrett, 1997). Compared with evaporation, condensation, sedimentation, runoff and other processes in the natural water cycle(Horton, 1931), the process of social water cycle is represented by seven major engineering activities: water intake, storage, water treatment, water distribution, wastewater collection, wastewater treatment And wastewater discharge (Merrett, 1997).

Wang Hao divides the social water cycle into water intake, water usage, water drainage, backwater. The water intake system is the beginning of the social water cycle, the water usage system is the core, and the drainage system is the sink end(Wang Hao, 2011). Wang Hao also proposed that the social water cycle is a composite water cycle with a "natural-artificial" binary driving force and structure (Wang Hao, 2003).

(3) Urban water cycle

The urban water cycle is a complex cycle body formed by the natural water cycle and the social water cycle highly coupled in the urban area.

The discipline that studies urban water cycles is urban hydrology, which is developed on the basis of hydrology. Due to the more complex hydrological cycle and more external influences and interventions in urban areas, the urban water cycle should be studied separately. The main research contents include the impact of urbanization on hydrological processes, urban water supply and drainage, urban water environment, urban flood control, urban water resources, urban hydrological models and hydrological prediction, and urban water conservancy engineering.

The urban water cycle is a cyclical process that takes place in urban areas and is based on the natural water cycle and dominated by the social water cycle (Shao Yisheng, 2014).

UNESCO has studied the various components of the urban water cycle (UWC) and the main pathways of water flow, as shown in Figure 1(UNESCO, 2006). In the urban water cycle, the natural water cycle has changed due to the influence of urbanization.

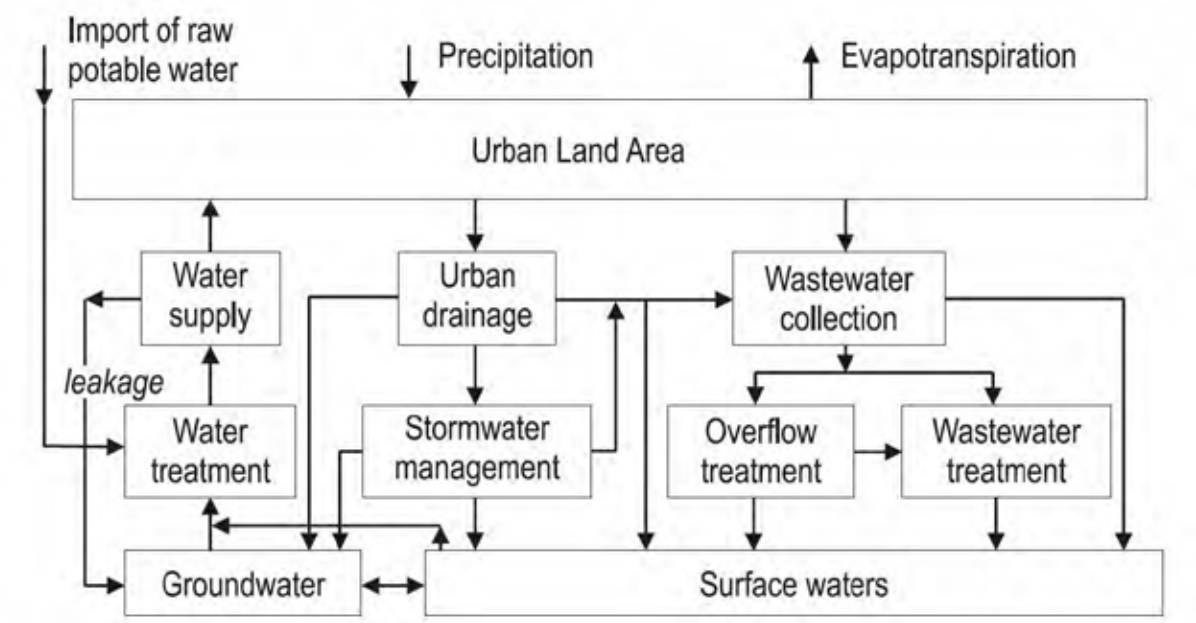

Figure 1 Urban Water Cycle - Major Composition and Water Flow Path (UNESCO, 2006)

2 What is the relationship between urban water systems and the water cycle?

(1) System overview

System science is a science that specializes in the evolution of complex systems and studies system composition, structure, feedback, and control. The purpose of systematic research is how to understand and control the system.

(2) Urban water system concept

The urban water system is based on the water cycle. The water system infrastructure is the carrier, and the comprehensive system is aiming at ensuring urban water security and improving the water environment. The urban water systemis an important part of the urban complex system. The general term for systems in the urbanization area contain flood control, water source development, water supply, water transport, water use, drainage, sewage treatment and reuse, and trans-regional water transfer, using, governance, configuration, conservation and protection. The urban water system involves the whole process of urban water resources development and utilization, protection and management (Chen Jining, 2014, Li Shuping, 2015, Shao Yisheng, 2004, Shao Yisheng, 2014). Urban water circulation system, including water source subsystem, water supply subsystem, water usage subsystem, drainage subsystem, recycling subsystem and rainwater subsystem.

(3) Urban water system problems

The development of urban water system from the solution of water, sewage, rainwater discharge to ecological civilization development process, most of China's cities have basically built a complete water supply and drainage system network and the corresponding water system supporting facilities. However, because the traditional urban water-related planning method is a single plan for their respective functions and services, and does not consider the overall water system service demand, therefore, the water system construction process in many cities in China does not conform to the development law of the water cycle, and the city lacks water. The problems of guilt and water pollution still exist, water resources are not fully utilized, water environment quality

is deteriorating, and urban water problems are still the limiting factors affecting urban economic development and people's living standards.

From 1978 to 2016, the urban water use population increased from 62.67 million to 450 million people, and the urban water supply scale increased from 7.875 billion m3 to 58.069 billion m3. The traditional urban water system has brought about a series of complex urban water problems in the process of adapting to the development trend of large cities and urban agglomerations, resulting in urban water disasters (Wang Guangtao, 2012, Cheng Xiaotao, 2009). The 2016 State of the Environment Bulletin shows that the quality of the national water environment is not optimistic. The lack of urban water resources has always been a major problem that has plagued most cities in China. Among more than 600 cities in China, there are currently more than 400 cities with insufficient water supply, including 110 cities with severe water shortages. The annual water shortage in the city is 6 billion cubic meters. Tianjin, Hebei, Shanxi, Inner Mongolia, Gansu and Qinghai The water resources of eight provinces, autonomous regions and municipalities directly under the Central Government, such as Ningxia and Xinjiang, are in short supply. On the other hand, in many cities in the Yangtze River Delta and Pearl River Delta regions where China's economy is developed, due to water pollution, some cities with rich water resources are also facing water shortage problems, and have to transfer water from remote areas with good water quality. But the treatment rate of sewage and the reuse of water resources are also low. The ecological crisis of the basin is largely due to the irrational development and utilization of urban water resources (Cheng Xiaotao, 2002).

There are also many severely water-deficient cities in coastal open cities such as Shanghai. The city can only rely on regional water transfer to solve urban water problems. Over-exploitation of water resources and trans-basin water transfer are the main means of solving most of the current water-deficient cities.

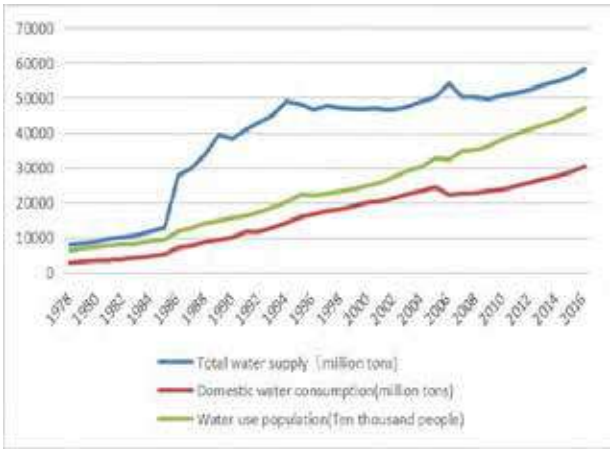

Figure 2 China's urban water supply over the years （sources:1978-2016 China Urban Construction Statistical Yearbook

In addition, the situation in China is also quite severe. According to the statistics of the National Flood Control and Drought Relief Headquarters Office, in 2010, 258 cities in China were in flood, most of which were torrential rains. From the distribution of the water retention points on June 1, June 19, and July 6 in Wuhan city(Seen in Figure 3), there is an increasing trend of change. The water retention points on July 6 is the most extensive, with as many water retention points and water retention road sections as more than 100 places, almost all three towns in Wuhan were flooded.

Figure 3 Schematic diagram of the city flood in wuhan city

In Hebei (North China), Zhejiang (East China), Harbin(Northeast), Guangzhou (South China), Wuhan (Central China), Northwest, Southwest(Wei Jun, et al,2018, Li Xuesong,et al,2018, Lin Changchun,et al, 2018, Zhai Jianming, et al,2017, Xie Zhiqiang, et al, 2017, Gao Feng, 2015), there have appeared varying degrees of urban flood, and urban flood has become a universal phenomenon throughout the country, not just the unique phenomenon of rainy cities in the south china.

Figure 3 Schematic diagram of urban water system problems（left: flood; medium:drought;right:Black stinky water body)

In the process of urban flood, the urban sponge system was occupied by urban construction land, resulting in water nowhere to go, resulting in urban flood. The water surface rate of rivers and lakes and the density of river networks have decreased, and there has been a situation in which people compete with water. For example, in the history of Wuhan, famous as“Yunmengze”,the area of sand lake was nearly 666.7 ha , but now it is less than 8 ha; Donghu lake has reduced 73 ha. The surrounding of Nanhu and Tangxun Lake are high-rise buildings, and Fanhu disappears.

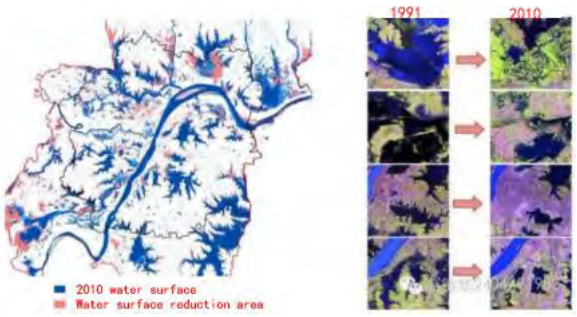

Figure 4 water area change situation in wuhan city（1991-2010）

(4) Analysis of the causes of urban water system problems based on water cycle theory

The causes of urban water system problems is, from the perspective of natural water cycle and social water cycle, urban development has brought the following effects to the urban water cycle:

1) Changes in the structure of the rainwater cycle

Most of the literatures believe that urbanization has brought about an increase in ground water impermeability. The traditional urban rainwater rapid discharge mode has led to an increase in rainwater runoff, a decrease in the rate of rainwater Infiltration, a change in the path of rainwater circulation, and a change in the structure of the rainwater circulation. These changes(Seen in Figure 5) arde prone to urban flood. At the same time, with the development of urbanized areas, natural channels and riverbeds were replaced by artificial channels and sewage pipe networks, resulting in profound changes in the way of runoff. Overall, these changes increase the rate of runoff propagation.

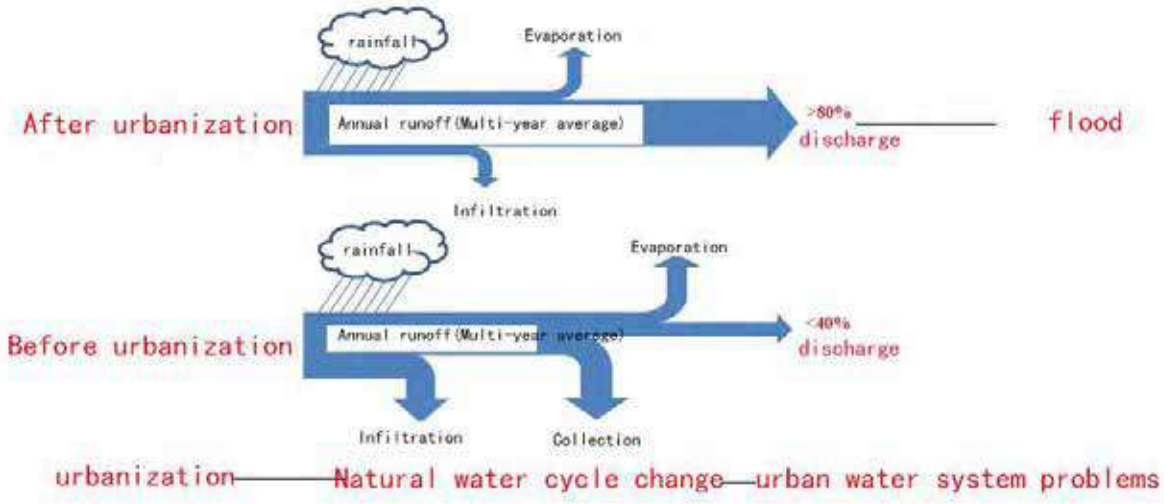

Figure 5 Schematic diagram of the impact of urbanization on the natural water cycle

In order to avoid changes in the natural water cycle caused by urban development and rapid urbanization, China proposed to build a sponge city and return to the hydrological state before urban development. Sponge City is to build a low-impact development rainwater system, that is, to follow the low-impact development concept in urban planning, implement low-impact development control objectives, and set up some low-impact development facilities to achieve the purpose of runoff control, runoff peak control, and rainwater resource utilization. Low-impact development facilities mainly include infiltration technology, storage technology, conditioning technology, transfer technology, and sewage purification technology, such as permeable paving,

green roof, sunken green space, penetrating pond, etc. Storage technology includes rainwater wetlands, rainwater tanks, etc. The adjustment technology includes regulating ponds, etc. The transfer technology includes planting ditch, infiltration pipe, etc., and the sewage interception and purification technology includes vegetation buffer zone and initial rainwater abandonment facilities. These technologies can be applied to various land types. Because they are different from traditional rainwater treatment measures, it is necessary to implement rainwater control schemes in various land types through the transformation of planning and construction, so as to make the path of rainwater circulation can be slower and shorter through microcirculation.

2) The social water cycle needs improvement

In the traditional water mode of one-way water cycle(Seen in Figure 6), the development of the city brings about an increase in water consumption, thereby reducing the reduction of groundwater recharge, while the increase in water consumption will lead to an increase in urban wastewater, resulting in pollutants in urban water bodies. The increase has thus aggravated the shortage of urban water resources, and the social water cycle lacks a closed link.

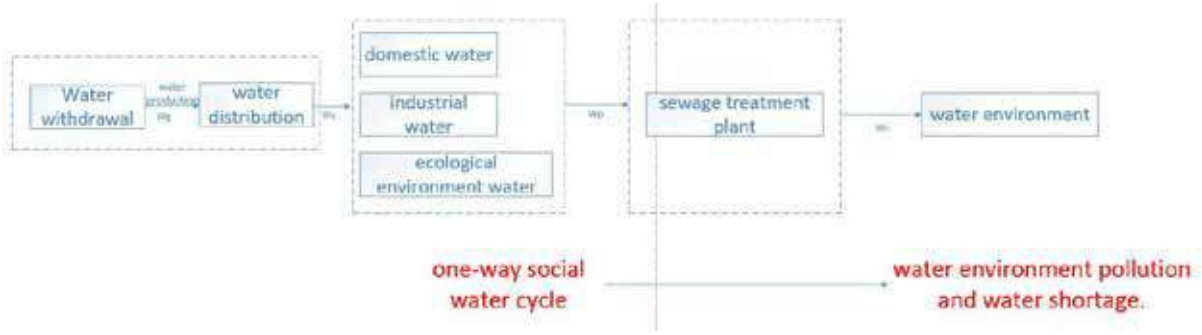

Figure 6 Schematic diagram of urban water pollution and water shortage caused by one-way social water cycle

Therefore, a benign circulation system for water resources should be constructed through the management of the urban water circulation system, composed with urban water intake, water supply and water distribution and drainage(Seen in Figure 7). Specifically, the following social water cycle improvement measures can be adopted:

- Improve sewage treatment rate and sewage treatment level, and reuse sewage,
- After the advanced treatment of wastewater, wastewater reaches the water quality of the corresponding water category, which will make wastewater re-enter the water supply system to reduce the water intake of fresh water in the city.
- Two major urban water systems, domestic water and industrial water systems, promote water reuse and establishment of micro-circulation of urban water systems.
- In industrial water, the industrial system is divided into industries that can recycle water internally, such as electricity and heat. The system consumes less water and has a high recycling rate. The amount of fresh water should be reduced.
- Centralized treatment of polluting industries: construction of industrial sewage treatment plants in industrial areas and centralized treatment of wastewater, including textile printing and dyeing industry, chemical industry, petroleum, papermaking, food processing, etc., can avoid environmental pollution.

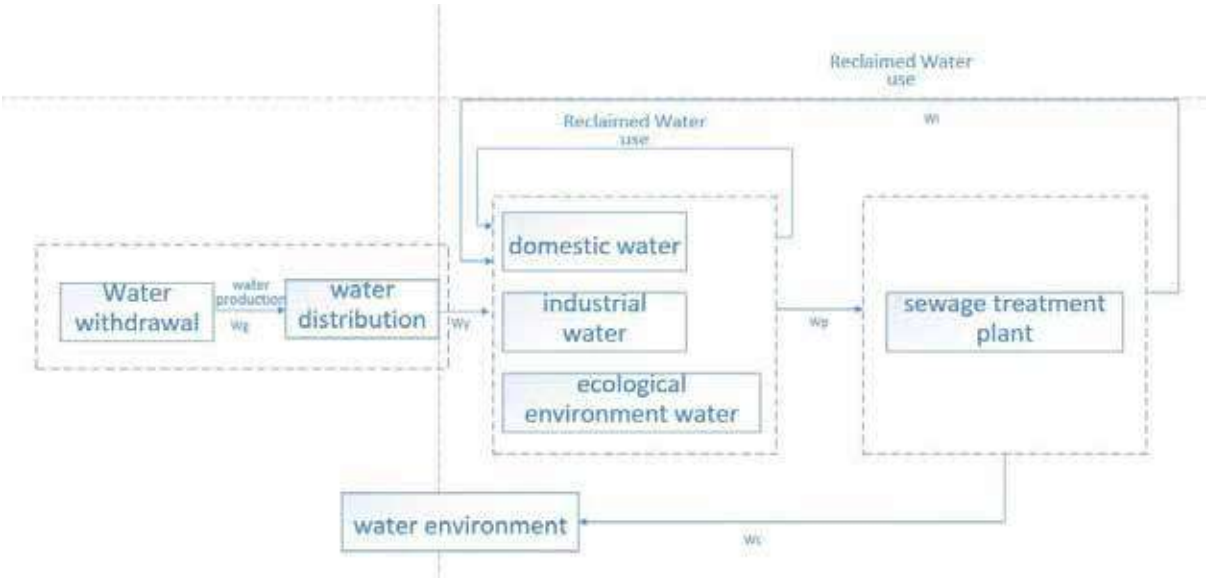

Figure 7 Schematic diagram of the construction of social water cycle system

- Control urban water consumption and reduce urban social water circulation flux：

The city is a densely populated area with a high intensity of water usage. The water consumption per capita and the water consumption per unit land are large. The surrounding agricultural land will decrease with the expansion of the city. Compared with agricultural and rural water use, urban water use mainly relies on centralized water supply system to provide urban residents with water for living, public services, municipal environment, etc., to ensure the basic domestic water demand of urban residents.

Urban water consumption is mainly related to urban development factors and urban water use indicators. It can be expressed by the following formula:

$$Q = D \times E$$

In the formula, Q represents the total amount of urban water; D represents the factors related to urban development, including population size, industrial development, land scale, environmental level, etc.; E represents indicators related to urban water use efficiency, including living water consumption per capita, the water consumption of the unit industry GDP , the water consumption per unit land, and the leakage rate. The system dynamics relationship among urban water consumption, urban development factors and urban water use efficiency indicators is as following Figure 8:

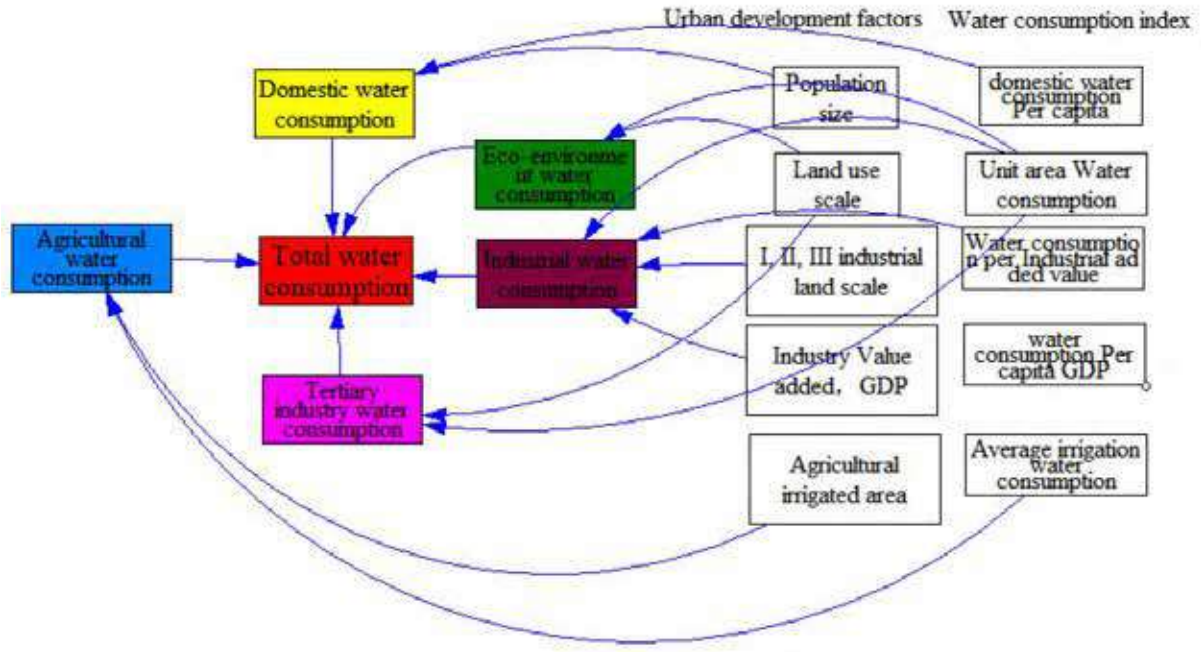

Figure 8 Conceptual diagram of system dynamics of urban development factors and water consumption (conceptual model)

Therefore, according to the city's own water resources, we should plan a reasonable population size and industrial structure, and reduce the social water circulation flux by improving water use efficiency. It can also effectively solve urban water environmental pollution and water shortage problems.

In short, in the case of meeting the the same amount demand for water in cities, the social water cycle process of urban water systems that directly serve the daily activities of the city (including urban water intake and water supply, water distribution, water usage, water treatment systems), by optimizing the system structure and operation Management measures (such as closing the circulating water, improving the sewage treatment level and reuse rate, reducing the leakage of water supply and drainage pipe network and facilities) can reduce the amount of water collected by the city from the natural water cycle system and the amount of water discharge after use. The water quality of wastewater has a negative impact on the water quality of the natural water cycle system. Conversely, the use of inappropriate and unscientific system structures and operational management measures will increase the burden on urban water distribution and water treatment systems, worsen the environmental quality of urban and regional water systems, and reduce the availability of urban and regional water resources.

3 Why should we prepare IUWSP?

Shao Yisheng (Shao Yisheng, 2004, Shao Yisheng, 2014) believes that China's current urban water-related planning is very diverse, the content is very rich, the professional foundation is relatively solid, the distinctive features of professional labor division, departmental management and system division is shown, and more subjects are planned and implemented. However, the current urban water-related planning lacks overall consideration based on the law of water circulation. There are obvious limitations. The systemic, hierarchical and coordination of planning is insufficient. The preparation and implementation of the planning is not satisfactory. Systematically solving the urban water problems is not working well.

At present, the urban water-related planning carried out in China mainly includes special plans for sponge cities, special planning for drainage projects, comprehensive planning for drainage (rainwater) and flood control, special planning for urban flood control , urban water system planning, urban water supply engineering planning, urban reclaimed water utilization planning, and comprehensive planning of urban water resources, comprehensive planning of water pollution prevention, etc. The content of urban water-related planning is very rich, and there are many main bodies in planning, and the planning scope and planning level are not uniform. The main targets and planning main objectives are different. The management and implementation departments are different, the time of planning appearance is different, the planning effect is not uniform, and it is difficult to coordinate effectively.

4 What is the IUWSP?

(1) The concept of IUWSP

IUWSP takes the urban water system as the research object, comprehensively solves the urban water problem, constructs a benign urban water cycle, and creates an effective planning means for urban space such as urban water resources, water security, water ecology and water environment.

Shao Yisheng(shao yisheng,2014) believes that urban water system planning is a framework system based on the principle of urban water cycle. It consists of IUWSP and urban water system special planning. The main goal of IUWSP is to optimize water system structure, improve water system function and promote the water system circulation, to ensure the safety of the water system; the main tasks of the comprehensive planning of the water system are to determine the water resources carrying capacity, water environment carrying capacity, water system facilities support capacity, water safety emergency rescue capability, and balance the water demand of the “three generations(living, production, ecology)”.

Kong Yanhong(Kong Yanhong,*et al*. 2013) also studied the preparation of urban water system planning, and proposed that the water system planning includes water environment system investigation and analysis, water resources optimization allocation, water system layout and space management, water environment protection, water environmental system security, planning and coordination, etc. Based on the overall urban planning, the plan integrates urban water resources, water systems, water supply, reclaimed water, sewage, rainwater and flood control systems, and urban blue line space control , which is a comprehensive plan for the organic integration of water-related special planning in urban and rural planning sequences. From the perspective of planning, Kong believes that the urban system planning is too macroscopic, the control detailed planning is too micro to accurately grasp the city's water problems, while the engineering facilities planning in the urban master planning focuses on the system layout and engineering facilities. So positioning the plan as: An important part of the urban master plan and the strategic plan for comprehensively solving urban water environment problems at the macro level, and the upper plan for each water-related special plan.

(2) Main objectives of IUWSP

According to the characteristics of different cities, the main objectives of IUWSP research are different. The major problems of water system should be identified based on the characteristics of each city. On this basis, different planning objectives and planning strategies are formulated.

According to literature research, the city is divided into water resource utilization cities, flood disaster prevention cities, and comprehensive coordination cities from the perspective of the water system. In various types of cities, the focus of IUWSP is different. The main problem of water resource utilization cities is how to improve the carrying capacity of water resources, to set cities by water, to set people by water, and to set production by water.

The main problem of flood disaster prevention cities is how to adapt to urban flooding through the optimization of urban space, and to prevent floods from occurring through engineering and non-engineering measures.

Comprehensive coordinated cities generally have various types of water problems, and the focus is on how to coordinate various water issues.

As a city with quantities of big river, Wuhan is rich in water resources. In mega-cities, its water consumption and sewage treatment capacity are huge, which leads to the demand for improved water supply quality and water supply safety and reliability in Wuhan. In the aspect of flood control and drainage, serious urban flood occurred in recent years. The situation requires that the comprehensive planning of Wuhan Water System focuses on how to improve the level of flood control and drainage in Wuhan; the water-rich cities as Wuhan city are also facing the problem of water environment management.

(3) The relationship between IUWSP and water-related planning

"The Law on Prevention and Control of Water Pollution" is a fundamental law for preventing and controlling water pollution, aiming at protecting and improving the water environment and ensuring the safety of drinking water in China. This Law has clarified the water pollution prevention and control planning system in China and has also clarified the construction plan for sewage treatment facilities. According to "the Law on Prevention and Control of Water Pollution", the coordination parts of IUWSP, water pollution prevention planning and construction scale of sewage treatment facilities includes:(Chen Liqun,2013) ①Water environment functional division;②pollutant discharge standard;③Total pollutant discharges;④Urban sewage treatment facilities and pipe network planning;⑤sewage outlets setting. The relationship between the water pollution prevention planning system and IUWSP is as following Figure 9:

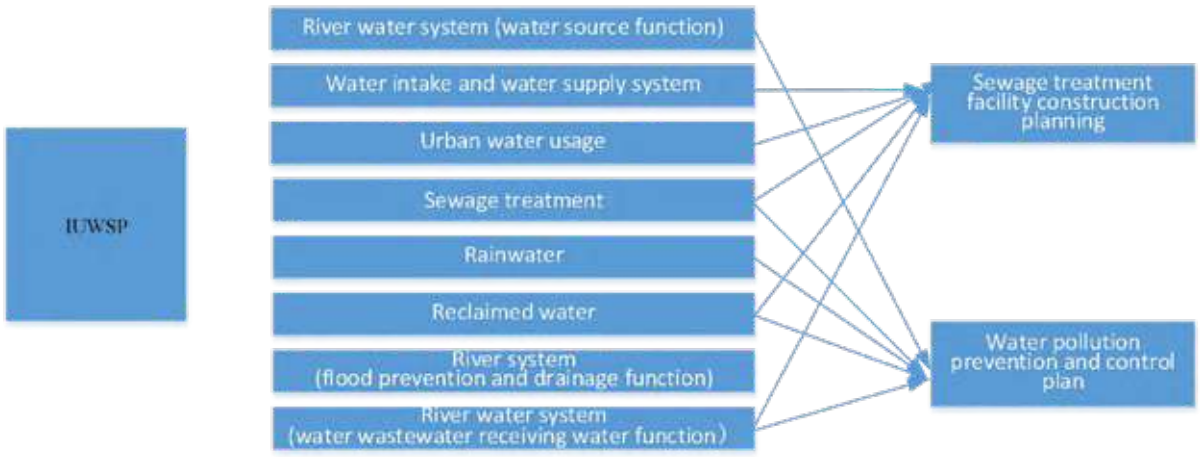

Figure 9 Relationship among IUWSP, water pollution prevention planning and sewage treatment facility construction

"The Water Law" has established a relatively complete water resources planning system, including flood control, drainage, irrigation, shipping, water supply, hydropower, fisheries, water resources protection, soil erosion, sand control and water conservation. The relationship between the water resources planning system and IUWSP is as follows Figure 10:

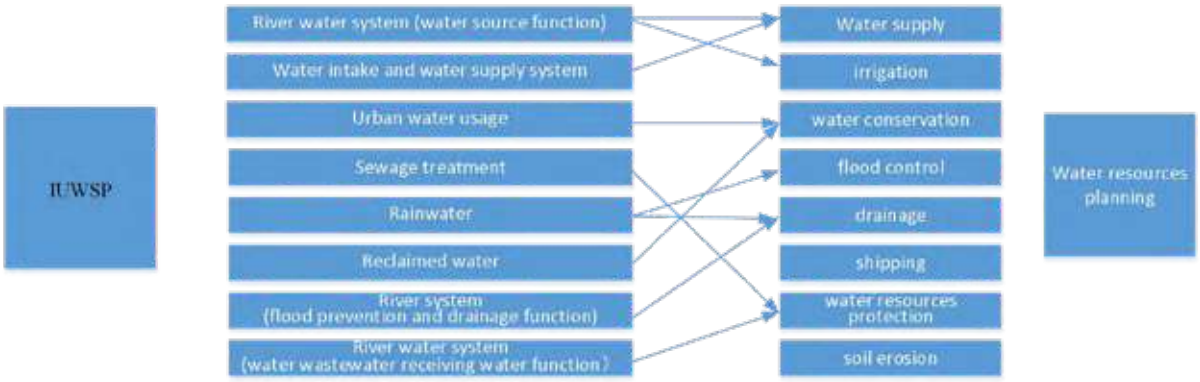

Figure 10 The relationship between the water resources planning system and IUWSP

(4) Planning and management mechanism for IUWSP

According to the functions of the Ministry of Natural Resources in china, IUWSP will be compiled by the Ministry of Natural Resources and its subordinate departments, emphasizing the overall management of the water resources system and avoiding unreasonable and uncoordinated individual plans.

Department of Water Ecology and Environment in Ministry of Ecology and Environmental Protection can: integrate the water function zoning and sewage outlets of the water conservancy department, the non-point source pollution control of the Ministry of Agriculture, and the groundwater pollution control responsibility of the national land department.

The organizational unit model for urban water-related special planning mainly consists of: planning bureau model, planning bureau and industry competent department model, and industry competent department model. To sum up, the urban water-related plan is the guiding document for the industry authorities to carry out water system infrastructure construction and management (Chen Liqun,2013).

From the above, the tasks of the Environmental Protection Bureau, the Planning Bureau and the Water Resources Bureau are relatively clear. The Environmental Protection Agency manages the water environment, sewage and reclaimed water, and the Water Resources Bureau manages water resources and flood control. The Planning Bureau conducts space control, including blue line control. The rest of the special projects such as rainwater, sewage, reclaimed water, water supply, flood control, drainage, etc. are all responsible for the construction department, some are managed by construction department in the Construction Bureau, some are managed by construction department in the Water Affairs Bureau, and some are managed by construction department in the Urban Management Bureau or the State-owned Assets Supervision and Administration Commission. Under various departments, there are also more companies to operate specifically, such as the Water Supply Group, the City Investment company in Water service, and the Reclaimed Water Company. These departments are franchised for water supply, sewage treatment and reuse of recycled water. However, traditional tasks such as flood control or drainage are generally handled by the drainage department(Chen Liqun,2013).

From the above analysis, urban water-related planning belongs to the scope of the city government. However, in order to facilitate the construction of urban water affairs, all relevant functional departments carry out construction and management, but Coordination and integration from the planning level is the current planning reform trends, like energy integrated planning(Huang Zishuo,*et al*.,2018), Comprehensive Transportation Planning, Communication planning.

(5) Implementation path of IUWSP

According to Chen Liqun's research on the implementation path of water system planning (Chen Liqun, 2013), implementation mechanism and management research of IUWSP , IUWSP belongs to the non-statutory planning at the macro level. There are two implementation paths: ① thematic form, relying on the urban development strategy. The planning or master plan is carried out in the form of IUWSP research, and its main results are incorporated into the urban development strategic planning or overall planning, and the implementation of IUWSP is guaranteed by the implementation of urban development strategic planning or overall planning.② Prepared separately. IUWSP guides subordinate planning - control detailed planning and water-related special planning.

(6) New IUWSP types have emerged

In the current practice, there are few types of projects for IUWSP, including " Wuhan City World Waterfront City and Water Special Project Planning ", " Water System Special Plan in Shenhai Qianhai Cooperation Zone " and "Water System Special Plan in Zhongxin Tianjin Ecology city ". The planning projects such as the Urban Water System Special Plan are dedicated to integrating water supply, rainwater, sewage, reclaimed water and all water-related systems, controlling and regulating the rainwater, utilizing water resources, water pollution management, and improving the water environment, building a safe, healthy and efficient water environment system.

5 How to prepare IUWSP

(1) construction process of the overall framework system

This paper takes the whole theory of urban water circulation as the most important goal and principle to guide the reform of IUWSP. Urban water systems are interconnected and mutually constrained to provide infrastructure for urban development.

This paper takes water source system, water supply system, sewage discharge system, water reuse system and rainwater discharge system in urban water system as the research object, and studies the urban water system planning method from the perspective of urban systematics. IUWSP that satisfies the urban water cycle theory is a good plan to guide the construction of the full text. The specific construction steps of theoretical framework system are:

① Through the analysis of the development history of urban water system planning theory, the characteristics of traditional urban water system planning theory are found. Under the new situation of urban water system development, the traditional urban water-related planning theory and method have a single planning target and urban water system demand. There are drawbacks in the shortcomings of the forecasting method, the lack of information feedback, the evaluation index system is not comprehensive, and the theory that does not reflect the water cycle.

② Based on the theory of water cycle, the concept and planning principles of urban water system circulation are proposed.

③ Under the guidance of the water cycle theory, a set of theoretical system framework for urban water system sustainable development planning that considers China's national conditions is proposed and designed, to meet water supply needs, optimize water resources utilization, improve water environment quality, and ensure urban flood safety. The function of each module in the theoretical system is actually designed.

④ Finally, the level of IUWSP and the general planning process are studied.

(2) The composition of the theoretical system of IUWSP

Introducing environmental protection, service level, resource utilization optimization, and safety assurance into the urban water system planning process, completely changing the traditional single planning method, which is just to solve their respective needs as the sole planning goal. Establishing total water consumption control, water efficiency control, and environment quality control and the number of floods control as controlling indicators. Establishing the theoretical framework structure of IUWSP and designing each functional module in the framework structure.

IUWSP consists of the following modules in Figure 11:

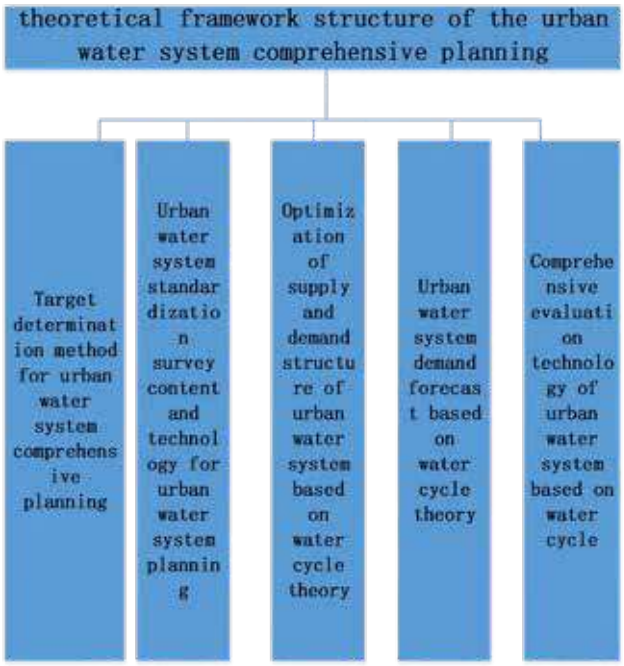

Figure 11 Theoretical framework structure of IUWSP

1) Target determination method for IUWSP

The urban water system planning under the guidance of traditional targets will not only lead to the emergence of "water shortage, water environment pollution, internal security", but also destroy the urban water environment and waste urban water resources. Under the urban water cycle theory, it is proposed to establish an urban water system planning target system consisting of four aspects: meeting urban water supply demand, optimizing water resources utilization structure, improving water environment quality, and ensuring urban safety.

In view of the lack of research on the implementation and guarantee system for the traditional urban water system planning, it is considered that the establishment of the urban water system planning implementation and guarantee system is also one of the objectives of the plan.

IUWSP target system is composed of the service level index system, the environmental protection index system, the urban security guarantee system, and the resource structure optimization system. The quantitative methods for the specific indicators are studied. The secondary indicators for improving service levels include: resource supply and pipeline network construction. Secondary indicators for improving the environment include rehabilitating the environment, protecting the environment, and saving water to protect groundwater. The

secondary indicators for urban security include security, redundancy, and emergency protection. The secondary indicators for resource structure optimization include: improving efficiency, energy saving and emission reduction.

2) Urban water system standardization survey content and technology for IUWSP

In the IUWSP, the principles of investigation design and implementation should be clearly defined, and the investigation methods should be clearly defined to comply with the principle of water cycle. The purpose of the survey is not only to establish a database of water system information, but more importantly, to investigate the current water system and to discover the problems of the current urban water system that does not meet the principle of water cycle development.

The urban water system standardization survey according to water circulation includes the various components of the water system: water resources, water plants and other infrastructure, water use indicators, water pollution and flood disasters, pipe network construction, flood control standards, and the establishment foundation of the water system (urban population, economy, industry, natural environment).

The survey methods are divided into two categories: data collection surveys and field surveys.

Studying the establishment method of GIS database for urban water system standardization survey according to water cycle, and on this basis, proposing the current urban water system analysis and diagnosis method.

According to the water cycle and metabolism theory, a standardized survey of urban water systems is organized. The content of the standardized survey will include the following: survey methods; survey departments and information lists; survey content; form a database.

3) Optimization of supply and demand structure of urban water system based on water cycle theory

Guided by the above framework, the optimization of water supply and demand structure, the optimization of rainwater supply and demand structure, and the optimization of water and pollutants supply and demand structure are the key to IUWSP. Guided to propose planning responses to key tasks in the supply of urban water system infrastructure. The above three parts are used as a new countermeasure analysis framework to form a complete planning response model. A series of water problems appearing in the future urban water system planning reform can be analyzed according to this new framework and model.

The urban water supply and demand structure is the key to study the urban water resources carrying capacity, and it is the main aspect of supporting the development factors of the city. The water resources carrying capacity is mainly composed of the urban water supply capacity and demand capacity, and the two are mutually constrained. The study of urban water resources is a primary part and a key part of comprehensive urban water resources planning.

The drainage structure of urban water supply and drainage system in China must be established on the basis of China's national conditions. The per capita water resources are small, the infrastructure is weak, and the rainfall is concentrated. This is the basic situation of China, which determines that China must take water-saving measure. The development model of social, environmentally friendly society and intrinsic safety protection focuses on urban connotative development.

According to the characteristics of urban development in China, on the basis of water usage feature, natural conditions and urban scale, population density, urban form, topography and geomorphology in studying urban,

with reference to the experience and lessons of the development process of foreign water systems, IUWSP priorities of different cities should be proposed.

4) Urban water system demand forecast based on water cycle theory

In the IUWSP, the water supply and demand forecast mainly includes various urban water demand. The sewage treatment demand is mainly determined by the water supply demand, and the urban rainwater discharge demand is mainly determined by the urban drainage standard.

In the formulation of planning schemes and strategies, the urban water system construction needs are first defined, and the demand forecasting methods are studied. The most important is to identify the various demand impact factors and construct the systematic dynamics equation of demand.

Urban water system demand forecasting technology is one of the key technologies for IUWSP. Its specific contents include the following: urban water demand forecast; urban water environment governance demand forecast; urban rainwater discharge demand forecast.

5) Comprehensive evaluation technology of urban water system based on water cycle

In the traditional urban water-related planning, the evaluation content focuses on the ability and level of urban water system to solve water problems, water supply planning to solve water supply security, sewage planning to solve sewage treatment, water system planning to solve water system layout, and sponge city planning to solve stormwater runoff control and Rainwater resource utilization, flood control planning to solve urban flooding caused by internal flooding problems, urban flood control planning to solve flood safety problems. While in the IUWSP under the water cycle theory, the evaluation content includes the efficiency of urban water system infrastructure, urban flood control standards, the connection between drainage pipe network standards, the supply capacity of urban water supply facilities, the quality of urban water environment, the perfection of urban sewage treatment facilities, and the efficiency of urban water usage.

Evaluation plays a three-pronged role in urban planning for water cycles. First, the evaluation determines the value of each option and the advantages and disadvantages between the programs. Second, the evaluation provides decision-making information for decision makers. Third, the evaluation provides planners with ideas and directions for the development of water systems.

Evaluate the status and level of the current urban water system development, identify the phenomenon that does not meet the development principles of the water cycle theory, and define the direction of urban water system development; the focus of the planning is to investigate the plan to meet the the water system needs, at the same time whether it meets the requirements of ecological environment and resource consumption.

It puts forward an evaluation index system composed of indicators such as flood control and drainage standard suitability, green infrastructure development rate, water environment quality, urban water supply service level, urban water system development coordination degree, etc. The comprehensive evaluation technology of urban water system network oriented to water cycle is studied.

6 Conclusion

This paper takes water source system, water supply system, sewage discharge system, water reuse system and rainwater discharge system in urban water system as the research object, and studies IUWSP method from the perspective of urban systematics. IUWSP that satisfies the urban water cycle theory is a good plan to guide the construction of the full text. On this basis, Establishing the theoretical framework structure of IUWSP and designing each functional module in the framework structure.

7 References

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