

Research on Water Supply and Demand in the Huaihe River Water Network Planning

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Abstract: As one of the significant rivers in China, the Huai River's water network planning and the balance of water supply and demand are of vital importance to the regional economic and social development as well as the stability of the ecological environment. This paper first analyzes the current situation and planning background of the Huaihe River water network, and then deeply dissects the specific manifestations and causes of the contradiction between water supply and demand in this basin. Based on this, a series of countermeasures and suggestions for achieving a balance between water supply and demand are proposed, aiming to provide strong theoretical support and practical reference for the scientific formulation and effective implementation of the Huaihe River water network planning. Promote the sustainable utilization of water resources and coordinated regional development in the Huai River Basin.

1. Introduction

In recent years, due to the rapid development of the economy and society, the advancement of urbanization and climate change, problems such as water shortage, intensified water pollution and deterioration of water ecology have become prominent in the Huai River Basin. The contradiction between water supply and demand has been continuously escalating, seriously restricting sustainable development. Water network planning is a key means to optimize water resource allocation and enhance utilization efficiency. Against this backdrop, analyzing the current situation of the water network, the contradiction between water supply and demand and its causes, and proposing balanced countermeasures can provide a basis for the scientific formulation of water network planning, which is of great significance for ensuring water supply and ecological security in the basin and promoting coordinated regional development.

2. Current Situation and Planning Background of the Huaihe River Water Network

2.1 Current Situation of the Huaihe River Water Network

The Huai River water network is composed of the main stream, tributaries, and water conservancy projects such as lakes, reservoirs, and irrigation districts. It has multiple functions

including flood control, water supply, irrigation, shipping, and ecological protection. Currently, a configuration pattern has been initially formed, with the main stream as the backbone, tributaries as the veins, and reservoirs and lakes as the storage and regulation nodes. However, there are still four major problems: First, the layout is unreasonable. In some areas, water conservancy facilities are weak, the allocation capacity is insufficient, and the uneven distribution of regional water resources is prominent. Second, the engineering is aging and in disrepair. Some reservoirs, pumping stations and other facilities are outdated and their functions have declined, which affects water use efficiency and operational safety. Thirdly, there is poor connectivity. There is a lack of effective connection facilities between water systems and projects, making it difficult to optimize the allocation of water resources. Fourth, water ecological problems are prominent. Some rivers and lakes are severely polluted and their ecosystems are damaged, which affects the quality and sustainable utilization of water resources.

2.2 Background of the Huai River Water Network Planning

With the rapid economic and social development and the continuous advancement of ecological civilization construction in the Huai River Basin, the demand for water resources is increasing day by day. In response to the increasingly severe water resources situation, to resolve the contradiction between water supply and demand, to improve the water ecological environment, and to ensure the sustainable development of the regional economy and society, the state has successively issued a series of policy documents, putting forward clear requirements and goals for the planning and construction of the Huai River water network. According to relevant plans, the overall goal of the Huaihe River water network planning is: By optimizing the water network layout, improving the water conservancy project system, strengthening water resource allocation and management, enhancing water resource utilization efficiency, and improving the water ecological environment, a modern water network system that is "complete in system, safe and reliable, intensive and efficient, green and intelligent, and unobstructed in circulation" will be constructed, providing a solid water security guarantee for the high-quality economic and social development of the Huai River Basin.

3. Analysis of the Contradiction between Water Supply and Demand in the Huai River Basin

3.1 Specific Manifestations of the contradiction between Water Supply and Demand

(1) Contradiction between total supply and demand

Although the total amount of water resources in the Huai River Basin is relatively abundant, due to the large population and rapid economic and social development, the demand for water has been continuously increasing, and the contradiction between the total supply and demand has become prominent. It is predicted that by 2030, the total water demand of the basin will exceed 65 billion cubic meters, while the available water supply will only be about 60 billion cubic meters, with a gap of over 5 billion cubic meters. The contradiction between total supply and demand will further intensify. In dry years, due to reduced precipitation and runoff, the available water supply drops sharply, making the contradiction between supply and demand more acute. This may lead to severe water shortages in some areas, affecting the operation of the economy and society as well as people's livelihood.

(2) Contradiction between supply and demand in terms of temporal and spatial distribution

The temporal and spatial distribution of water resources in the Huai River Basin is uneven, further intensifying the contradiction between water supply and demand. In terms of time distribution, precipitation and runoff are mainly concentrated in summer, while in spring and winter, the amount of precipitation and runoff is relatively small, but the water demand is relatively high,

resulting in a more prominent seasonal water shortage problem [1]. In terms of spatial distribution, water resources are relatively abundant in the southern mountainous and hilly areas, while those in the northern plain are relatively scarce. Moreover, the northern plain is an important agricultural production area and industrial base in the Huai River Basin, with a large demand for water and a more severe contradiction between water supply and demand.

(3) Supply and demand contradiction of water quality type

With the rapid economic and social development of the Huai River Basin, the problem of water pollution has become increasingly prominent, leading to a serious problem of water quality-based water shortage. The water quality of some rivers and lakes has been severely polluted, failing to meet the requirements for domestic water use, agricultural irrigation water use and industrial water use, which has led to a significant reduction in the amount of available water resources. In addition, the problem of groundwater pollution has become increasingly prominent. In some areas, groundwater can no longer be used as a source of drinking water, further intensifying the contradiction between water supply and demand [2].

3.2 Analysis of the Causes of the Contradiction between Water Supply and Demand

(1) Natural factors

The first is the impact of climate change. Global warming has led to changes in the precipitation pattern in the Huai River Basin. The phenomenon of uneven temporal and spatial distribution of precipitation has become more prominent, and extreme weather events occur frequently, resulting in unstable total water resources and a reduction in the amount of available water resources. The second is the influence of water resource endowment. The total amount of water resources in the Huai River Basin is relatively abundant, but the per capita water resources and the average water resources per mu are relatively low, only about one fifth and one third of the national average respectively. The water resource endowment is poor and it is difficult to meet the water demand of the rapid economic and social development. In addition, the temporal and spatial distribution of water resources in the Huai River Basin is uneven, further intensifying the contradiction between water supply and demand.

(2) Human factors

First, the growth of water demand is driven by economic and social development. With the advancement of urbanization and industrialization, the proportion of high-water-consuming industries is high and water-saving technologies are backward, resulting in serious waste of water resources. Agricultural land is vast, traditional irrigation methods have not been completely replaced, the proportion of high-water-consuming crops is high, and water demand remains high. The increase in urban population and the improvement of residents' living standards have led to a continuous rise in per capita water consumption, exerting considerable pressure on urban water supply [3].

The second issue is that the water resources management system and mechanism are not yet perfect. The river basin involves multiple provinces and has the problem of "multi-headed management", lacking a unified coordination mechanism and making cross-regional allocation difficult. In terms of the pricing mechanism, the prices are relatively low and fail to fully reflect the scarcity of water resources and the cost of their use, resulting in weak water conservation awareness in some regions and industries. The water resources monitoring system is not perfect, with insufficient facilities, low data accuracy and timeliness, which affects the scientific nature of management decisions.

The third issue is the lagging planning and construction of the water network. The water network planning is not closely connected with economic and social development and the supply and

demand situation of water resources, lacking forward-looking and scientific nature, and thus is difficult to meet the demands of water resource management in the new situation. Some water conservancy projects have lagged behind in progress due to insufficient funds and long construction periods. The water network's connectivity and storage capacity are inadequate, making it impossible to achieve efficient cross-regional and cross-temporal allocation of water resources, thus exacerbating the contradiction between supply and demand.

4. Countermeasures for Balancing Water Supply and Demand in the Planning of the Huaihe River Water Network

4.1 Optimize the allocation of water resources and enhance the efficiency of water resource utilization

(1) Strengthen the construction of cross-regional water resources allocation projects

In line with the planning goals of the Huaihe River water network, we should accelerate the construction of cross-regional and cross-basin water resource allocation projects, and build a water resource allocation pattern that is "interconnected in the north and south and mutually reinforcing in the east and west", to alleviate the water shortage problem in the northern plain areas and cities [4]. At the same time, we should strengthen the joint dispatching of existing water conservancy projects, give full play to the role of reservoirs, lakes and other water storage and regulation projects, improve the spatio-temporal allocation capacity of water resources, and ensure the safety of water supply during the dry season. By optimizing the dispatching plans of key water conservancy projects and rationally regulating the allocation of water resources within the basin, the demands for agricultural irrigation, urban water supply and ecological water use can be met.

(2) Promote water conservation and efficiency improvement in agriculture

Agriculture is a major water consumer in the Huai River Basin. Promoting water conservation in agriculture is a key measure to achieve a balance between water supply and demand. The specific measures and goals are shown in Table 1.

Table 1 Measures and Targets for Water Conservation and Efficiency Enhancement in Agriculture

Category of measures	Specific content	Quantitative goals
Optimization of planting structure	Adjust the layout of crops based on water resource conditions, reduce the planting area of high-water-consuming crops, and promote drought-resistant and water-saving crops	Reduce the proportion of high-water-consuming crops by more than 15% in water-scarce areas
Promotion of water-saving technologies	We will intensify the promotion of efficient water-saving irrigation technologies such as drip irrigation, sprinkler irrigation and pipe irrigation, and build high-standard water-saving projects for farmland	The effective utilization coefficient of farmland irrigation water has been raised to above 0.65
Strengthening of water management	Establish a total control and quota management system for agricultural water use, and implement metered charging for agricultural water use	The rate of water waste in agriculture has been reduced to below 8%

(3) Strengthen water conservation and emission reduction in industry

In light of the characteristics of industrial water use in the Huai River Basin, efforts should be made to enhance water conservation and emission reduction in industry and improve the efficiency of industrial water use. First, optimize the industrial structure, strictly restrict the development of high-water-consuming and high-pollution industries, encourage the development of water-saving

and environmentally friendly industries, promote industrial transformation and upgrading, carry out technological transformation of traditional high-water-consuming industries, and reduce water consumption per unit of output value [5]. Second, promote water-saving technologies in industry, enhance water recycling and reclaimed water reuse, and increase the reuse rate of industrial water. Third, we should strengthen the treatment of industrial wastewater, strictly enforce the discharge standards for industrial wastewater, promote centralized treatment and reuse of industrial wastewater, reduce the discharge volume of industrial wastewater, improve water environment quality, and increase the amount of available water resources.

(4) Promote water conservation in daily life

With the acceleration of urbanization, the demand for domestic water is constantly increasing. It is of vital importance to promote water conservation in daily life. The specific measures and goals are shown in Table 2.

Table 2 Measures and Targets for Water Conservation in Daily Life

Category of measures	Specific content	Quantitative goals
Promotion of water-saving appliances	Strengthen market supervision and enforce the promotion of water-saving toilets, faucets, shower heads and other appliances	The popularization rate of water-saving appliances among urban residents has increased to over 95%
Renovation of water supply network	Update the old water supply network and repair the leaking and damaged pipes	The leakage rate of urban water supply networks is controlled within 10%
Utilization of reclaimed water	Promote reclaimed water in areas such as greening, cleaning, and industrial cooling, and build reclaimed water utilization projects	The utilization rate of urban reclaimed water has been raised to over 25%

4.2 Strengthen the protection and governance of water resources and improve the quality of water environment

(1) Strengthen the protection of surface water environment

First, we will intensify efforts to control pollution from industrial enterprises, urge them to improve their sewage treatment facilities, and ensure that industrial wastewater is discharged up to standard. Accelerate the construction and upgrading of urban sewage treatment plants, enhance the capacity and standards for treating domestic sewage, promote full coverage of urban sewage networks, and reduce the direct discharge of domestic sewage. Strengthen the control of agricultural non-point source pollution, promote technologies such as soil testing and formula fertilization, and green pest and disease control, advance the resource utilization of livestock and poultry breeding waste, and reduce the impact of agricultural non-point source pollution on surface water [6-7]. Second, we will enhance ecological restoration of rivers and lakes, carry out ecological river construction along the main stream of the Huai River and its major tributaries, implement protection and restoration projects for lakes and wetlands, improve the self-purification capacity of water bodies, and enhance the quality of surface water. Third, establish and improve the surface water monitoring system, strengthen real-time monitoring of the water quality of the main stream of the Huai River, its major tributaries and lakes, promptly grasp the changes in water quality, and provide data support for water resource protection and governance.

(2) Strengthen the protection and governance of groundwater

To strengthen the protection and governance of groundwater, first, demarcate no-extraction zones and restricted-extraction zones for groundwater. Groundwater extraction in no-extraction zones is strictly prohibited, and the amount of groundwater extraction in restricted-extraction zones is

restricted. Gradually achieve a balance between groundwater extraction and recharge. Measures such as closing some groundwater extraction Wells and promoting the use of surface water instead of groundwater for irrigation can be taken to reduce the amount of groundwater extraction. Second, control groundwater pollution sources. Prohibit the discharge of sewage, garbage and other pollutants into the ground. Strengthen the anti-seepage treatment of industrial solid waste and domestic garbage landfills to prevent pollutants from seeping into the ground and polluting groundwater. For contaminated groundwater, groundwater remediation technologies are adopted for treatment to improve the quality of groundwater [8]. Third, establish a groundwater monitoring network, strengthen the monitoring of groundwater levels and water quality, and keep abreast of the dynamic changes of groundwater in real time, providing a scientific basis for groundwater protection and governance.

4.3 Improve the management system and mechanism of water resources and enhance the management level

(1) Improve the unified management mechanism for water resources in river basins

Given the characteristic of the Huai River Basin spanning multiple provinces, it is necessary to strengthen the unified management of water resources in the basin, establish and improve the water resources coordination and management institution of the Huai River Basin, coordinate the development, utilization, protection and allocation of water resources within the basin, break the administrative regional boundaries, and achieve unified planning, unified dispatching and unified management of water resources. Strengthen communication and coordination among the provinces (municipalities) in the basin, establish a joint conference system for basin water resources management, hold regular meetings to study and solve major issues in basin water resources management, and form a joint force for basin water resources management.

(2) Improve the pricing mechanism for water resources

Reasonable water resource prices are an important means to promote water conservation and efficient utilization. The water resource pricing mechanism should be improved based on the scarcity of water resources and water usage costs in the Huai River Basin. The water resource prices should be gradually raised to fully reflect the scarcity and usage costs of water resources. Implement classified water pricing. For residential water use, adopt a tiered water pricing system. For non-residential water use, implement a progressive surcharge system for exceeding the plan and quota. Set higher water price standards for high-water-consuming industries. Regulate water demand through the price lever, enhance users' awareness of water conservation, and reduce water waste. At the same time, we should strengthen the collection and management of water resources fees to ensure that they are collected in full and used exclusively for the development, utilization, protection and management of water resources.

(3) Strengthen the monitoring and informatization construction of water resources

Strengthen the construction of the water resources monitoring system in the Huai River Basin, increase the number of monitoring stations, improve monitoring facilities, and enhance the accuracy and timeliness of monitoring data. Establish a monitoring network covering the volume of water resources, water quality, water demand, and operation of water conservancy projects within the basin to achieve real-time monitoring and dynamic management of water resources. Promote the informatization of water resources, establish a water resources management information system for the Huai River Basin, integrate information resources such as water resources monitoring data, water use data, and water conservancy project data, achieve information sharing and efficient utilization, provide informatization support for water resources planning, dispatching and management, and enhance the scientific and refined level of water resources management.

4.4 Optimize the planning and construction of water networks and enhance their functions

(1) Scientifically formulate water network planning

In combination with the economic and social development plan and ecological environment protection plan of the Huai River Basin, scientifically formulate the Huai River water network plan to ensure that the water network plan is in line with the regional development needs and matches the water resources supply and demand situation. During the planning and compilation process, the carrying capacity of water resources should be fully considered, the scale and layout of water network construction should be reasonably determined, the construction plan of water conservancy projects should be optimized, and attention should be paid to the connectivity, regulation and storage capacity and ecological nature of the water network to achieve the optimal allocation and efficient utilization of water resources, while protecting and improving the water ecological environment. Strengthen the forward-looking research on water network planning, fully consider the impact of factors such as climate change and economic and social development on water supply and demand, and improve the scientificity and adaptability of water network planning [9-10].

(2) Promote the construction of smart water networks

By leveraging new-generation information technologies such as big data, the Internet of Things, and artificial intelligence, we will promote the construction of a smart water network in the Huai River Basin to enhance the operational efficiency and management effectiveness of the water network. In water conservancy project construction, intelligent technologies are integrated, and intelligent monitoring equipment, automatic control equipment, etc. are installed to achieve intelligent operation and remote monitoring of water conservancy projects. Establish an intelligent system for water network operation and dispatching. Based on changes in water supply and demand and meteorological conditions, automatically optimize the dispatching plan to achieve precise allocation of water resources. Strengthen the monitoring and early warning of water network safety, establish early warning systems for water network engineering safety, water quality safety, water supply safety and other aspects, promptly identify and handle potential safety hazards, and ensure the safe operation of the water network.

5. Conclusion

Although the Huaihe River water network has formed a basic configuration pattern, it still faces problems such as layout, aging, connectivity and ecological issues. The supply and demand of water resources in the basin are confronted with three contradictions: total volume, temporal and spatial distribution, and water quality type. Through measures such as optimizing allocation, strengthening protection, improving management, and promoting the construction of smart water networks, the contradiction can be effectively alleviated. In the future, it is necessary to further study the long-term impact of climate change on the supply and demand of water resources, deepen the collaborative mechanism between water resources and ecological protection, and at the same time expand the application of smart technologies in water network dispatching, promote cross-regional collaborative management, and provide more precise support for the sustainable utilization and high-quality development of water resources in the Huai River Basin.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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