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A Scheme for a Sustainable Urban Water Environmental System During the Urbanization Process in China

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ABSTRACT

Urbanization is a potential factor in economic development, which is a main route to social development. As the scale of urbanization expands, the quality of the urban water environment may deteriorate, which can have a negative impact on sustainable urbanization. Therefore, a comprehensive understanding of the functions of the urban water environment is necessary, including its security, resources, ecology, landscape, culture, and economy. Furthermore, a deep analysis is required of the theoretical basis of the urban water environment, which is associated with geographical location, landscape ecology, and a low-carbon economy. In this paper, we expound the main principles for constructing a system for the urban water environment (including sustainable development, ecological priority, and regional differences), and suggest the content of an urban water environmental system. Such a system contains a natural water environment, an economic water environment, and a social water environment. The natural water environment is the base, an effective economic water environment is the focus, and a healthy social water environment is the essence of such a system. The construction of an urban water environment should rely on a comprehensive security system, complete scientific theory, and advanced technology.

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1. Introduction

Industrialization, informatization, urbanization, and agricultural modernization were the focuses of the 18th National Congress of the Communist Party of China; all of these are factors that are conducive to the development of a moderately prosperous society. Urbanization plays a key role in the realization of an all-round moderately prosperous society, and involves systematic engineering, including the economic use of resources, the protection of natural ecosystems, and balanced development between towns and small, medium-sized, and large cities. Urban construction, which is an important part of economic development in China, is also part of urbanization. To protect the natural environment from pollution and to establish measures to recover from preexisting pollution and habitat destruction, it is necessary to establish a sustainable system for the urban water environment [1].

The continuous expansion of urbanization results in threats to urban water security, the deterioration of water quality, a decrease in water quantity, and the degradation of water ecology, which

prevents such urbanization from being sustainable [2,3] (Fig. 1). Therefore, correlations between the water environment, society, and the economy should be simultaneously coordinated in order to promote sustainable and healthy urbanization.

Based on a characterization of the urban water environment, this study aims to ① investigate the functions of the urban water environment, ② explain the basic theory of the urban water system, and ③ construe sustainable and supporting systems for the urban water environment.

2. Functions of the urban water environment

The functions of the urban water environment are mainly associated with water security (i.e., flood regulation), water resources, water ecology, water landscapes, water culture, and water economy; these functions are regarded as integral parts of a whole [3] (Fig. 2). Well-developed and/or protected water security, water resources, and water ecology will safeguard the system of the urban water environment, while a well-maintained water landscape, water culture, and water economy can promote the environmental benefits of the system [4]. In terms of the relationship

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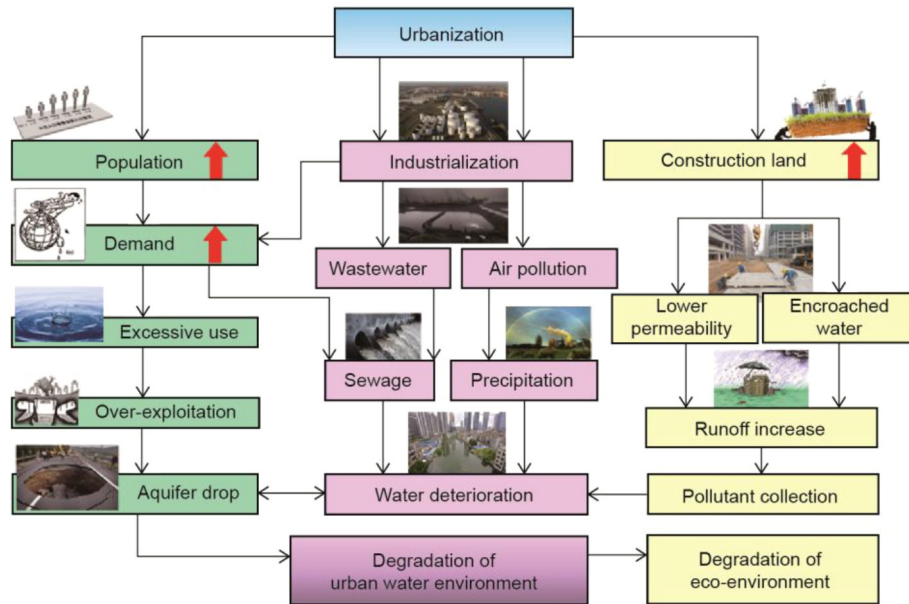


Fig. 1. The pressure of urbanization on the urban water environment.

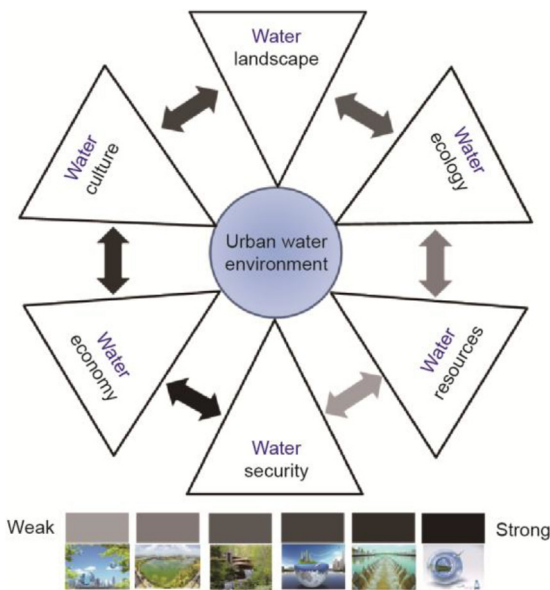


Fig. 2. Functions of the urban water environment and their relationships. Black is associated with a strong influence, whereas gray represents a weaker influence.

between nature and the human factors of the urban water environment, it is necessary to improve storage and drainage capabilities, water-use efficiency, and the water landscape [5]. A new type of system that saves water and protects the environment will be generated in this way, and will be favorable to the development of sustainable and healthy urbanization.

3. Theories on the urban water environment

3.1. Geographical location

Social and economic phenomena can be quantitatively described on a spatial or regional scale in terms of geographical location, using the methods of domination, region, comprehension, and dynamic equilibrium [2,6]. Elements that depend on geo-

graphical location include natural instincts, transportation, the aggregation effect, labor, the market, and so on. A regional development plan can be perfected appropriately based on an analysis of the geographical location in order to identify socioeconomic advantages. Regarding the geographical location, firstly, a town should be located near a river or a lake that can provide sufficient water resources and that can determine the dominant industry. Secondly, the industrial layout should be reasonable. For example, relocating certain industries may result in the transformation and upgrading of urban functions. Finally, the urban water environmental system should be a stable and balanced ecological system.

3.2. Landscape ecology

Landscape ecology is defined as the management of resources and the environment on landscape and regional scales by means of the regional-level analysis of geography and the structurally vertical analysis of ecology. It is necessary to completely investigate the urban spatial layout and the ecological processes of a planned city, which predominantly involve the ecological units of the anthropogenic landscape and the unstable, fragmented, and gradual urban landscape [7]. An urban landscape contains blocks (patches), corridors, and matrices. In the process of urbanization, an ecological landscape plan is applied in order to investigate the evolution of the urban water landscape, preserve heterogeneity, and preserve ecological processes; this can improve economic, social, and ecological benefits [1].

3.3. Low-carbon economy

A low-carbon economy can appropriately deal with economic development, economical energy usage, and emission reduction; in addition, it can match low-carbon production with consumption, and coordinate a correlation between the regional development policy and the region's endowment of resources [8]. A low-carbon economy is an effective path for urbanization: namely, low-carbon urbanization. Towns can be constructed in a way that encourages low energy consumption, low pollution, and high output. Hence, it is possible to apply low-carbon concepts in spaces,

industries, travel systems, services, and peoples' livelihoods when constructing an urban water environmental system.

4. Establishing an urban water environmental system

The urban water environment includes both natural and social properties, and is one of the most important infrastructures supporting the urban economy. The water in cities exists as a spatiotemporal distribution, and possesses renewable, economic, and ecological functions [1]. The urban water environment is an artificially enhanced system of the natural water environment. It consists of a natural water environment, an economic water environment, and a social water environment; the foundation of all of these environments is the natural water environment, whose core is an efficient economic water environment, and whose essence is a healthy social water environment [9] (Fig. 3).

4.1. The urban natural water environment

An urban natural water environment is based on the recharging processes between the atmosphere, surface water, and groundwater, which occur through precipitation, evaporation, transpiration, surface runoff, and soil infiltration [10,11]. The natural water cycle deeply influences the urban water environment, which includes the environmental restoration of water systems. Precipitation is one of the most important factors of an urban natural water system, and has a very significant role in the environmental restoration of water systems. Precipitation enters the network of rivers and/or groundwater, which are deeply affected by permeability, slope, soil texture, and rainfall intensity.

In the process of urbanization, the impervious area increases with an increase of the hardening rate; this can change the proportion of runoff and infiltration and weaken the recharge of groundwater [11]. An increase in urban drainage channels can rapidly

reduce runoff, but can lead to serious soil erosion. Soil particles in rivers can result in deposition and water pollution, which can hinder flood discharge. The over-exploitation of groundwater can result in disturbed hydrology of the surface water, deteriorating water quality, and weakened flood discharge in the urban natural water environment, ecology, landscape, and culture.

Given a healthy urban water environment and a low-carbon economy, the urban natural water environment depends on restoring natural river channels and improving the urban water network [12]. Rainwater utilization can ensure the sustainable development of the urban natural water environment. In the process of urbanization, it is necessary to deal appropriately with the correlations between the urban water system and urban spaces by means of comprehensive planning ideas, which can ensure the integration of spatial structure and river systems. It is necessary to pay attention to non-flood lands and to strengthen the construction of the urban water system and of non-flood lands for the mutual promotion of social and economic benefits. To enhance the urban natural water environment, it is necessary to improve the efficient collection and utilization of rainwater, increase the surface permeability rate, and promote rain-collecting roof and road-surface materials.

4.2. The urban economic water environment

The water economy depends on the sustainable utilization of water resources, which involves water treatment, conservation, and development. The aims of the sustainable utilization of water resources are to safeguard sufficient water for the social, economic, and ecological systems, and to ensure safe water quality for human and ecosystem health [13,14]. The growing demand for water quality and quantity due to urban growth, population increase, and economic development results in serious environmental problems. These problems can be solved by the sustainable development of the water economy, by improving the utilization of water

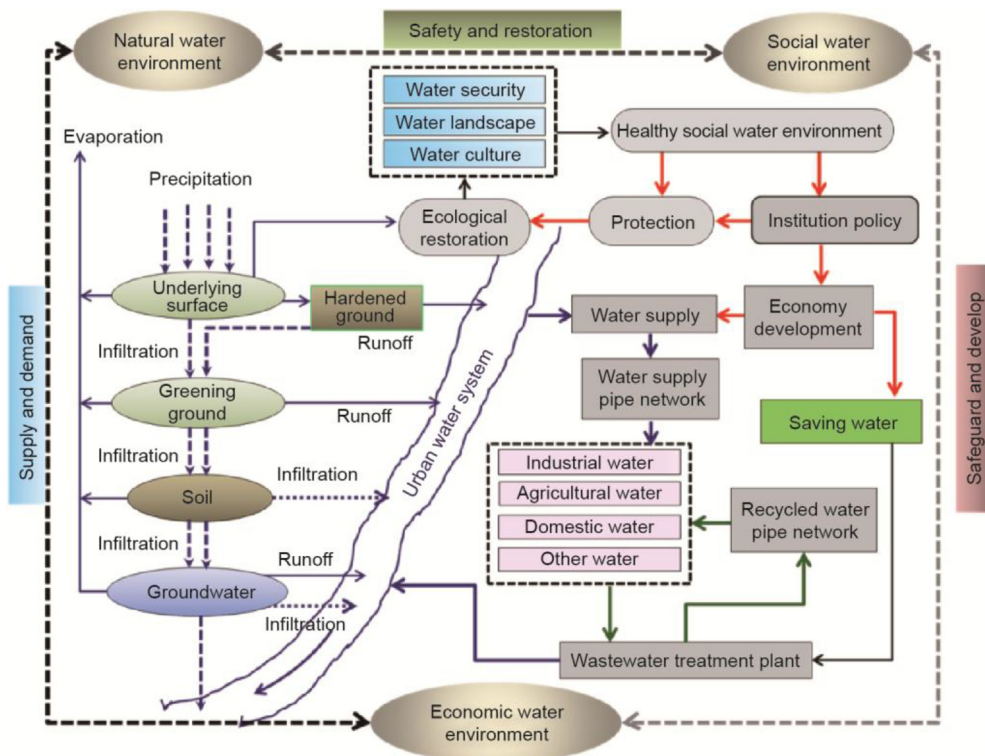


Fig. 3. The composition and structure of the urban water environment.

resources, and by establishing a water-recycling economy, water-saving economy, and low-water economy.

A water-recycling economy is well-known to be the application of water movement in a natural ecological system toward an economic system. It can integrate economy, society, and the environment into a new economy—that is, the economy of sustainable water resources, which is associated with human subjective activity through pipes and ditches [12]. A water-saving economy is associated with adjusting and optimizing water resource allocation, improving the pattern of water use, increasing the rate of water utilization, and preventing the waste of water resources. A low-water economy involves reducing, as far as possible, excessive dependence on water resources by transforming economic development and technological innovation. It is essential to increase the utilization of water resources in order to promote a water-recycling economy, water-saving economy, and low-water economy.

The principles of water economy include reduction, reuse, regeneration, recycling, and water resource management in urbanization processes. Based on the theories of water resource management and ecological economics, an efficient and low-carbon economic system can be developed by implementing technical innovation projects. Comprehensive scientific measurements can ensure the sustainable development of the economic system through policies and regulations. The sustainable utilization of water resources can change the old pattern of water resource availability/consumption/sewage discharge, which is defined as a one-way flow of linear economy, and can instead realize a complex ecosystem of reciprocity water cycling—that is, the cycle of water resources availability/consumption/sewage treatment/water recycling.

4.3. The urban social water environment

An urban social water environment realizes the sustainable development of the urban water environmental system, which can ensure the protection of the natural and economic urban water environments [13]. Based on hydrological characteristics, it is possible to establish a healthy social water environmental system that involves reasonable usage of water resources and that can develop the landscape and cultural functions of the urban water environment. A good urban social water environment can strengthen the protection of water resources and the water environment, promote water ecosystem restoration and protection, and assist in the development of a water environmental system.

A social water environment can be established through rational urban water environment planning that involves the following factors: a good water ecosystem; connection with external spaces; a reasonable internal structure, landscape, and ecology; and a harmonious social water environment [15]. A social water environment includes ecological, social, and esthetic principles. The ecological principles involve taking the bearing capacity of the urban water environment into account, increasing biodiversity, and strengthening the integration of human and natural landscapes. The social principles are to integrate regional culture and art, improve living conditions, and promote urban cultural progress [16]. The esthetic principles correspond to esthetics and behaviors, and can form a continuous water landscape system.

A water landscape displays mutually dependent correlations with the water culture, and is the external form of the water culture. Urban water culture includes natural and artificial water-scapes, which can stimulate cultural ideas. Based on coordinated development concepts regarding resources, the environment, ecology, health, and security, it is possible to construct a harmonious relationship between humans and water.

5. Conclusion

The urban water environment consists of the natural water environment, the economic water environment, and the social water environment; its foundation is the natural water environment, its core is an efficient economic water environment, and its essence is a healthy social water environment. During the process of urbanization, an urban natural water environment is established by the integration of urban water systems and urban spaces. An efficient low-carbon urban economic water environment can be developed using the theories of water resource management and ecological economics, according to the “5R” principles: rethinking, reducing, reusing, recycling, and repairing. The urban social water environment is improved by the rational distribution of urban water environmental planning. We suggest that the urban water environment has an essential role in healthy urbanization and in realizing a harmonious relationship between people and water.

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Compliance with ethics guidelines

Huibin Yu, Yonghui Song, Xin Chang, Hongjie Gao, and Jianfeng Peng declare that they have no conflict of interest or financial conflicts to disclose.

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