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Strategies for Water Resources Regulation and Water Environment Protection in the Beijing–Tianjin–Hebei Region

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Abstract: Shortages in water resources and pollution of water environment have become major obstacles in the coordinated development of the Beijing–Tianjin–Hebei region. This study analyzes the status quo and challenges for regulating water resources and water environment protection in the Beijing–Tianjin–Hebei region, and proposes corresponding strategies. This includes building an water ecosystem involving mountains, rivers, forest, farmland, lakes, and sea using technical approaches; establishing a healthy water resources recycling and efficient utilization model; developing production and living modes adapted to the carrying capacity of the water ecology; improving water quality; ensuring the health of regional water ecosystems; establishing a coordinated management system for the regional water environment; strengthening industry cooperation and pollution reduction; and promoting peri-urbanization and pollution abatement in rural areas. This study aims to provide decision support tools for comprehensive ecosystem control in the Beijing–Tianjin–Hebei region, and construction of an ecological civilization in China.
Keywords: Beijing–Tianjin–Hebei region; water resources and water environment; regulation and protection; strategy

1 Introduction

The coordinated development of the Beijing–Tianjin–Hebei region has been a major strategic and historic decision by the Communist Party of China Central Committee. However, protecting the ecosystem is the primary challenge that remains in enabling the coordinated development of the region. The current shortage of water resources and severe water pollution poses a threat to human well-being in the region. As such, there is an urgent need to develop strategies in water resources regulation and water environment protection, as an essential means to advance coordinated development of the Beijing–Tianjin–Hebei region and improve natural ecosystems.

2 Status and challenge of water resources regulation and water environment protection in the Beijing–Tianjin–Hebei region

2.1 Status of water resources regulation

2.1.1 Inadequate total water resources in the Haihe River basin

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The Haihe River basin is located in the political, cultural, and economic center of China. The central plain is an important grain production area, while the mountainous region in the northwest is a national energy base, an extremely strategic position taking over Beijing's non-capital functions.

In recent years, water resources shortages in this basin have become severe. According to the 2016 Haihe River Water Resources Bulletin, the amount of surface water and groundwater resources in the Haihe River basin in 2016 was approximately 2.04×10^{10} m^3 and 2.804×10^{10} m^3, respectively. The total water resources were approximately 3.879×10^{10} m^3, accounting for 19.8% of precipitation. The 150 large and medium-sized reservoirs in the entire basin stored 1.052×10^{10} m^3 of the total annual permanent water [1].

In 2016, the total water supply from all water supply projects in the basin was approximately 3.631×10^{10} m^3. Of this total, local surface water, groundwater, diverted water, and other water sources accounted for 22.8%, 53.7%, 17.6%, and 5.9%, respectively. The water consumption in the whole basin was 2.508×10^{10} m^3, including 60.6% used in agriculture, 13.2% for industrial use, 19.0% for domestic purposes, and 7.2% in ecosystems; this accounts for 69.1% of the total water supply. The total discharge of sewage was 5.511×10^9 t in the Haihe River basin. Industrial and construction sewage discharge was 2.208×10^9 t, accounting for 40.1% of the total, whilst domestic sewage discharge was 2.694×10^9 t, accounting for 48.9%; and tertiary industry sewage discharge was 6.09×10^8 t, accounting for 11.0%.

2.1.2 Increase in the severity of water resources shortage in the Haihe River basin

Over the past six decades, a long-term decreasing trend in water resources has occurred in the Haihe River basin. The annual surface water volume from 1956 to 1979 was approximately 2.8×10^{10} m^3. From 1980 to 2000 this was approximately 1.8×10^{10} m^3, and from 2001 to 2007 it was an estimated 1.2×10^{10} m^3. Between 2008 to 2016, this figure was approximately 1.5×10^{10} m^3. With the reduction of precipitation and an increase in water resources development and utilization, surface water resources in the Haihe River basin have consistently decreased. This has also caused a continual decline in the gross volume of the water resource in the basin. Given the current population in the basin, the available water resource per capita is 270 m^3, equivalent to 12.8% of domestic usage and 3.3% of the world average. This is also far below the threshold of 500 m^3 per capita per year as absolute water scarcity [2]. Rapid social and economic development since the 1980s, has also considerably affected the underlying surface, further reducing the amount of surface runoff to the sea.

Due to the accelerating global climate warming in recent years, various water facilities such as upstream reservoirs in the region have created water shortages in the central plains. In this area, the excessive consumption of water due to industrial and agricultural development, and urbanization has caused a sharp decline and compensation imbalance in groundwater levels, and weakened surface runoff capacity. This has ultimately resulted in frequent cease to flow events during the dry season. The number of cease to flow days per year has increased from 78 d in the mid to late 1960s to 268 d in 2000. In the 1960s, there were only two rivers with more than 180 cease to flow days, while one-third of rivers in 2000, including the Baigou, Nanjuma, Tang, Poyang, Weihe, Weiyun, and Zhangweixin rivers did not exceed 180 days. Additionally, some of the reaches of the Yongding River gradually experienced year-round ceases to flow.

2.1.3 Supply of shallow groundwater for extensive agricultural consumption

Based on the 2016 Haihe River Water Resources Bulletin, water storage, diversion, extraction, and inter-basin water diversion accounted for 12.8%, 28.2%, 15.1%, and 43.7% of water supply from surface water sources, respectively. Inter-basin water diversion includes the water resources from the Yangtze and the Yellow rivers. In terms of groundwater, the proportion of shallow water, deep water, and brackish water were 80.6%, 18.8%, and 0.6%, respectively [1].

For water use in the Haihe River basin, there was a reduction in water use of 5.39×10^8 m^3 in 2016 compared with 2015. Specifically, agricultural and industrial water use decreased by 1.025×10^9 m^3 and 1.24×10^8 m^3, respectively, mainly due to the Hebei Province. However, domestic and ecosystem water use increased by 2.12×10^8 m^3 and 3.98×10^8 m^3, respectively.

The proportion of water consumption in the Haihe River basin in 2016 from agriculture, industry, household use, and the ecosystem was 67.9%, 10.0%, 13.8%, and 8.3%, respectively, with water consumption ratios of 77.3%, 52.4%, 50.2 %, and 80.5%, respectively.

2.1.4 High intensity of water resources exploitation and utilization, and high efficiency of water use

In the last 10 years, the utilization ratio of surface water resources has exceeded 60%, while the utilization ratios

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of surface water resources in the northern and southern Haihe River basin were more than 80% and 60%, respectively. The utilization ratios of surface water resources in the Tuhai and Maqihe River basins were low but still over 40%. In general, the utilization ratio of surface water resources in the Haihe River basin was far higher than the international criteria of 40% [3].

Large-scale exploitation of groundwater in the Haihe River basin began in the 1970s. With the increasing intensity of the utilization of surface water resources, the utilization ratio of shallow groundwater in the plain area has continually increased. The average volume of the shallow groundwater resource in the plain between 1995 and 2007 was 1.41×10^{10} m^3, whilst the amount of annual average exploitation was 1.72×10^{10} m^3; a 122% utilization ratio. The utilization ratio of shallow groundwater reached 149% in the southern Haihe River basin. This excessive exploitation of groundwater has caused a series of environmental geological problems such as a sharp drop in groundwater level, ground subsidence, and ground fissures.

The Beijing–Tianjin–Hebei region accounted for 0.9% of the country's water resources, providing 4% of the country's water supply, supporting 8% of the country's population, 8% of the irrigated area, and contributing 11% to China's gross domestic product (GDP). Due to the dire water supply and demand situation in the Beijing–Tianjin–Hebei region, the intensity of water resources utilization and water use efficiency was at a very high level. In 2013, water efficiency evaluation indicators such as water consumption per capita, water use per 10 000 US dollars GDP, water use per 10 000 US dollars of industrial value-added, irrigation water per mu, and the effective utilization coefficient of irrigation water in the Beijing–Tianjin–Hebei region were greater than other regions in China.

The human development index (HDI, ranging from 0 to 1) [4], where countries classified as developed countries have a HDI > 0.9; developing countries have a HDI between 0.5 and 0.8; and less developed countries have a HDI < 0.5 (Fig. 1). The Beijing–Tianjin–Hebei region can be divided into two grades [5]. The first grade was Beijing (0.869) and Tianjin (0.843), where water use per 10 000 US dollars GDP was 116 m^3 and 103 m^3, respectively. Utilization efficiency had approached or reached the level of developed countries; significantly higher than the world average (where average water use of 10 000 US dollars GDP was 506 m^3). The second grade was the Hebei province (0.735), where water use per 10 000 US dollars GDP was 449 m^3, and water resource utilization efficiency was higher than developing countries, but was still further from developed countries. Therefore, there is a need to maximize the potential for future water resource utilization in Hebei.

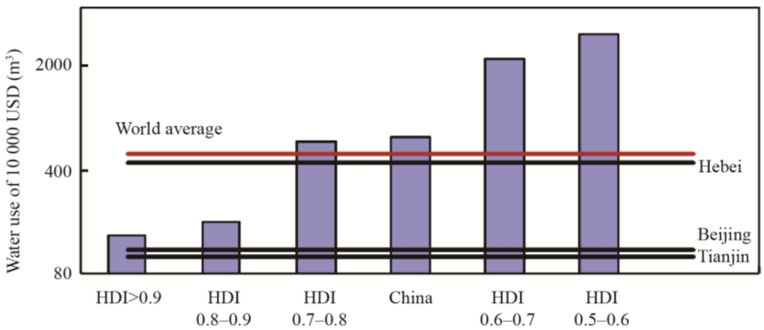

Fig. 1. Comparison of water use of 10 000 US dollar GDP between the Beijing–Tianjin–Hebei region and countries at different HDI levels (in 2016).

2.1.5 Internal potential tapping and external water diversion required to balance regional water resource supply and demand

Although Beijing and Tianjin are at the first grade of the HDI with limited water-saving potential, further water-saving strategies still need to be implemented. This includes fully tapping the water-saving potential of various industries, moderately controlling the scale of demand, promoting the Beijing–Tianjin–Hebei integrated strategy, and decreasing the rigid demand from population growth and urbanization. In conjunction with these measures, there needs to be a continual enhancement to the consciousness of water-saving, improvements to the water-saving system, and prevention of the water-extravagant phenomenon. In the second grade, due to long-term over-exploitation of groundwater and increased rigid demand for water resources caused by social and economic development in Hebei Province, there were a large number of historical debts in using water from natural ecosystems with a high proportion of industries with high water consumption and heavy pollution. Thus, further restructures and optimization of the industrial structure is necessary.

With the year 2030 set as the target year, the future supply-demand balance of the Beijing–Tianjin–Hebei region needs evaluation from a water-saving potential perspective. The evaluation process highlights two major aspects. First, the supply of water resources should account for the regional water resource condition context and the state of aquatic ecosystems. This is so that the current status of surface water supply may be maintained, there may be full use of water diverted in the first phase of the South-to-North Water Diversion Project, and there is increased use of unconventional water resources to prevent overexploitation of groundwater, and properly restored groundwater levels. Second, there is a 2.07×10^9 m^3 potential water-saving volume that can be tapped in terms of water demand. The rigid demand for domestic water use brought by rapid urbanization was also considered.

The *Key Results in the Allocation Stage of the National Comprehensive Water Resources Planning* showed that water supply and demand in the Beijing–Tianjin–Hebei region is approximately 3.029×10^{10} m^3 and 3.171×10^{10} m^3 in 2030, respectively. Thus, the shortfall is an estimated 1.42×10^9 m^3, mainly because of the rigid demands of domestic and industrial uses in the Hebei Province. The threat of water resource scarcity continues to be an issue.

To protect water resources, restore the water environment and promote the future sustainable development of the economy and society in the Beijing–Tianjin–Hebei region, we should focus our efforts on “internal potential tapping and external water diversion.” This will enable the full expansion of the potential water use, efficiently utilize externally diverted water, and further increase external water diversion if necessary (Fig. 2).

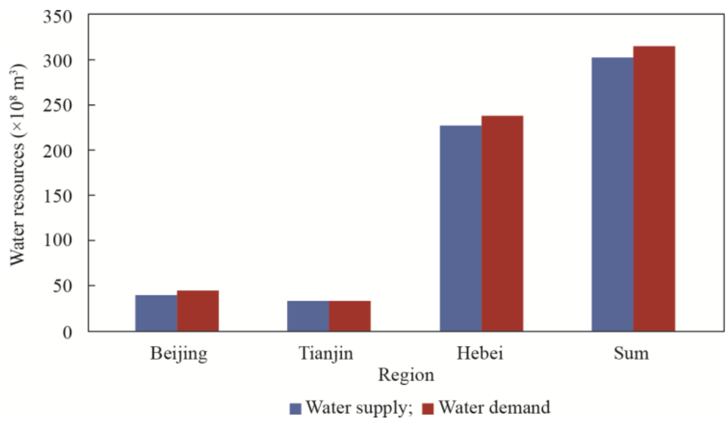

Fig. 2. Supply and demand predictions for water resources in the Beijing–Tianjin–Hebei region in 2030.

2.2 Status of water environment protection

2.2.1 Water environment in Haihe River basin are still highly polluted

The *China Environmental Status Bulletin* in 2016 indicated that the Haihe River basin is heavily polluted, based on key pollution indicators: chemical oxygen demand, biochemical oxygen demand, and ammonia nitrogen. Based on the evaluation of water quality for a 15 565.2 km long river throughout the year, 44.6% of the evaluated river length exceeded Grade V, while it was close to 70% in Tianjin. Of the 70 monitoring sections of provincial boundaries in this basin, 61.8% were higher than Grade V. The water quality in the lake area was between Grades I–III in lakes Baiyangdian, Hengshui, Kunming, Fuhai, and Dongchang which was only 2.8%. Of the 480 water function zones in the river basin, 147 met the water quality target with a rate of 30.6%. As such, the target rate of primary water function zones (excluding development and utilization zones) and secondary water function zones was 32.8% and 29.7%, respectively. According to the water body types, the target rate of river-type water function zones was 32.1%, the target rate of lake-type water function zones was 15.3%, and the target rate of reservoir-type water function zones was 35.3%.

Based on the National Science and Technology Program for “Water Pollution Control and Treatment”, the field data of the Haihe River project showed that the proportions of black-odor water in Beijing, Tianjin, and Hebei were 33%, 97%, and 35%, respectively. Proportions of black-odor water in the mountain were at 10%, while the proportion in the plain was as high as 86%, indicating an uneven spatial distribution in Shijiazhuang.

2.2.2 Inadequate water flow has resulted in a weak hydrological process

The plains are laden with sluices and dams, fragmenting and channelizing river. As such, river hydrodynamics have disappeared with poor connectivity and fluidity. The guaranteed rate of water flow has been below 30% in the main rivers, which cannot meet environmental requirements for maintaining habitat integrity. From 2001 to 2012,

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the ratio of wastewater and runoff in the Haihe River basin ranged from 18.2% to 71.6% with an average ratio of 35.7% and peaking at 71.6% in 2002 (Fig. 3).

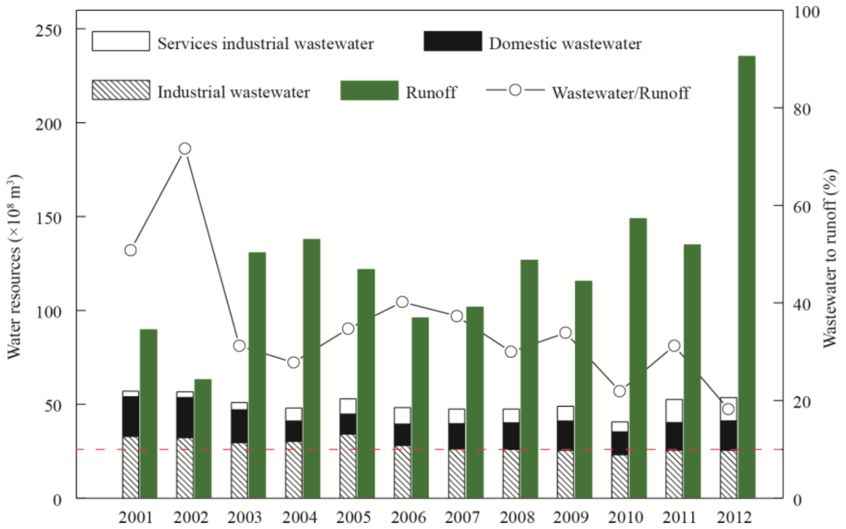

Fig. 3. The runoff, ratio of wastewater to runoff, and wastewater classification between 2001–2012.

2.2.3 Emerging contaminants are mainly distributed in rivers traversing through urban and agricultural areas

Most emerging contaminants are pharmaceuticals and personal care products (PPCP). PPCP was found to be widely distributed in rivers traversing through the mountains, farmland, and urban areas. Specifically, PPCP pollution was higher in rivers travelling through farmland and urban areas than the mountains.

In terms of the composition of emerging contaminants, the proportion of caffeine (CAF) was the highest in farmland and urban areas, and the proportion of drugs such as sulfadiazine (SDZ) and sulfamethoxazole (SMX) was higher in urban areas. Urban sewage treatment plants were the main source of PPCP in cities, while scattered point and non-point sources were the main sources of PPCP in rural areas.

2.2.4 Unhealthy natural ecosystems, decreasing biodiversity, and degraded ecological functions

The riverine ecosystems of more than half the rivers in the Haihe River basin were below the normal level of ecosystem health, and it is difficult to provide adaptive habitats for the biological communities to live and reproduce. The health of more than 30% of rivers was extremely poor, with more than 45% in this category for rivers in the central plains and downstream coastal sections. This has led to the species depletion in the Haihe River basin and lower macroinvertebrate diversity ranging from 0.22 to 2.73 in the Shannon-Wiener index.

2.2.5 Shortage of groundwater from decreasing water quantity and a reduction in water quality

The shallow underground water level in the plain of the Beijing–Tianjin–Hebei region dropped significantly between 1959 to 2003, and the water level difference in some regions was close to 30 m. Regional cumulative over-capacity exceeded 1.55×10^{11} m^3, leading to a large number of groundwater depression cones.

The proposition of shallow groundwater contamination in this region is at 72%, with monitoring of carcinogenic, teratogenic, and mutagenic pollutants. There were more than 1100 potential groundwater pollution sources in the centralized drinking groundwater source protection and recharge regions. There were also 1.26×10^4 groundwater pollution sources such as landfills, chemical plants, and gas stations, of which 40% were polluted.

2.3 Challenges for water resources regulation and water environment management

2.3.1 Imbalance in "society–nature" dual water circulation

The water shortage in the Beijing–Tianjin–Hebei region was serious in China, and the total amount of water resources was a "congenital deficiency." The average volume of the water resource was 3.7×10^{10} m^3 between 1956 and 2000, only accounting for 1.3% of the national average over the same period. The water resources per capita was 269 m^3, only 12.5% of the national average. The demand for rapid socio-economic development has caused over-exploitation of water resources in this region. To be specific, the development and utilization intensity of water resources reached 70.2% in Tianjin, 82.9% in Hebei, and 90.8% in Beijing. The lack of natural water resource supply and the rapid increase of industrial wastewater and urban water return had as much as 35.7% of the ratio of wastewater to runoff in the Beijing–Tianjin–Hebei region from 2001 to 2012. Unconventional water resources were to be the main replenishment of rivers in this region, highlighting the dominant characteristics of the social water cycling process. Urban unconventional water resource recycling and risk control measures for water quality directly impact upon the safe use of regional water resources, water quality, and the health of aquatic ecosystems.

2.3.2 Complex effects of black-odor water and water scarcity are clear

The phenomenon of river cease to flow events, wetland shrinkage, and black-odor water has become more common in the Beijing–Tianjin–Hebei region. The shortage of water resources and the deterioration of the water environment in half of the rivers has severely damaged habitats of aquatic organisms, and thus, their ecological functions have declined. Watershed ecosystems are gradually changing from open waterbodies to closed and inland waterbodies. The key causes of the prominent problems of aquatic ecosystems in the Beijing–Tianjin–Hebei region can be mainly attributed to three imbalances. First, the deficiency, over-exploitation and utilization of water resources, and the unbalanced relationship between social and economic development and regional water resources has become the root cause of the severe water shortage situation in the Beijing–Tianjin–Hebei region. Second, the dense population, aggregated industry, and accumulated discharge of polluted water and replenishment with unconventional water resources are directly responsible for black odor. Third, the lack of regional joint coordination mechanisms for aquatic ecosystem management, uneven water resources benefits, the lack of overall forward design for upstream and downstream urban-rural layouts and industrial development, the absence of coordination mechanisms for accessibility standards, emission standards and law enforcement, and the spatial imbalance between regional economic development and aquatic ecosystem protection are largely responsible for the extremely unhealthy ecosystems in the Beijing–Tianjin–Hebei region.

3 Strategies to develop water resources regulation and water environment security in the Beijing-Tianjin-Hebei region

Currently, there are strong water resource constraints, heavy ecosystem pollution, and high riverine ecosystem degradation in the Beijing–Tianjin–Hebei region. The focus on water resources, aquatic ecosystem management, and economic and social development has been unbalanced. The water ecological civilization construction has lagged behind requirements of regional economic and social development, becoming a major bottleneck restricting the integration of Beijing, Tianjin, and Hebei, and the national ecological civilization construction. Strategies to develop water resources regulation and water environment security have been proposed with a focus on promoting the continual improvement of aquatic ecosystem health and realizing the coordinated development of the Beijing–Tianjin–Hebei region.

3.1 Building an integrated ecosystem involving mountains, rivers, forests, farmland, lakes, and the sea using technical approaches

Mountains, rivers, forests, farmland, lakes, and the sea are within a common living circle, and profoundly represent the essence of human and natural life processes. It is an organic whole of energy flow, substance circulation, and information transfer between different natural ecosystems. It is also a living organism with close human dependence and high biodiversity at a larger regional scale. As such, holistic protection, systemic restoration, and comprehensive governance is required. The water resources of the east line and middle line from the South-to-North Water Diversion Project as external inputs are meant for full use based on the existing water resources from the Yellow River. This is to alleviate the pressure on the regional water supply and provide basic drinking water security. At the same time, it is necessary to enhance the performance of water generation and conservation, the utilization ratio of the water resource and water purification capacity based on water generation, water conservation, water-saving, and water purification. The goal of healthy and sustainable drinking water can be achieved through coordination between internal potential tapping and external water diversion. Finally, a water ecological corridor is to be constructed to control the over-exploitation of groundwater and appropriately restore groundwater to ensure ecological base flow and form an aquatic ecosystem involving the mountains, rivers, forests, farmland, lakes, and the sea.

3.2 Establishing a healthy recycling and efficient utilization model for water resources

Diversifying water resources, including conventional and unconventional sources, may be realized through the development of new technologies and the improvement of industrial and agricultural management. This will support

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the development of the healthy recycling and efficient utilization model for water resources. The key issue that needs to be addressed is the degree of water resource exploitation and the rational allocation of conventional water resources in industry and agriculture. For unconventional water sources, three major issues need addressing: (1) highlighting technological innovation, developing new technologies, and realizing commercial desalination; (2) controlling and governing industrial and agricultural wastewater discharge, reasonably adopting existing technologies or improving manufacturing processes, and realizing sewage or wastewater recycling internally in industry and agriculture; and (3) improving the health risk assessment and management systems, and making overall plans for the healthy recycling and efficient utilization of water resources. Efforts should be made to develop unconventional water resources mainly composed of reclaimed water, manage environmental risks, and organically combine the natural water cycle with the social water cycle. Ultimately, a healthy, efficient, and green water recycling and utilization model needs to be established in conjunction with these approaches, and groundwater pollution and drinking water contaminants such as fluorine and nitrate need effective handling to ensure drinking water security.

3.3 Developing production and living modes adapting to the carrying capacity of aquatic ecosystems

The carrying capacity of aquatic ecosystems is an organic combination of water resource, water environment, and ecological carrying capacities. Its main content includes water supply and demand, ecosystem resilience and environmental capacity, and signals for assessing aquatic ecosystem health.

The production and living modes adapting to the carrying capacity of aquatic ecosystems are suggested to develop in three areas. First, in agriculture, adjusting the planting structure, saving water in the fallow farmland, and keeping production stable with water-saving according to the total amount of water resources. Second, in industry, continuing to optimize the industrial structure, and limiting or eliminating industries with high water consumption and high pollution based on water pollution capacity and ecological capacity. Third, in human settlements, comprehensively considering ecosystem stability and resilience, rationalizing urban pattern and population adaptation to water resource distribution, and advocating for living modes with water-saving. The goal will be eventually reached that urban development, population, and production are decided by water.

3.4 Improving water environment quality and ensuring the health of regional water ecosystems

To address the problems of water pollution treatment, the protection of aquatic ecosystems is critically important. Basic policies that prioritize protection and natural restoration, and a system of water ecological protection and restoration should be established to promote water ecosystem service functions. First, strengthen the reduction of source emission and cleaner production in major industries such as chemical, pharmaceutical, and steel, and reduce the environmental risks of heavy metals and persistent pollutants. Second, develop technological innovation, upgrade domestic sewage treatment, and reduce the discharge of nutrients and emerging contaminants. Lastly, develop green agriculture, including reductions in the use of chemical fertilizers and pesticides and promoting clean farming with decreases in environmental exposure to pesticides and antibiotics, to restore healthy river ecosystems and significantly increase biodiversity.

3.5 Establishing a coordinated management system for the regional water environment

To establish and implement a coordinated management system for the regional water environment, we need to combine scientific decision-making at the basin scale with efficient management at the administrative region scale, incorporating fine-grained and differentiated water pollution risk levels. Based on the coordinated development of the economy and environment, and the lowest cost to achieve improvements to water quality, we propose to promote the formulation of the *Ecology–Environment–Resources Red Line Protection Act*, establish a management system for ecological protection red line, unify regional environmental standards in the river basin, establish joint early-warning and law enforcement systems in water resources and the water environment, innovate a green development evaluation system, implement a system for evaluating the environmental protection performance of officials, develop an industrial development mechanism based on the carrying capacity of ecosystems, construct a regional ecological compensation mechanism, improve information disclosure and public participation mechanisms, and establish an ecological and environmental government management platform.

3.6 Strengthening industry cooperation and pollution reduction

The economic integration of the Beijing–Tianjin–Hebei region is not only to migrate manufacturing industries with high pollution from Beijing to Tianjin and Hebei, but also to adjust the industrial structure. This is to achieve a development goal with high fusion, efficiency, and coordination. In the meantime, two major issues require resolution. First, the different boundaries between economic regions and administrative regions. Developing an open economy and enhancing benefit coordination is important in the Beijing–Tianjin–Hebei region. Second, the difference between economic foundation and infrastructure construction. Compared to the more developed economy and better infrastructure construction in Beijing, the integration of economy and transportation is needed in Tianjin, and Hebei during the Beijing-Tianjin-Hebei coordinated development.

Collaborative management of resource and environmental issues are major challenges for the coordinated development of Beijing, Tianjin, and Hebei. One of the prerequisites for the coordinated and sustainable development of the Beijing–Tianjin–Hebei region is the coordinated management of the ecosystem. The development concept should change from “3R” to “5R” (i.e., Rethink, Reduce, Reuse, Recycle, and Restore). Specifically, rethink is to study the capital and labor cycles and the natural resource cycle. Reduce includes the reduction of the original input of production materials and the extension to meet reasonable demands. Reuse is to extend from multiple uses, waste reclamation to full use of renewable resources, strengthening the share of infrastructure and information resources, and developing “remanufacturing” using waste as a raw material. Recycle is to change the extensive and open production process of economic systems to an intensive and closed process, forming a technical system and an industrial system of the circular economy. Restore, is the gradual restoration of the natural ecosystem degraded by human activities. Harmony with nature will ultimately benefit human well-being.

3.7 Promoting peri-urbanization and pollution abatement in rural areas

Peri-urbanization is a process of relocating villages to towns or counties (not cities) and is an effective way to address decentralized pollution treatment in rural areas. In general, rural sewage mainly originates from toilet flushing, laundry, rice washing, vegetable washing, and bathing. These activities generally do not contain toxic substances except nutrients such as nitrogen and phosphorus, as well as a large amount of bacteria, viruses, and parasite eggs. Due to different traditions, living modes and economic levels, the quality and quantity of rural domestic sewage may differ significantly. The process of “peri-urbanization” will significantly alleviate a number of issues in rural domestic sewage including scattered distribution, strong randomness, extensive discharge, small sewage flow, complex components, and intense biodegradability. In the process of promoting peri-urbanization, even though the total amount of rural pollution may increase, the uniformity of peri-urbanization will concentrate pollution and facilitate its treatment to meet higher discharge standards.

4 Conclusion

It is imperative that the shortage of water resources, water pollution, and ecological degradation faced by the coordinated development of the Beijing–Tianjin–Hebei region is addressed. Seven strategies have been proposed to be implemented as soon as possible. Specifically, multi-pollutant synergetic control such as steel, chemicals and dyeing, improvement of water-saving and recycling rate in high water-consuming industries, control of agricultural non-point source pollution and water-saving irrigation, and enhancement of water environmental capacity and carrying capacity of aquatic ecosystems should be core measures. This aids the coordinated development of the Beijing–Tianjin–Hebei region and its ecological civilization construction. This will help further realize the comprehensive improvement of ecosystems in the Beijing–Tianjin–Hebei region.

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