Contradiction between Supply and Demand of Water Resources in the Hulun Lake Basin and Its Control Measures

Shali WEI *

Hulunbuir Meteorological Bureau, Hulunbuir 021008, China

Abstract The balance of water resources in lake basins in arid and semi-arid areas is related to regional ecological security and sustainable economic development in pastoral areas, and the conflict of water use in the Hulun Lake basin has long restricted the ecological stability of the lake. In view of the current situation of water resources supply and demand in the Hulun Lake basin, the prominent contradiction between supply and demand of water resources is identified, and the targeted control measures are proposed from four dimensions: ecological water replenishment scheduling, industrial water use control, cross regional collaborative governance, and water resources system improvement. This paper could provide practical reference for the sustainable utilization of water resources in the basin and the long-term ecological protection of the Hulun Lake.

Key words Hulun Lake basin; Contradiction between supply and demand of water resources; Ecological water demand; Regulatory measures

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The Hulun Lake is located in the hinterland of the Hulun Buir Grassland in Inner Mongolia. The Kherlen River and the Urxun River are the two main surface runoff sources of the lake, and groundwater and atmospheric precipitation are auxiliary water sources. As a rare large lake in the arid and semi-arid areas of northern China, the Hulun Lake has multiple ecological functions such as regional water conservation, wildlife habitat, local climate regulation, and supports economic and social activities such as livestock breeding in the basin, small-scale farmland irrigation, and domestic water supply for township residents. In recent years, the average annual temperature in the region has continued to rise, and the evaporation of water surface has increased year by year. The spring snowmelt runoff has significantly decreased, extreme drought events occurred frequently in summer, and the supply capacity of natural water resources has gradually declined. At the same time, the total number of livestock in the pastoral areas of the basin has steadily increased, the irrigated area of artificial forage bases around the lake continued to expand, and the population agglomeration in towns and villages has driven a slight increase in domestic water demand. The occupation of ecological water replenishment by production and domestic water has become a normalized phenomenon, leading to a widening gap in the supply and demand of water resources in the basin year by year. Existing studies mostly focus on the analysis of water level evolution, water eutrophication and lakeside wetland vegetation degradation of the Hulun Lake, and there is still room for supplement in the systematic analysis on supply and demand balance of water resources in the basin. Based on the actual supply and demand of water resources in the Hulun Lake basin, the supply and demand scale of ecological, production and domestic water by category is calculated, the outstanding contradictions in the current allocation of water resources are combed, and the adaptive regulation measures are put forward in combination with the development characteristics of grassland and pastoral areas in the basin. It could help to achieve the coordinated development of ecological protection and economic water use in the Hulun Lake basin.

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* Corresponding author.

1 Current situation of supply and demand of water resources in the Hulun Lake basin

1.1 Supply conditions of water resources in the basin The Hulun Lake basin has a temperate continental arid and semi-arid climate. The total precipitation in the whole region is relatively small, and the spatial and temporal distribution is extremely uneven. Precipitation is concentrated during the short-term flood season in summer, with scarce effective precipitation in winter and spring. Regional evaporation is strong, resulting in significant loss of natural water bodies and weak natural water conservation foundations. The surface water resources in the basin mainly rely on the two main streams that enter the lake, the Kherlen River and the Urxun River, for replenishment. River runoff is the core source of water volume in the lake. Affected by climate fluctuations, the runoff of the two rivers has a significant interannual variation, and there is a great difference in water volume between wet and dry years. It directly causes the periodic rise and fall of the water level of the Hulun Lake, and the stability of surface water supply is poor[1]. Groundwater is an important auxiliary water supply source for the watershed, providing a basic guarantee for regional water use. However, the shallow groundwater reserves in the basin are limited, and the supply channels are single, relying only on atmospheric precipitation and river side seepage for replenishment. When encountering continuous drought, the ground-

water level drops synchronously, making it difficult to make up for the water gap formed by surface runoff. The current watershed lacks large-scale water conservancy and storage facilities, which cannot regulate the annual and interannual distribution differences of natural runoff. The problem of imbalanced spatial and temporal allocation of water resources is prominent, and the lack of innate water supply conditions is the core root cause of regional water resource supply – demand contradictions.

1.2 Composition of water resource demand in the basin In combination with the actual development of the Hulun Lake basin, regional water use is divided into four categories: ecological water, livestock production, agricultural irrigation, and urban-rural domestic water. There are significant differences in water demand characteristics and water use scale of each category. Ecological water is the rigid water with the highest priority in the basin. It is mainly used to maintain the stable water area of the Hulun Lake, ensure the survival of lakeside wetlands, maintain the basic runoff of rivers, and ensure the normal growth of grassland vegetation. It is the basic guarantee for stabilizing the structure and function of the ecosystem in the basin, and has irreplaceable ecological value. Animal husbandry is the dominant industry in the basin, and its water use has the highest proportion in production water, mainly meeting the needs of livestock for drinking water and grassland maintenance. With the continuous improvement of regional standardized breeding systems and the expansion of artificial forage planting areas, the demand for water in animal husbandry is steadily increasing, and water pressure continues to increase. The area around the lake is distributed with grass planting plots and a small amount of grain cultivated land. Agricultural water relies on river diversion and shallow groundwater extraction. Regional agricultural irrigation is still dominated by traditional methods, with extensive water use patterns and high ineffective water resource consumption. There is ample room for water-saving transformation and improvement. The urban and rural domestic water covers towns along the lake and grassroots settlements, coupled with the temporary increase in water consumption brought by the floating population during the peak tourist season. The overall proportion of this type of water use is not high, but it is directly related to people's livelihood security and has high requirements for water supply stability and water quality safety. From the perspective of the overall pattern of supply and demand in the basin, the total amount of water resources during the flood season can fully cover various water needs in the region, and the supply and demand during the normal season are basically balanced. However, the total amount of water supply in the basin during persistent dry years is insufficient, and the supply – demand gap is prominent. Under the constraint of the total amount of water resources, production water continues to occupy the space for ecological water use, and the hydrological and ecological balance of the basin is damaged, leading to ecological problems such as shrinkage of lake waters, desertification of lakeside land, and wetland degradation, and further increasing the vulnerability of the ecosystem of the Hulun Lake basin.

2 Prominent contradictions between supply and demand of water resources in the Hulun Lake basin

2.1 Imbalance in spatial and temporal allocation of water resources, with a concentrated outbreak of supply and demand gaps during the dry season The precipitation and runoff in the Hulun Lake basin are concentrated in the summer flood season. During the wet season, there is abundant water from the river channel, but the basin is lack of reservoir, barrage and other regulation and storage projects. A large amount of surplus runoff in the flood season flows into the lake and evaporates, which cannot be reserved for supply in the dry season. The period from November to next May is the dry season in the basin, during which the river runoff decreases significantly and the intensity of groundwater extraction increases synchronously. The continuous diversion of water from animal husbandry and agriculture squeezes the ecological runoff into the lake, resulting in insufficient water supply to the lake and a rapid decline in water level[2]. The spatial and temporal distribution of water resources is misaligned, resulting in a polarized situation of idle water loss during the wet season and water competition among various industries during the dry season.

2.2 Low efficiency of industrial water use, and the intensified competition between production and ecological water The extensive water use mode has long been used in the pastoral and agricultural areas of the basin. The phenomenon of flood irrigation in grassland and farmland is common, and the effective utilization coefficient of irrigation water is far lower than the national average level. Small-scale breeding bases lack supporting circular water supply facilities, resulting in extremely low reuse rates of drinking water resources for livestock. Under the premise of limited total water resources, inefficient production water continues to consume natural runoff, and a large amount of water that should have been supplied to the lake is occupied by industrial activities. The security space of ecological water continues to be compressed, forming a negative cycle of "industrial scale expansion – rising water demand – continuous shrinkage of lake".

2.3 Unclear rights and responsibilities for cross administrative water use, lack of coordination in upstream and downstream allocation The upper reaches of the Kherlen River are located within the territory of Mongolia, while the upper and lower reaches of the Urxun River cross multiple banner areas. A unified linkage mechanism for cross-border and cross-banner water resource allocation has not yet been established. Priority is given to ensuring local animal husbandry and agricultural water intake in the upstream area, without reserving sufficient downstream ecological runoff into the lake. The cross-border river reach lacks the negotiation channel of normalized water volume, and the upstream water volume is reduced in dry years, which directly aggravates the insufficient water supply of the Hulun Lake. It is difficult to coordinate water demands between upstream and downstream, domestic and overseas, and a single territorial management model cannot resolve conflicts over water resources across the entire

region.

2.4 Imperfect water resource management system, and insufficient rigid constraints on ecological water The current management of water resources in the basin focuses on ensuring production and domestic water supply, and does not include the minimum ecological water level of the lake and the basic runoff of rivers as mandatory control indicators. Ecological water usage quota is not sufficiently accounted and reserved in the approval process of water intake permit[3]. There is lack of price regulation mechanism for water resources in the basin, coupled with low water extraction costs for animal husbandry and agriculture, makes it difficult to rely on economic leverage to promote water-saving transformation. The detailed rules for the implementation of supporting policies for ecological water replenishment and water resource compensation are not perfect, and the problem of regional water use imbalance is difficult to resolve for a long time.

3 Regulation measures to alleviate the contradiction between supply and demand of water resources in the Hulun Lake basin

3.1 Improving the water conservancy regulation and storage engineering system, and optimizing the spatial and temporal redistribution of runoff Firstly, it should promote the construction of key water conservancy facilities for regulating and storing water in the basin. It plans to build new small and medium-sized river blocking reservoirs and ecological water replenishment gates in the middle reaches of the Kherlen River and the Urxun River. During the flood season, surplus runoff could be stored. During the dry season, water could be directed to downstream rivers and lakes for replenishment, filling the gaps in inter annual and intra annual regulation of runoff in the basin and reducing the supply – demand gap of water resources during the dry season. Secondly, it should renovate the existing dispersed water diversion channels, install water diversion metering gates, quantify and verify the upstream animal husbandry and agricultural water intake, strictly reserve the basic ecological runoff of the river channel, and safeguard the bottom line of lake inflow supply. Thirdly, it should optimize the inter basin emergency water supply mechanism, do a good job in the daily operation and maintenance management of the diversion channel from Hailar River to the Hulun Lake, start emergency ecological water supply in extreme dry years, quickly make up the water deficit of the lake, and maintain the appropriate ecological water level of the lake.

3.2 Promoting the water-saving transformation of the entire industry, and reducing the total demand for production water The water-saving technology transformation should be implemented for pastoral and agricultural areas by industry, and ineffective water consumption should be reduced from the source. It should comprehensively promote drip irrigation and sprinkler irrigation technology in the field of grassland agriculture, to replace traditional flood irrigation mode. The irrigation water quotas for artificial forage bases should be established, the tiered price control for water exceeding quotas should be implemented, and the effective utilization coefficient of irrigation water should be improved. It should promote standardized circulating drinking water facilities in the field of animal husbandry, collect and treat breeding wastewater for secondary use in grassland spraying, and reduce the scale of fresh water intake. It should guide pastoral areas to optimize breeding models, moderately control the total inventory of overloaded livestock, implement rotation and rest grazing systems, and reduce the pressure on water resources from the perspective of industrial scale. Simultaneously, water-saving publicity and practical training should be carried out for pastoral areas, the water-saving awareness of grassroots Gacha and breeding households should be enhanced, and their extensive water use habits should be transformed.

3.3 Building a cross-border and cross-region collaborative governance mechanism, and coordinating the allocation of water resources across the entire region Internally, it should set up joint water resources dispatching special teams at banner and county level in the Hulun Lake basin, uniformly check and ratify the production and ecological water consumption quota of each region, sign the upstream and downstream water supply guarantee agreement, incorporate the inflow into the lake and river base flow guarantee into the annual assessment of local government, and restrict the excessive water intake behavior of upstream. Externally, it should establish a normalized negotiation platform for cross-border rivers between China and Mongolia, hold regular consultations on the amount of inbound water of the Kherlen River, negotiate to determine the minimum ecological discharge flow of cross-border river reach, and stabilize the supply of inbound runoff of Mongolia to Hulun Lake. An integrated water resources monitoring network for the basin should be built, and automatic monitoring stations for flow and water level should be set up in cross-border river sections and major lake entrances to achieve real-time sharing of water volume data throughout the basin, providing data support for cross regional water allocation.

3.4 Establishing a sound rigid constraint system for water resources, and improving the ecological water security system First, it should establish the principle of priority management and control of ecological water, set the minimum ecological water level of the Hulun Lake and the minimum drainage base flow of two rivers into the lake as the hard preconditions for water intake permission, and complete the calculation of ecological water reserve quota before the approval of all animal husbandry and agricultural water intake projects, to prevent production water from occupying ecological runoff without restrictions. Second, it should establish a differentiated water resource pricing mechanism, significantly increase the water fee standards for exceeding quotas in agriculture and animal husbandry, rely on water costs to force water users to carry out water-saving renovations, and use water fees specifically for watershed ecological water replenishment and lakeside wetland restoration projects. Third, it should improve the ecological compensation system for the basin, and allocate ecological compensa-

tion funds from downstream water benefit areas to upstream water source protection areas such as Gacha, banner and county, to compensate for the economic losses caused by the control of industrial water intake in the upstream and balance the interests of upstream and downstream water use. Fourth, it should refine the water resources assessment and accountability system, include the control of total water use in the basin and the maintenance of ecological water levels in the lake in the performance assessment of local governments, punish the responsible parties for excessive water intake and damage to natural river runoff in accordance with the law, and rely on institutional constraints to ensure long-term supply-demand balance of water resources.

4 Conclusion

The contradiction between supply and demand of water resources in the Hulun Lake basin is a complex problem formed by the superposition of natural climate evolution and regional human development activities. The imbalance of water resources distribution in time and space, extensive industrial water use, fragmentation of cross regional governance, and insufficient control mechanism constraints are the four core causes of the contradiction. There is a continuous shortage of water resources in the current watershed during normal and dry years. If systematic regulation is not implemented, it will continue to cause irreversible ecological damage such as shrinkage of lake waters, desertification of lakeside grasslands, and decline in biodiversity. To resolve the conflict between supply and demand of water resources in the basin, it cannot rely solely on short-term emergency ecological water replenishment. It is necessary to establish an integrated regulation system of "engineering regulation and storage + industrial water conservation + cross regional collaboration + institutional control": relying on water conservancy projects to optimize the spatial and temporal distribution of natural runoff, compressing the total demand for production water through water-saving transformation, coordinating the distribution of water resources throughout the entire region through cross-border and cross-county collaborative mechanisms, and safeguarding the bottom line of ecological water in the lake with a rigid water resource management system. The coordinated implementation of multiple measures can gradually narrow the gap between supply and demand of water resources in the basin, balance the demand for water for industrial development in pastoral areas and ecological protection of the Hulun Lake, achieve long-term sustainable use of water resources in large-scale lake basins of arid and semi-arid regions, and build a solid ecological security barrier for grasslands in northern China.

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(From page 74)

cal education majors to implement fostering virtue through education and cultivate high-quality applied sports talents. "Internet + ideological and political education" effectively solves major challenges for private institutions including fragmented education, insufficient educational carriers and simplistic evaluation frameworks. This paper identifies key bottlenecks of five-education integration in private physical education majors and constructs a long-term educational mechanism from five dimensions: educational concepts, digital platforms, curricula, evaluation and supporting guarantees. Private universities should take full advantage of digital ideological and political education, continuously advance teaching reforms, promote deep five-education integration, and cultivate well rounded high-quality physical education professionals.

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