Study on the Sustainable use of Regional Groundwater Resources

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Abstract. Water resources have become a major factor limiting the sustainable development of China's economy and society, and at the same time China's water resources are developed and utilized in a relatively sloppy manner, China is facing multiple pressures of population, resources and environment, and the problems of water shortage, water environment deterioration and flood disaster prevention are becoming increasingly prominent. The rapid development of economic and social demand for water resources is increasing, and the people's desire to improve the ecology and environment is becoming more and more urgent. How to fully consider the sustainable use of water resources, effectively solve the contradiction between water demand and supply, development and protection, improve the level of planning and scientific decision-making, promote economic development and water carrying capacity to adapt to accelerate the transformation of economic growth and structural adjustment is of great importance.

1 Introduction

China is one of the countries with serious shortage of water resources in the world. The Party Central Committee and the State Council attach great importance to water resources, and have identified food, energy and water resources as three strategic resources, making it clear that sustainable utilization of water resources is a strategic issue to support China's social and economic development. The water consumption in some areas of China has greatly exceeded the available amount of water resources, and the uncontrolled development and utilization of water resources has led to the problems of river breakage, lake shrinkage and groundwater over-exploitation, so the sustainable utilization of regional groundwater resources is analyzed and studied.

2 Regional Overview

Qing'an County is located in the heart of Heilongjiang Province, at the intersection of the Songnun Plain and the remaining veins of the Xiaoxinganling Mountains, in the middle and upper reaches of the Hulan River Basin. Geographical coordinates: 127º30'-128º35'E, 46º30'-47º35'N. It is 47km away from Suihua, 146km away from Harbin, the provincial capital, and belongs to Suihua's half-hour economic circle and Harbin's one-and-a-half-hour economic circle, 170km away from Yichun, the forest capital, 280km away from Hegang, the coal city, 260km away from Daqing, the oil city, and 470km away from Heihe, the port of Russia, which is an

important transportation hub along the HAI line, facing the oil and agricultural areas, and backed by the forest and mining areas. It has a broad market with forest and mining areas at its back. Yisui highway, Jina highway and Hajia railroad run through the territory, the traffic is extremely convenient and the location advantage is obvious[1-3].

The planning of the development zone determines that the total land area of the development zone is 661.28hm^2, of which 661.28hm^2 is for construction, of which 12.52hm^2 is for public administration and public service facilities, 14.54hm^2 is for commercial service facilities, 463.71hm^2 is for industry^2, 3.45hm^2 is for logistics and warehousing, 127.69hm^2 is for roads and transportation facilities, 6.97hm^2 is for public utilities, 32.4hm^2 is for green areas and squares. 127.69hm^2, 6.97hm^2, 32.4hm^2.The location of the development zone is as shown in Figure 1.
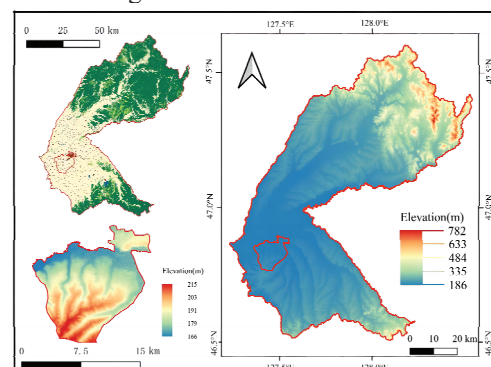

Fig. 1. Location map of the development area.

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3 Regional groundwater resource demand analysis

The water demand forecast should be based on the future water-saving society construction target, and implement the requirement of giving priority to water conservation, taking into account the current situation of water supply, water-saving potential and water supply capacity, as well as the reasonable water demand to meet future development, while also fully considering the need to protect the basic ecological environment and local residents' living water demand. The water demand forecast is carried out using methods such as the quota method and the water consumption index method per unit of construction land[4-6].

3.1 PROJECTIONS BY WATER USE SECTOR (QUOTA METHOD)

(1) Domestic water demand

According to the "Master Plan of Qing'an County Industrial Park (2020-2035)", the forecast of living water demand is divided into two parts, one part is the forecast of living of residents in the industrial park, and the other part is the forecast of living of employees of enterprises in the park. According to the plan, the population scale of the near-term plan (2020-2025) reaches 20,000 people, of which the rural residence are all fixed enterprise employees, and the population scale of the long-term outlook (by2035) reaches 42,000 people, all fixed enterprise employees[7-10].

$$Q = P \cdot q$$

Where: Q is the total domestic water consumption; P is the population size and q is the water quota.

Using Public Notice (1), we get $Q_1 = P \cdot q_1$; $Q_2 = P_2 \cdot q_2$.

The water consumption quota of each planning area is determined according to

the Outdoor Water Supply Design Standard (GB50013-2018) and other relevant documents and the actual situation of the area. It is determined that the domestic water quota for employees is 40L/person-d, and the predicted domestic water demand in Heilongjiang Qing'an Development Zone is shown in Table 1.

Table 1. Domestic water demand forecast table.

Level year	Total population (10,000 people)	Water consumption quota (L / person ·d)	Annual water consumption (million m³)
2025	2.0	40	29.2
2035	4.2	40	61.32

(2) Industrial water demand

1) Industrial output

According to the Fourteenth Five-Year Plan of National Economic and Social Development of Qing'an County and the National Economic Statistical Yearbook of Qing'an County in 2020, the growth rate of industrial output value of Qing'an County is predicted to be 8.5% from 2020 to 2025 and 7.2% from 2025 to 2035. The current industrial added value of the development zone is 195 million yuan, and the predicted industrial added value of the development zone is 293 million yuan in 2025 The current industrial added value of the development zone is 195 million yuan, and the predicted industrial added value of the development zone in 2025 is 293 million yuan, and the industrial added value in 2035 is 586 million yuan.

2) Industrial water quota

Investigate the current output value and water consumption of the main water-using enterprises in the planning area in 2020, analyze the water consumption of 10,000yuan output value as the water consumption quota, and calculate the current industrial water consumption of 10,000yuan output value in the planning area as 65.4m³ / million yuan, and the industrial water reuse rate is about 75%.

Based on the "Study on the micro water quota index system in Songliao basin", the water demand quota for industry is predicted by the method of increasing the reuse rate, and the relationship between the new water quantity per unit of added value and the reuse rate of water consumption is used for the quota prediction[11-13]:

$$q_2 = \lambda \cdot (1 - \eta_2)/(1 - \eta_1) \cdot q_1$$

Where: q_2 - new water per unit of added value for the planning level year, m³ / million;

λ - is the production value coefficient, more stable this time take 1;

q_1 - reasonable unit value added new water for the current level year, m³ / million;

η_2 - the planning level annual water use reuse rate;

η_1 - status quo level annual water use reuse rate;

n - the length of the forecast year.

According to the results of the survey statistics of Qing'an town, the industrial water reuse rate in 2020 is 75%, and according to the National Water Conservation Action Plan, water conservation policies and regulations, market mechanisms and standard systems tend to be perfected, technical support capabilities are continuously enhanced, management mechanisms are gradually improved, the initial effect of water conservation appears, and the industrial water reuse rate above the scale reaches more than 91%[14-17]. According to the water conservation requirements, considering the development of alternative industries and the improvement of water conservation level in the future period, the new water volume of industrial 10,000 yuan added value will still show a decreasing trend, and combined with the adjustment and transformation development plans of major local industrial industries, the industrial water reuse rate in 2025 and 2035 is reasonably predicted. In summary, the industrial water demand in 2025 in the development zone is 1,427,500m³; the industrial water demand in 2035 is 1,379,700m³.The planned annual water consumption per unit output value is shown in Table 2.

Table 2. Table of water consumption per unit of output value in the planning level year.

Serial number	Level Year	Reuse rate (%)	New water volume in million yuan of

			added value (m^3 / million yuan)
1	Base year	75	65.4
2	2025	82	48.72
3	2035	91	23.54

(3) Environmental water demand

According to the specification, water for urban environment includes water for watering roads and green areas. According to the "Master Plan of Qing'an County Industrial Park (2020-2035)", the analysis determines the road area and green area of Qing'an Development Zone in the current situation and planning level year, and then the water consumption quota is determined according to the norms, from which the water demand for its urban environment is analyzed and predicted. The urban greening quota is 0.1 million m^3 /d.km^2, and the quota for road sprinkling is 0.2 million m^3 /d.km^2, and the number of greening sprinkling days is taken as 60 days for the time being, taking into account the actual local situation. According to the analysis of the above indicators to calculate the water demand of urban environment in the water supply area[14-20].The calculation results of the boundary water demand are shown in Table 3.

Table 3. Environmental water demand results table.

Level year		2025	2035
Urban Greening	Green space area (km^2)	0.55	0.32
	Water demand quota (m^3/km^2·d)	0.1	0.1
	Number of days (d)	60	60
	Water demand (million m^3)	3.3	1,92
Road watering	Road area (km^2)	1.2	1.21
	Water demand quota (million m^3 /km^2 ·d)	0.2	0.2
	Number of days (d)	60	60
	Water demand (millionm^3)	14.4	14.52
Environmental water demand (million m^3)		17.7	16.44

(4) Other water requirements

According to the Outdoor Water Supply Design Standard (GB50013-2018), the leakage of water from the pipe network is 10-12% of the sum of comprehensive water for urban residents, industrial water and urban green roads; the unforeseen water is 8-10% of the sum of comprehensive water for urban residents, industrial water, urban green roads and leakage of water from the pipe network[21]. The unpredicted water volume is 8-10% of the sum of the four water volumes: comprehensive water for urban residents, industrial water, water for urban green areas and roads, and water leakage from the pipe network. By strengthening water management and transforming the pipeline network year by year, the leakage of water from the pipeline network will be gradually reduced. The current forecast of the leakage of

water from the pipeline network is 12% in the current year and 8% in the planning year, and the unforeseen water is 10% in the current year and 8% in the planning year. This calculation of the planning area pipe network leakage and unforeseen water, the specific results are detailed in Table 4, Table 5.

Table 4. Table of predicted results of water loss from pipe network.

Level year	The first three water requirements (million m^3)	Leakage rate (%)	Water demand (million m3)
2025	189.65	8	15.17
2035	215.73	8	17.26

Table 5. Table of unpredictable water forecast.

Level year	The sum of the first four water requirements (million m^3)	Specific Gravity %	Water demand (million m^3)
2025	204.82	8	16.39
2035	232.99	8	18.64

(5) Total water demand

The water demand of Qing'an Development Zone includes the above-mentioned residents' comprehensive domestic water demand, industrial water demand, urban environmental water demand, water leakage from the pipeline network, etc. Based on the predicted water demand of the above-mentioned industries, the total water demand of the Development Zone is calculated, and the specific results are shown in Table 6.

Table 6. Summary of water demand.

Level year	2025	2035
Life	29.2	61.32
Industrial	142.75	137.97
Urban Environment	17.7	16.44
Pipe Network Leakage	15.17	17.26
Unpredictable	16.39	18.64
Total	221.21	251.63

3.2 WATER CONSUMPTION INDEX METHOD PER UNIT OF CONSTRUCTION LAND

According to the urban water supply engineering planning specification (GB 50282-2016) in the urban water consumption calculation method and quota index, the annual water demand of the planning level of Heilongjiang Qing'an Development Zone is predicted. According to the Master Plan of Qing'an County Industrial Park (2020-2035), the area of different categories of land in the development zone in 2025 is 543hm^2, of which 543hm^2 is urban construction land, and the total area of different categories of land in 2035 is 661.28hm^2, of which 661.28hm^2 is urban construction land.The annual water demand results of the recent planning level are shown in Table 7, Table 8.

Table 7. Recent planning level annual water demand results table.

Summary of planned sites for 2025 (hm²)			Water requirement calculation			
Site Code	Site Name	Total Land Area	Quotas m3/ (hm².d)	Water requirement/ Days (m³/d)	Days of operation (d)	Water requirement (million m³)
A	Land for public administration and public service facilities	2.05	50	102.5	300	3.08
B	Commercial service facility land	10.88	50	544	300	16.32
M	Industrial Land	101.16	50	5058	300	151.74
W	Logistics and warehousing land	3.45	20	69	300	2.07
S	Land for roads and transportation facilities	58.87	20	1177.4	60	7.06
U	Land for public facilities	0.39	25	9.75	60	0.059
G	Green space and square land	40.7	10	407	60	2.44
H11	Urban construction land	96.58				182.77
Total planning site		661.28				

Table 8. Table of water demand results for the long-range planning level.

Summary of planned sites in 2035 (hm²)			Water requirement calculation			
Site Code	Site Name	Total Land Area	Quotas m³ /(hm² • d)	Water requirement/ Days (m³/d)	Days of operation (d)	Water requirement (million m³)
A	Land for public administration and public service facilities	2.05	50	102.5	300	3.08
B	Commercial service facility land	10.88	50	544	300	16.32
M	Industrial Land	174.66	50	8733	300	261.99
W	Logistics and warehousing land	3.45	20	69	300	2.07
S	Land for roads and transportation facilities	66.16	20	1323.2	60	7.94
U	Land for public facilities	2.75	25	68.75	60	0.41
G	Green space and square land	17.77	10	177.7	60	1.07
H11	Urban construction land	661.28				293.51
Total planning site		661.28				

According to the method of water consumption index per unit of construction land, the water demand of the park is deduced, and the daily uneven coefficient is 1.3. The water demand in 2025 is 1.459 million m³, and the water demand in 2035 is 2.2578 million m³.

3.3 TOTAL WATER DEMAND ANALYSIS

The water demand prediction results of the above two methods are compared and analyzed (see Table 9), the calculation results of the construction land index method according to the Urban Water Supply Engineering Planning Code are larger, considering that the "unit construction land use index method" predicts the water demand of the park mainly from the perspective of the park land type, this method does not take into account the development orientation of the park, the main industrial type, the production scale of the construction project, the advanced degree of technology and other factors. This method does not take into account the development orientation of the park, the main industrial type, the production scale of the construction project, the advanced degree of technology and other factors, and the prediction result is large, and the water consumption quota does not meet the requirements of water conservation; the prediction method of the water consumption industry is based on the water consumption quota and considers the water consumption of different industries separately, taking into account the current industrial water consumption and the projects to be settled in the park, and the prediction result of the water demand of the water consumption industry is closer to the actual situation.Comparisons of the results for the different prediction methods are shown in Table Table 9.

Table 9. Comparison table of results of different prediction methods.

Level year	Sub-industry quota method	Water consumption index method per unit of construction land	Recommended water volume
2025	221.21	140.59	221.21
2035	251.63	225.78	251.63

4 Evaluation of sustainable groundwater use in the development area

4.1 Resource sustainability analysis

Groundwater resources in Qing'an County are relatively abundant, and the average multi-year total groundwater recharge in the plain area is 298.35 million m^3 , with a total recharge modulus of 105.3 million m^3 /km^2 *a, of which 23.987 million m is infiltrated by atmospheric precipitation , accounting for 80.4% of the total recharge, 55.16 million m is infiltrated by surface water bodies , accounting for 18.5% of the total recharge, and 3.32 million m is recharged laterally in front of the mountain , accounting for 1.1% of the groundwater recharge. Therefore, the main source of groundwater recharge in Qing'an County comes from atmospheric precipitation, and the proportion of surface water recharge is not significant. The multi-year average groundwater extractable volume is 234.71 million m^3. The extractable modulus is 82.9 million m^3 /km^2 *a. The groundwater resource demand of Qing'an Economic Development Zone is 221.21 million m^3 in 2025 and 251.63 million m^3 in 2035. The groundwater resource demand of Qing'an Development Zone is within the range of groundwater extractable volume, so from the perspective of resources, the groundwater resource of the Zone can achieve sustainable use of resources.

4.2 Engineering Sustainability Analysis

Qing'an town east water supply project, in the eastern part of town to play water source deep well, water purification plant seat, water supply scale for 9000m / d, treatment process for raw water a drop aeration ~ iron removal valveless filter tank → aeration machine aeration → manganese removal filter tank → water discharge. The current water distribution network is 31551m, with DN500-DN100 pipe diameter.

Qing'an County Qing'an town new water supply project new water source 25 eyes, 23 with 2 ready, mining well row line distance 400m, was "plum blossom type", eye Isui highway auxiliary road in three rows of vertical arrangement. The scale of water extraction 31800m^3/d, water supply scale of the water plant is 30000m^3/d, to solve the contradiction of water supply and demand in Qing'an town.

The groundwater extraction project in Qing'an County can meet the water requirements for the national economic development of Qing'an County, improve the living standard of residents and promote the construction of a harmonious society. The construction of the project can make the local water resources reach a reasonable allocation, strictly in accordance with the designed extraction amount for reasonable and orderly exploitation of groundwater, and firmly prohibit over-extraction of groundwater, so as not to affect the service life of the water source, and to achieve the sustainable use of regional groundwater resources.

5 Conclusion and Recommendations

A study based on the forecast of water demand in the Qing'an Development Zone. The study was based on dynamic planning for water source selection, scientific formulation of water resource allocation plans for the development zone, and comprehensive analysis of the impact of the implementation of the plans, resulting in a complete study of sustainable water resource protection for new centralised water use areas. The model was constructed with an eye to the overall situation and fundamental nature of water resources issues. Based on the planning, horizontal year, regional characteristics and water use forecasts of the new centralised water use case area, the water source comparison and impact analysis of the case area were carried out, and a sustainable water resource security plan for the new centralised water use case area was demonstrated.

Heilongjiang Qing'an Economic Development Zone, after the analysis of water demand forecast restraint, the regional groundwater resource demand is 221.21 million m3 in 2025 and 251.63 million m3 in 2035, which is much smaller than the multi-year average groundwater extractable amount of 234.71 million m3 in Qing'an County, from the perspective of resource sustainability, the sustainable use of regional groundwater resources is feasible.

Give full consideration to groundwater abstraction projects, groundwater abstraction projects in the area of Heilongjiang Qing'an Economic Development Zone are in line with national laws, relevant industrial policies, relevant planning, management of water function zones and other regulations. The comprehensive economic development characteristics and water resources conditions can effectively improve water supply safety, guarantee sustainable groundwater resources abstraction and coordinate the contradiction between water supply and demand. Therefore, from the engineering point of view, the sustainable utilization of regional groundwater resources is feasible.

Acknowledgments

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