A Tug-of-War on Water

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Abstract. Considering the relationship between the water demand, available water resources and the form of the regional ecosystem, we establish the model on the basis of urban ecosystem. For water demand, we take the urban living water demand, industrial water demand, natural environment water demand and agricultural water demand into consideration. For available water resources, surface water, groundwater and other water resources are taken into consideration. The water scarcity situation in this region can be measured by the index of balance of water supply and demand and the water scarcity rate. The city of Qingdao is chosen as the research object, which is in seriously short of water. In the process of analyzing the supply and demand of water resources in Qingdao, for different quantities, regression analysis is made with various ways. We find that if no measures are taken, the situation of water scarcity will be intensified in the coming 15 years in Qingdao and the index of balance of water supply and demand will be 1.376.

1.Introduction

In recent years, due to the increasing demand for water, and uneven distribution of fresh water resources on the earth, in many parts of the world, there are different degrees of water shortage. Qingdao City, Shandong Province, China has been a serious water scarcity city, Qingdao city is located in the southwest of Shandong peninsula. At the same time, because of the special geographical position and climate characteristics of Qingdao City [1]. The development and utilization of water resources is difficult. In this paper, the supply and demand balance of water resources in Qingdao city is analyzed and predicted.

2.Solutions

Step 1: Water demand

1. Living water demand

According to the national standard of living water for urban residents[2], the per capita quota set 100L per people per day in 2015.According to the historical data of the residents in Qingdao City, the forecast of the population in the next 15 years can be done, get the demand of water as shown in the summary table.

2. Industrial water demand

We have improved the model of Lu Zhengbo's "Qingdao industrial water demand forecast" [3], namely: the industrial water reuse rate uses the logarithm of the form to fit. Calculated by the regression equation, we obtain the final forecast equations:

$$\mathrm{Y} = -4.132 - 3.081X_1 + 0.213X_2 + 0.028X_3 - 0.007X_4 + 0.008X_5$$
$$X_1 = 0.00753054t^2 - 30.09736479t + 30072.760$$
$$X_2 = 45$$
$$X_3 = 1.1560689t^2 - 4462.5529t + 4452761.4462132$$
$$X_4 = -0.0108t^2 + 48.687t - 53472$$
$$X_5 = 1066.5\ln t - 8026.1$$

In these equations,

X_1: Total industrial output (10^3 billion yuan)

X_2: Industrial output value accounted for the proportion of the total output value of the national economy (%)

X_3: Electricity generation (10^8km*h)

X_4: Population (million people)

X_5: Reuse ratio of industrial water (%)

3. Natural environment water demand

Table 1: Environmental water demand grade of Shandong rivers basin ($10^8 m^3$)

Number of cities	Least	Light	Secondary	Major	Optional
8	8.62	8.62-17.36	17.36-30.89	30.89-45.74	45.74

According to the relationship between quality of the urban ecological environment and the demand of water [4], actual optimal water demand is in the range of "Major". Qingdao is located in the river basin in Shandong, so in order to simplify the calculation, we choose 3 billion 200 million cubic meters in "Major" range, the optimal water demand is 32/8 = 4 billion cubic meters and we assume this is a constant.

4. Agricultural water demand

We predict the agricultural water demand in exponential form by the data from 2001 to 2009.The forecast equation is:

$y = 7.923 \times 10^4 e^{0.5692x}$

Step 2: Water supply

1. Surface water supply

We predict the surface water supply (P’) in logarithmic form by the data from 2001 to 2009.The forecast equation is:

$y = 2.898 * \ln(696.3x)+30000$

In this step, we use P01 to express the surface water, which contains the seawater desalted and diverting water.

2. Underground water supply

We predict the underground water supply in exponential form by the data from 2001 to 2009.The forecast equation is:

$y = 36590 \times e^{-0.12874x}$

Table 2: Our water demand forecast without intervention

The year	W_1	W_2	W_3	W_4	W	90%W
2016	1.060	3.176	4.000	3.187	11.423	10.281
2017	1.087	3.330	4.000	3.011	11.427	10.284
2018	1.113	3.500	4.000	2.844	11.457	10.311
2019	1.140	3.686	4.000	2.687	11.513	10.361
2020	1.168	3.888	4.000	2.538	11.594	10.434
2021	1.195	4.107	4.000	2.398	11.699	10.529
2022	1.223	4.341	4.000	2.265	11.829	10.646
2023	1.252	4.592	4.000	2.140	11.983	10.785
2024	1.280	4.859	4.000	2.021	12.161	10.945
2025	1.309	5.143	4.000	1.909	12.361	11.125
2026	1.338	5.442	4.000	1.804	12.584	11.326
2027	1.368	5.758	4.000	1.704	12.830	11.547
2028	1.398	6.090	4.000	1.610	13.097	11.788
2029	1.428	6.438	4.000	1.521	13.387	12.328
2030	1.458	6.803	4.000	1.436	13.697	12.328

Step 3: Our forecast without intervention

This the summary table (Table 3) about our forecast showing how the water situation will be in 15 years.

Table 3: Our water supply forecast without intervention

The year	P_1'	P_2	P	η	σ
2016	5.700	3.467	9.167	1.122	0.108
2017	5.718	3.410	9.128	1.127	0.112
2018	5.735	3.361	9.095	1.134	0.118
2019	5.750	3.317	9.068	1.143	0.125
2020	5.765	3.279	9.044	1.154	0.133
2021	5.779	3.245	9.025	1.167	0.143
2022	5.793	3.126	9.008	1.182	0.154
2023	5.806	3.190	8.995	1.199	0.166
2024	5.818	3.167	8.985	1.218	0.179
2025	5.830	3.147	8.976	1.239	0.193
2026	5.841	3.129	8.970	1.263	0.208
2027	5.852	3.113	8.965	1.288	0.224
2028	5.863	3.100	8.962	1.315	0.240
2029	5.873	3.088	8.960	1.345	0.256
2030	5.883	3.077	8.960	1.376	0.273

- With the increase of the number of urban population, the city living demand will be higher and higher.
- Under the premise that industrial production accounts for 45% of the gross economic production in Qingdao, with the increasing of population and power generation, although industrial water reuse rate is rising in the form of logarithm in the ideal state, the industrial water demand is still increasing rapidly.
- In order to maintain a better quality of the ecological environment, that is, to meet the green space water, replenishment of rivers and lakes, recreational water demand, we assume that the water demand of this area in a constant.
- With the development of Qingdao's economy, the acceleration of the process of urbanization in rural areas, and the application of agricultural water saving technology, the rural water consumption will be reduced in the form of index.
- After considering the above four points, in the case of the guaranteed rate of 90%, the water demand in Qingdao still gradually increases, and it is expected to reach 12.328 billion cubic meters in 2030.

3.Result

Through balance index η, it can be seen that, under no intervention, $\eta \geq 1$, which indicates that Qingdao City is in dry state. And in the next 15 years, the water scarcity situation will become more and more serious, by 2030 η will reach 1.376, and σ will reach 0.273. Visibly, taking measures to keep the balance is no time to delay.

Analysis: The influence to the citizens

Because the city water scarcity is becoming more and more serious, the supply of running water is not adequate to the demand of citizens, so many people choose to drink water from wells, lakes, and even from rains, resulting in that their health conditions are difficult to protect [5]. What's more, sometimes water supply system have to supply water in a regular time and control the quantity of water, forcing many companies to cut production, stop production which causing huge losses to the national economy, and bringing a lot of inconvenience to daily life of citizens, reducing the quality of their life seriously. When the water scarcity develops to the worst condition, maybe citizens can't survive in this city.

References

[1] Li Xingyun.On water resource sustainable utilization strategy in Qingdao

[2] Jiang Cuiling.Calculation method for urban eco-environment water demand

[3] Lu Zhengbo.Prediction of industrial water demand in Qingdao City
[4] Sun Nansi.Present situation of water resources in Qingdao and its protection measures
[5] Boon P J etc.River conservation and management