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Water Resources Carrying Capacity Forecast of Jining Based on Non-Linear Dynamics Model

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Abstract

In order to alleviate the problem of water resources shortage of Jining City, make reasonable use of water resources, and improve the water resources capacity of Jining City, the methods of the water resources capacity are researched. The system dynamics method is choosed to forecast the Water Resources Carrying Capacity (WRCC) of Jining City in the next 20 years. Three plans are taken, and the predicted results are analyzed. It has a certain significance to practice.
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Key words: Jining City; water resources; capacity; method; Forecast

1. Introduction

Water is the original of life and the natural resources which cannot be replaced and supports the Earth society system's development. The resources that under the certain economical engineering factor, supporting the human economic activity, participating in the nature hydrologic cycle, balancing environment ecological equilibrium and can be used directly or indirectly, includ water quality and water quantity two aspect [1]. There are so many research about water resources on broad, such as Souro D. Joardor[2], Kuylenstierna[3], Falkenmark[4], Jonathan M.Harris[5] and so on. The research of water resources start very late in our country, the research system of water resources is still imperfect, and education training system is especially weak [6]. There are many research methods of water resources

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carrying capacity, as a new method, the Non-Linear science had already been widely applied in geoscience [7], environmental science [8], atmospheric sciences [9] and management science [10].

2. Choice of research area and data

Jining which situated at the north west of Shandong Province, also at the border region of the Huanghuai sea level original and the Shandong province's south central mountainous region. With fertile soil texture, the moderate rainfall, the sufficient illumination, the amphibious good communications and the glorious cultural history, is the important grain cotton and kapok production base and the energy base in our country. After reform and open policy, the lives of the people also have the enormous improved. But with the development economic society, the questions, such as, the water pollution, the sharply increased need of water, the seriously waste of water and so on, become more and more serious.The water resources in this area gradually transfer from a water resources relatively rich area into a supply and demand contradictory incisive area.And the water resources question has become the restriction factor to the social economy sustainable development. So Jining is chosen as the research area.It is very important to the water resources security as well as the economical.

The date used in this article mainly refers to "Jining Synthesis Yearbook", "Jining Water Resources Bulletin" and "Shandong Province Water Rresources Plan" and so on.

3. WRCC forecast of Jining

This research forecasts the main water used department of the Jining various counties, mainly includes the domestic water, the production water and the ecological water. The population and per capita water use are the mirror of the domestic water. The production water embodies the total GDP and the corresponding water consumption. Uses the Non-Linear dynamics to forecast the water using condition of Jinin various counties in the next 20 years.

$$dx_i/d_t = r_i x_i \quad (i=1,2,\ldots n) \tag{1}$$

In the formula, xi stands for various types of variable, ri stands for average growth rate per annum, t stands for time.

3.1 The forecast of the production water demand of Jining various counties in the next 20 years

(1) Plan one: According to industry and agriculture situation of Jining, the agricultural water demand reduces at the rate of 0.2% speed per annum,and the industry water demand increases at the rate of 3.6% speed per annum. The industry water includes the tertiary industry water. Take industry and agriculture water demand of various counties in 2010 as initial value, and forecast the production water demand of Jining various counties in the next 20 years using dynamics model.

(2) Plan two: Discuss the change of production water demand based on the consumption of water resources per GDP. The province data are used duing to the missing data of Jining. According consumption of water resources per GDP of Shandong Province every year to calculate the average growth rate in the next 20 years.The rate are -5.714% in 2010-2020, and -3.333% in 2020-2030. Then according to Jining's situation and the technological development, decision consumption of water resources per GDP of average growth rate are - 4.83% in 2010-2020, and - 3.83% in 2020-2030. Take consumption of water resources per GDP of various counties in 2010 as initial value, and forecast consumption of water resources per GDP of Jining various counties in the next 20 years using dynamics model.Then the result multiply by corresponding water demand and available water of Jining equals the production water of various counties in the next 20 years.

(3) Plan three: ①The forecast of demand water of per ￥10000 value added of industry. The demand water of per ￥10000 value added of industry declines at the rate of 4.7% per year in 2003-2022 according to the Academy of Macroeconomic Research's findings[11], which belong to National Development and Rreform Commission. Then referencing relevant documentation[12], our country's demand water of per ￥10000 value added of industry declines at the rate of 7.3% per year in 1997-2002, and 10% per year in 2002 year. The industry water per￥10000 of Shandong province declines at the rate of 8% per year ,so according to the actual situation of Jining, the industry water per￥10000 declines at the rate of 6% in 2010-2020 and 8% in 2020-2030 per year. Take demand water of per ￥10000 value added of industry of various counties in 2010 as initial value and forecast demand water of per ￥10000 value added of industry of Jining various counties in the next 20 years using dynamics model.

② The demand water of per ￥10000 value added of agriculture.

The demand water of per ￥10000 value added of agriculture declines at the rate of 4.3% per year in 2003-2022 according to the Academy of Macroeconomic Research's findings[11]. The agriculture water per￥10000 of Shandong province declines at the rate of 5% per year, so according to the actual situation of Jining, the agriculture water per￥10000 declines at the rate of 4%. Take demand water of per ￥10000 value added of agriculture of various counties in 2010 as initial value and forecast demand water of per ￥10000 value added of agriculture of Jining various counties in the next 20 years using dynamics model.

③The added value of industrial,agriculture and total water used

The added value of industrial and agriculture growth rate are calculated according to the data of "Jining Synthesis Yearbook" and "Jining Water resources Bulletin" .The average growth rate of industrial and agriculture added value are 5.5% and 4.9% in Shandong province. Take it as initial value and forecast the added value of industrial and agriculture of Jining various counties in the next 20 years using dynamics model.

The demand water of the industrial and agriculture of Shandong province in the next 20 years are calculated by which the multiply by the added value of industrial and agriculture the needed water of per ￥10000 value added of industrial and agriculture then added the needed water before.

3.2 The forecast of the domestic water demand of Jining various counties in the next 20 years

The data of domestic water's dynamic variation of Jining various counties in the next 20 years come from "Jining Synthesis Yearbook" and "Jining Water resources Bulletin" .The average annual growth rate can be calculated on the basis of these data .And through calculating the rate is 2.01%.

The data of "Shandong Province Water resources Plan" are used duing to the missing data of Jining in forecasting the domestic water demand.In the "Shandong Province Water resources Plan", the water consumption norms of domestic water are 105, 114, 121L/d in town and 70, 80, 90 L/d per capita in village in 2010,2020,2030. The urbanization levels of Shandong Province are 60% in 2020 and 70% in 2030. Duing to the discrepancy of urbanization level of Shandong Province, the urbanization level of urbanized area(Shizhong, Rencheng, Yanzhou, Zoucheng and Qufu) is the level of Shandong Province. And the urbanization levels of other various counties are 50% in 2020 and 60% in 2030. Forecast the domestic water demand of Jining various counties in the next 20 years using dynamics model.

3.3 The forecast of the total water demand of Jining various counties in the next 20 years

The total water demand is the production water plus the domestic water and the environmental water. And the environmental water is 3.8% times more than the adding of the production water and the

domestic water. The data of the total water demand forecasting of Jining various counties and different plans the next 20 years.

Table 1. Total water demand in the next 20 years in Jining of different plans   Unit：$10^8 m^3$

various counties	Plan 1				Plan 2				Plan 3			
	2015	2020	2025	2030	2015	2020	2025	2030	2015	2020	2025	2030
Shizhong	1.46	1.49	1.53	1.56	1.98	2.33	2.62	2.96	5.23	6.52	7.89	9.3
Rencheng	1.91	1.99	2.1	2.21	2.51	2.94	3.31	3.73	4.94	6.02	7.15	8.31
Weishan	2.63	2.67	2.72	2.78	3.58	4.2	4.74	5.36	3.32	3.53	3.78	4.04
Yutai	3.99	3.98	3.97	3.97	5.4	6.34	7.17	8.13	4.44	4.56	4.7	4.86
Jinxiang	3.4	3.42	3.43	3.44	4.69	5.5	6.22	7.03	3.94	4.08	4.26	4.43
Jiaxiang	1.89	1.93	1.95	1.99	2.58	3.02	3.4	3.84	3.09	3.47	3.88	4.32
Wenshang	1.47	1.52	1.54	1.56	2.01	2.37	2.66	2.99	1.67	1.69	1.74	1.8
Sishui	0.72	0.75	0.78	0.83	0.9	1.05	1.17	1.32	0.98	1.05	1.13	1.22
Liangshan	3.05	3.07	3.07	3.09	4.2	4.93	5.56	6.29	3.42	3.49	3.6	3.72
Qufu	1.43	1.46	1.51	1.55	1.95	2.27	2.56	2.9	2	2.16	2.37	2.57
Yanzhou	2.43	2.48	2.52	2.6	3.36	3.93	4.43	5.01	2.81	2.93	3.07	3.23
Zoucheng	2.82	2.99	3.16	3.36	3.72	4.34	4.88	5.5	3.37	3.55	3.79	4.03

Then the figures(Fig.1-Fig.3) of total water demand in the next 20 years in Jining of different plans can be get according to the corresponding data.
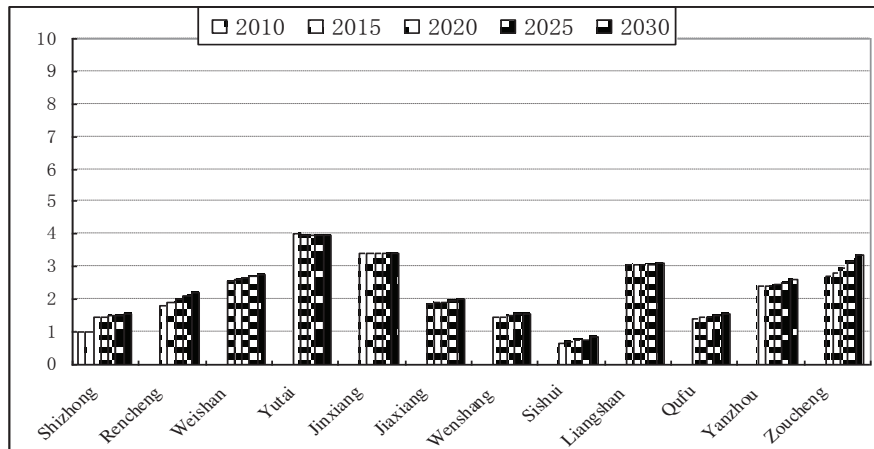

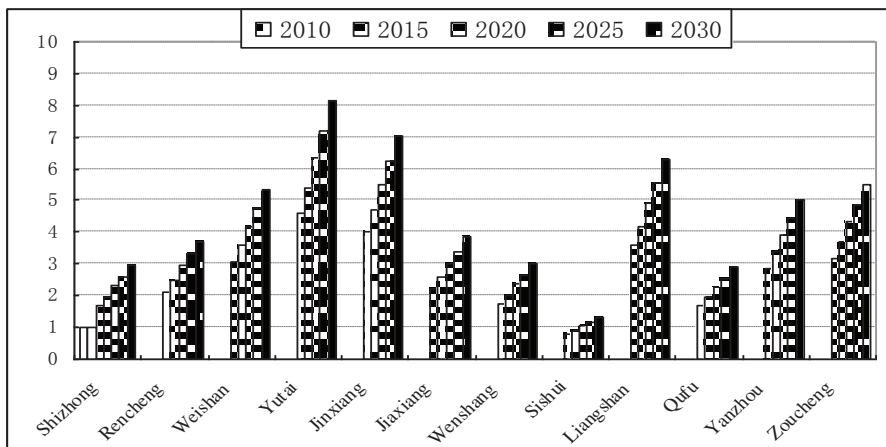Fig.1. Forecast of water demand on Plan 1 in Jining cities and counties

Fig.2. Forecast of water demand on Plan 2 in Jining cities and counties
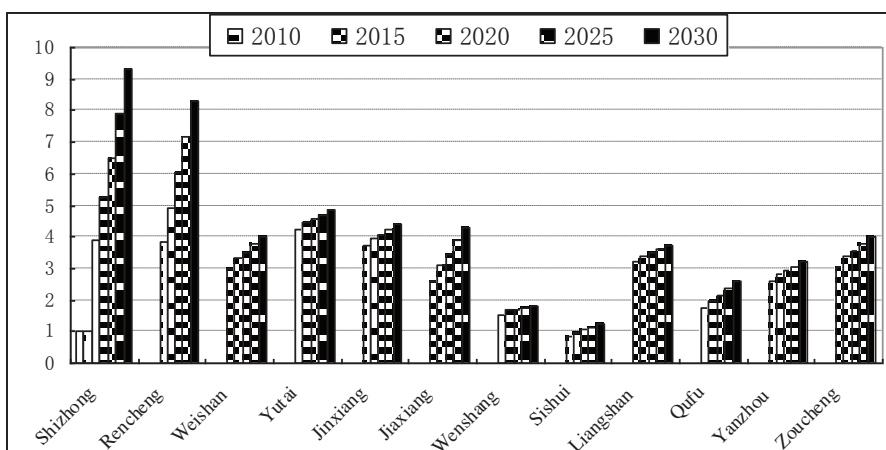

Fig.3. Forecast of water demand on Plan 3 in Jining cities and counties

It can be seen from Figure 1 that, the tendency of the water consumption is stable growth according to the plan 1. It can meet the water demand in the next 20 years in the present condition and water supply project, if the reasonable measures are taken. Meanwhile the set of data also indicate that the water condition are stable in the past 10 years. In Plan 2 duing to missing data consumption of water resources per GDP of average growth rate is the same to Shandong Province. It can be seen from the tendency of augmenter that the augmenter of Shizhong, Rencheng and Qufu are lesser and other cities are biggish. That is to say if using the data of Shandong Province to calculate the water consumption per unit, it is little to Shizhong ,Rencheng and Qufu and big to other cities. It can be seen from Figure 3 that the demand water of Shizhong and Rencheng are bigger than others.

By contrasting longitudinally three plans, in the city, it is clear that the hand randking of Shizhong and Rencheng's water demand is plan 3>plan 2>plan 1. And other cities' hand randking is plan 2>plan 3>plan 1. The difference of three plans is the forecast of production water demand. Plan 1 according to the tendency of normal water demand increasing the water demand is least and best fit to the development of

present condition. Plan 2 and plan 3 embody respectively the water consumption and the water consumption of average growth per unit. Through analysing plan 2 and plan 3 it can be seen that the water consumption of average growth of Shizhong and Rencheng is bigger, meanwhile, the water consumption is bigger. In order to develop sustainably, the level of value to water resources' development utilization and project should be taken serious. The development of other cities' economy and population is stable owing to the restraint of economic capabilities.

4. Conclusion

This article analyse the method of researching WRCC, and take the Non-Linear dynamics as the model of forecasting WRCC. Forecast which on the basis of socioeconomic sustainable development theory and the target is Person - Ecological environment - Society - Economy coordinated development the water demand of Jining various counties in the next 20 years using dynamics model. It gives a basis for water resources mixed and adjustment of industrial structure of Jinin city. The result of water resources forecast is analysed vertically and horizontally. The tendency of water consumption is analysed horizontally and the water demand condition is analysed vertically.

Acknowledgements

References

[1] Liu Changming,Wang Hongrui. Study on the Relation About Water Resources,Population, Economical and Social Environment [J]. journal of natural resources,2003,18(4):635-644.

[2] Souro D. Joardar. Carrying Capacities and Standards as Bases towards Urban Infrastructure Planning in India: A Case of Urban Water Supply and Sanitation. Urban Infrastructure Planning in India, 1998, 22(3):327-337.

[3] Kuylenstierna JL,Bjorklund G,Najlis P.Sustainable water next with global implications:everyone's responsibility. Natural Resources Forum, 1997,21(3):181-190.

[4] Falkenmark M.,Lundqvist J. Towards water security: political determination and human adaptation crucial. Natural Resources Forum, 1998,22(1):37-51.

[5] Jonathan M. Harris,Scott Kennedy. Carrying capacity in Agriculture: Globe and Regional issues. Ecological Economics, 1999, 29(3):443-461.

[6] Yan Denghua,Wang Hao,Wang Jianhua, et al. The Plan of International Hydrographic Develop and Water Research System Build [J]. Journal of Chinese Geography,2004,59(2):249-259

[7] Lin Zhenshan. The Competition Mechanism Between Multinational and China's Enterprises Below WTO [J]. Economic Geography ,2003,23(2):171-174.

[8] Song Jianjun,Zhang Qingjie,Liu Yinqiu, The Analysis and Suggestions about Water Security Level in China in 2020 [J]. Macroeconomic Study,2004,(6):3-6.

[9] Chinese water resources net.http://www.ewater.net.cn/,2005-03-22.

[10] Institute of waterpower planning and design..The Water Resources for the Technical Details [S],2002.

[11] Geng Fuming. Research on Regional Water Resources Carrying Capacity and Allocation[M]. Nanjing: school of hydrology and water resources of Hehai University ,2007.

[12]Sun Qingyi. The Study of Stagnant Waters and the Sustainable Utilization of Water Resources in the 21th Centry in Jinin [M].water resources bureau of Jinin.water resources office of Jinin.