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Application research on the sustainable development index system of the allocation of the regional water resources

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ABSTRACT

According to the water resources situation and national economic development planning of Qian'an city, I established the scheme of water resources allocation. Basing on it, I applied the double standard layers of sustainable development evaluation index system of the water resources allocation and basing on the fuzzy mathematics, analytic hierarchy process as well as multiple attributes weighted integration method, I made the index system quantitative and evaluated it comprehensively and then to evaluate water resources allocation scheme of Qian'an with two purposes, On one hand, to illustrate the rationality of evaluation index system according to the water distribution scheme and on the other hand, to provide the decision-making basis for the adjustment of water allocation scheme in Qian'an.

Key words: water resources allocation; sustainable development; index system; analytic hierarchy process; Double standard layer

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INTRODUCTION

Qian'an located in the northeast of Tangshan city of Hebei province. From the aspect of geographical position, Qian'an ranges from east longitude of 118° 27′ to 118° 56' and north latitude of 39° 51' to 40° 15'. Bounded by the Great Wall and QingLong county on the north, facing the Lulong county separated by the Qinglong river in the east, bordering on Luan county to the south and neighbored by Qianxi county to the west[1].

Qian'an city locates in the golden delta organized by Beijing, Tianjin and Hebei, west from the capital Beijing 100km, southwest from tianjin 100km, east from Qinhuangdao 75km, south from Jingjingang 90km and also 90km apart from Tangshan city. The three railways, Beijing to Qinhuangdao, Dalian to Qinhuangdao and Beijing to Shandong, as well as Beijing-shenyang expressway, 102 national highway and three fondle highway are all the transit traffic from west to east. Ping-Qing highway and Bergen water railway make the south and north communicating, which indicate that the transportation there is convenient[2].

Qian'an city located in Luan He river basin in which there are 16 rivers and the total length is 311km. There are 12 rivers that belong to Luanhe river system, such as Luanhe river, Qinglonghe river, Shahe river and so on and there are 4 rivers like West Shahe river, which belong to coastal water system. Among the 16 rivers, Luanhe, Qinglonghe, white Yanghe, cold Shahe and west mouth Shahe have large amount of water in flood season but less water in non-flood season. As general practice, the five rivers will not flow break and the surface water resources is substantial. The other 11 rivers belong to seasonal river, the water of which suddenly rise or diminish in rainy season, while dry up to zero flow or subsurface flow in spring, autumn and winter[3].

The city belongs to warm temperate semi-humid continental monsoon climate with the dry spring, hot summer accompany the concentrated rainfall , fair autumn with significant temperature difference between day and night and cold, dry and windy winter.

According to the analysis data of rainfall from 1956 to 2006, the city's mean annual rainfall was 639mm, but the annual variation of rainfall and the yearly rain distribution were not balanced, the maximum annual rainfall of l088mm (1977), and the minimum annual rainfall of 355.8mm (2002); During a year, the rainfall mostly concentrated in the flood season and the rainfall accounts for more than 80% of the whole year.

The annual average temperature was10.1 ℃. Extreme maximum temperature was 38.9 ℃ (6,28 in 1953), and the extreme minimum temperature was 28.2 ℃ below 0℃(12 ,29 in 1989) with frostless period of l68d. The maximum frozen depth was 0.9 meters; Average annual water evaporation was 1784.6mm (Φ20mm pan) and the drought index was about 1.8[4].

Investigation and assessment of water resources development and utilization

About social and economic development, taking the recent ten years as an analysis series, we can analyze the major social and economic index. Over the past decade, the total population and the agricultural population have taken on steady growth trend. The growth rate of agricultural population is slower than that of total population which reflects the urbanization process of Qian'an; the growth rate of GDP in Qian'an increases faster, especially in recent years, and the current Qian'an economy has ranked the top county level at present. Restricted by land resources and the influenced by all kinds of social covering, the cultivated land area is shrinking from 1996 to 2003 but due to the strengthened land management, the cultivated land area from2003 to 2006 basically remained unchanged; The effective irrigation area as a whole took on an increasing trend, with the increasing trend from 1996 to 2001 and tending to be stable since 2001; Forestry area also took on a growing trend, which is embodied that 1996~1999 increased greatly and following years increasing slower. The livestock quantity in Qian'an from 1996 to 2006 overall showed the increasing trend and the number of cattle increased from 0.51 million in the 1996 to 0.551 million in 2006.

If taking the year 2006 as the current year, we can find out that the total population of present situation in Qian'an city is 69.2 million, including the10.99 million urban population, 671370 mu cultivated land and 504001 mu effective irrigation area. And the big livestock adds up to 100612 heads at the end of the year and GDP reaches 313.4 billion yuan.

About water infrastructure and water supply capacity survey statistics, Qian'an water supply project mainly includes surface water supply project and groundwater water supply project. Surface water supply project is divided into storage engineering, water diversion project and water engineering; Groundwater water supply project mainly for motor-pumped wells.

Storage project mainly refers to the reservoir and Shuitangba. At present, Qian'an has 19 seats existing small reservoirs, including 7 small (1) type reservoirs and 12 small (2) type reservoirs, with a total capacity of 1687 million m^3, bringing the total capacity for 1123.7 million m^3.

The flood control project of phase I completed during 2003 to 2004 in which 3 rubber dam and artificial lake were constructed. The area of the artificial lake was 141 hm2 and average depth was 2.5 m and the storage quantity was 352 million m^3/a.

Qian'an has 17 water diversion projects totally. but due to the imperfect supporting of engineering construction, and the minor or without water in spring and winter, at present, only 9 seats water diversion projects, namely Qingquan, East dense, DaZhuang, head ridge, three ridge,east gap, big mouth and five, cold water and Yang Dian are in operation. In 2006, water diversion projects totally drew water 2097 million m3.

There are 55 existing water-lifting engineering in qian'an now, including 17 in Luanhe river ,7 in QingLongHe ,13 in Shahe river and 18 in West Shahe. In addition, there are 133 scattered pumping points and in 2006, water engineering water supply 6,250,000 m^3.

About social economy water, according to the stuff offered by Qian'an, Qian'an totally has 7162 drainages nowadays and the total installed capacity adds up to58.96 kw, in which motor-pumped Wells takes 6773 and the total installed capacity is 55.75kw.The 90% of motor-pumped wells are used for irrigation water, the 6.5% are for urban and rural residents drinking water and the 3.5% are used as industrial water.

As with water supply, the water consumption of Qian'an city takes on increasing trend in general. In terms of the water structure, living water, with smaller proportion, also has the tend to grow but at a low speed; Agricultural water is larger comparatively speaking and water consumption from 1996 to 2000 kept increasing while after 2000, agricultural water consumption tend to be stable, keeping in between 1.04~1.09 billion m^3.The growth of

agricultural water consumption has a direct link with the increase of Qian'an effective irrigation area; Industrial water changed slightly larger and experienced high-low-high changing phases. Under the condition of the steady increase of industry augmenter, the change of water consumption reflects the change of water -using efficiency; water consumption grew steadily changes to industrial water efficiency changes.

From 2003 to 2005, the total water consumption of social economy changed a little, which is corresponding to current water supply. Taking the average water consumption index from 2003 to 2005 as the present social and economic water consumption index, the total yearly water consumption of Qian'an city is 230,900,000 cubic meters, including urban life water 7,240,000m^3, taking up 3.1% in the total water consumption, rural life water 8,790,000m^3, accounting for 3.8%, secondary industry water110,850,000 m^3, accounting for 48.0%, agriculture irrigation 97,150,000m^3, accounting for 42.1% and other kinds of industry water 6,870,000m^3, accounting for 3.0%.

About the level of water usage at present, the per capita consumption in the city Qian'an is 333.6m^3, and water usage per unit GDP is 73.7m^3/Million yuan. The indicator of municipal comprehensive water usage is 103.1L/person·d, of rural residents water usage is 58.6L/person·d, of farmland comprehensive irrigation is 286.2m^3/mu, of forest, herd and piscatorial water usage is 140.3m^3/mu, of the large livestock is 26L/herd·d, the small livestock is 12L/herd·d.

About analysis on the degrees of water resources development and utilization, take comprehensive consideration into the amount of surface water resources, entry water and surface water supply, the rate of surface water resources development and utilization is 17% now, which the rate in Luanhe River is the highest. Consider the supply of underground water exploitation and extraction, the present rate of groundwater exploitation has reached 113%.

About the present supply and demand analysis of water resources, with the consideration of full Irrigated on agriculture, the 50% probability of irrigation always demand water 371570000m^3, and the rates for the shortage of water is 14.6%; 75% probability of irrigation always demand water 396810000m^3, which always demand water 321680000 m^3, and the rates for the shortage of water is 18.9%. Above all, the water shortage of industry and life is little, and of agriculture is more.

Water analysis in situation

The total amount of water usage at the present year is 230900000m^3, the consumption of urban life is 958000m^3, of agriculture is 104020000m^3, of industrial is 110850000m^3.The per-capita consumption is 333.6m^3 and Million Yuan GDP is 73.7m^3.

At the premise of not reduce people's living quality and social developmental ability, we should take comprehensive measures to reduce the loss in the process of taking water and prevent the waste. The per capita consumption in the city Qian'an is 333.6m3, the water usage of Million Yuan GDP is 73.7m3,the per capita consumption in the nation is 435m3, the Million Yuan GDP for water usage is 273m3 .The per capita consumption in Hebei is 296m3, the Million Yuan GDP for water usage is 176m3. In 2005, the per capita consumption in Beijing is 87m3, the GDP for water usage is 51m3. Although below the average level of nation, but it is higher than the average level of entire province. Compared to other developed areas like Beijing, there are still some disparities. But it has the potential of saving water.

Regional water resources allocation scheme

First of all, we should be based on the status at the present year, with analysis of the current situation of water level, the arrangement structure of water supply is based on annual plan set status; Secondly, the level of annual plan should be refer to other planning sets, which include The National Development Plan for the Sectors in Qian'an City, The National Economic and Social Development of the Plan Programs for a Five Year. Combined with the situation of integrated water resource, the plan makes a combination of factors. It has set three plans for 2010 and 2020. Each of it can see in the table 1.

In table 1, "✓" means the factor that enters into force. "O"means the factor that is ineffective, and Ⅰ, Ⅱ respectively expresses one factor is of low and high level. Each configuration scheme stated below. The plan for the year 2006:the pattern of water supply and consumption is nearly the same with the present situation. Now make an analysis on the balance of water supply and demand at the present year.2010A plan: Water-demand keeps denotative growth and the capacity of water supply basic to maintain the status, the recycled water reuse effect. 2010B plan: water-demand keep denotative growth, consider increasing the capacity of water supply of conventional water and reclaimed water, rain, water drainage.2010C plan: in the basis of 2020B plan, compressed demand through water saving measures. 2020A plan: Water-demand keeps denotative growth and the capacity of water supply basic to

maintain the status, the recycled water reuse effect. 2020B plan: water-demand keep denotative growth, consider increasing the capacity of water supply of conventional water and reclaimed water, rain, water drainage.2020C plan: in the basis of 2020B plan, compressed demand through water saving measures.

This article selects it at the assurance of 75% to make analysis on the water supply and demand and according to the analysis.

Tab.1: Water Resources Allocation Program

Level years	present years	2010			2020		
Scheme code	2006	2010A	2010B	2010C	2020A	2020B	2020C
Large reservoir water	✓	✓	✓	✓	✓	✓	✓
the surface water	I	I	I	II	I	I	II
Control of Groundwater	✓	✓	✓	✓	✓	✓	✓
Agricultural water saving measures	I	I	I	II	I	II	II
Industrial and life water saving	I	I	I	II	I	II	II
Reclaimed water reuse	○	I	II	II	I	I	II
Mine drainage water use	I	I	II	II	I	I	II
The rain	I	I	II	II	I	I	II

Sustainable development index system of regional water resources allocation

Based on AHP method and growth rate, combined with current phrase instances of social justice, economic development[5],ecological amelioration[6] and rational exploitation etc, we introduced sustainable development index selection of regional water resources allocation and then built hierarchic model of double guidelines. Figure 1 for details.

Single index quantization

According to fuzzy membership degree, I apply power function to quantify it. It consists of three types as follow[7]:

Little-sized power function:

$$u(x)=\begin{cases}1, x<\alpha\\ \dfrac{\beta-x}{\beta-\alpha}, \alpha\le x\le\beta\\ 0, x>\beta\end{cases}$$

Large-sized power function:

$$u(x)=\begin{cases}0, x<\alpha\\ \dfrac{x-\alpha}{\beta-\alpha}, \alpha\le x\le\beta\\ 1, x>\beta\end{cases}$$

Algorithm power function:

$$u(x)=\begin{cases}0, x<\alpha\\ \dfrac{x-\alpha}{m-\alpha}, \alpha\le x<m\\ 1, m\le x\le n\\ \dfrac{\beta-x}{\beta-n}, n\le x<\beta\\ 1, x>\beta\end{cases}$$

So, we get assessment result of single index quantization, according to table 2,we can see that indexes on agricultural water liability, available resources development and industrial water reuse are low. It shows that on one hand Qian'an city has low usage degree on water resources exploitation, and large amount of water needs exploiting, which has bad influence on agricultural production such as inadequate cultivation; on the other hand, Qian'an city should enhance its industrial skills. The enchantment of industrial production skills and industrial water recycling are top priorities particularly. This is accorded with the present situation of years with water recycle water resources project, but there isn't compliance, visible evaluation result which is consistent with the fact.

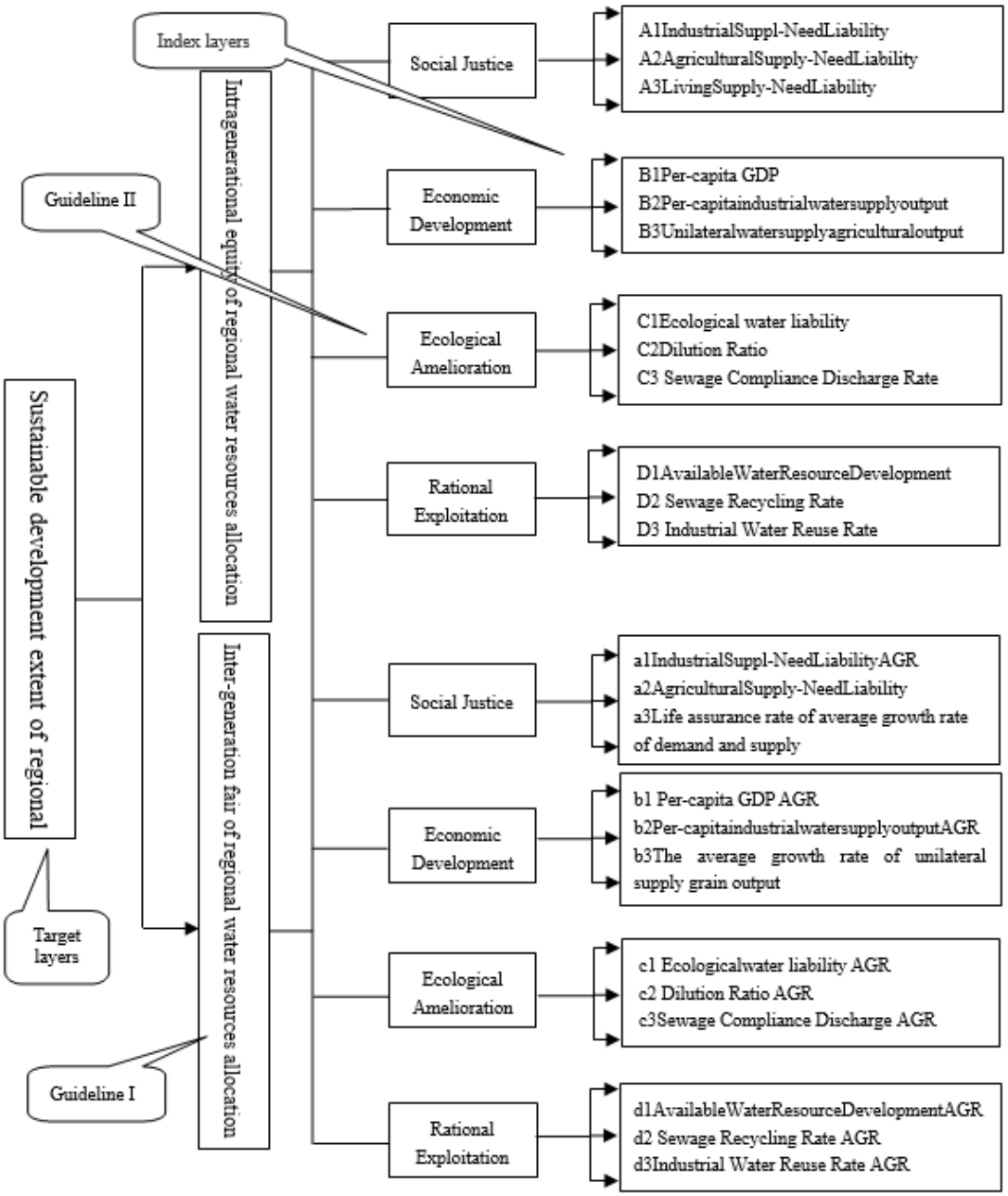

Fig. 1: Sustainable development index system of regional water resources allocation

Whether 2010 or 2020, only in full use of surface water, at the same time, take up industrial, agricultural water saving measures, Use water, mine drainage water conditions can achieve higher evaluation indexes. This illustrates that developing industry, agriculture, water, and use the rain, the water is to achieve regional mine drainage water resources allocation of sustainable development is an important means of achieving area water resources allocation of sustainable development of technical support. Only fully utilize water resources, actively develop water-saving engineering and water-saving measures of realizing the sustainable development of water resources, is the most effective and most direct approach.

As industrial water reuse of average growth rate rise ceaselessly, industrial water reuse by status evaluation indexes of the 0.333 in 2020 to 1.000 in 2020. This fully reflects the influence of Price fair index to future generations price fair, which can reflect the essence of intergenerational justice. Namely, it does not affect future generations, or to the development of future generations. This phenomenon in the development of reasonable index and economic development index is serious.

Tab. 2: Quantitative evaluation result of single index

target year			Status years	2010			2020		
Alternative Code			2006	2010A	2010B	2010C	2020A	2020B	2020C
intragenerational equity	social fair	Industry assurance of supply and demand	1.000	0.803	0.894	1.000	0.876	0.973	1.000
		Agricultural supply and demand assurance	0.298	0.512	0.763	1.000	0.645	0.791	1.000
		Life assurance of supply and demand	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Economic development	PCGDP	0.892	0.942	0.952	0.957	0.969	0.981	0.987
		Output per capita industrial water supply	0.930	1.000	1.000	1.000	0.984	0.990	0.990
		Grain output water unilaterally	0.239	0.491	0.491	0.600	0.801	0.801	0.803
	ecological improve	Ecological water assurance	1.000	1.000	1.000	1.000	1.000	1.000	1.000
		Unclean diameter ratio	0.964	0.586	0.586	0.586	0.190	0.190	0.190
		Sewage standard emissions	1.000	0.928	0.928	0.928	1.000	1.000	1.000
	reasonable development	Available water resources development degrees	0.425	0.489	0.502	0.514	0.515	0.529	0.542
		Sewage reuse ratio	0.000	0.114	0.114	0.351	0.498	0.498	0.644
		Industrial water reuse	0.333	0.433	0.433	0.533	0.767	0.767	1.000
Intergenerational justice	social justice	Industrial demand and supply reliability average growth rate		0.000	0.000	1.000	0.000	0.000	1.000
		Agricultural supply and demand assurance average growth rate		0.556	0.818	0.983	0.296	0.480	0.528
		Life assurance of supply and demand an average rate		1.000	1.000	1.000	1.000	1.000	1.000
	economic development	Per capita GDP average growth rate		1.000	1.000	1.000	1.000	1.000	1.000
		The average growth rate per capita industrial water supply output		1.000	1.000	1.000	1.000	1.000	1.000
		Grain output average growth rate unilaterally water supply		0.767	0.767	1.000	0.523	0.523	0.577
	ecological improve	Ecological water assurance average growth rate		1.000	1.000	1.000	1.000	1.000	1.000
		Sewage average growth path		0.344	0.344	0.344	0.616	0.616	0.616
		Sewage standard emissions average growth rate		1.000	1.000	1.000	1.000	1.000	1.000
	reasonable development	Available water resources development degree average growth rate		0.161	0.192	0.223	0.065	0.074	0.084
		Sewage reuse average growth rate		0.731	0.731	1.000	0.630	0.630	0.699
		Industrial water reuse average growth rate		0.188	0.188	0.375	0.232	0.232	0.357

Results of evaluating sustainable development of regional water resources allocation

Put the single index into the index quantization formula, we can see the estimated results of single index quantization.(Figure 3 for details.)。Multiply figures of each index by system overall index weight on the basis of previous figures, we can get the overall results of sustainable development index system of regional water resources allocation (Figure 2 for details).Multiply them by weight of guideline Ⅱ and add them together, we get the result of guideline Ⅱ (Figure 3 for details).Multiply them by weight of guideline Ⅰ,we get the result of is(Figure 4 for details).

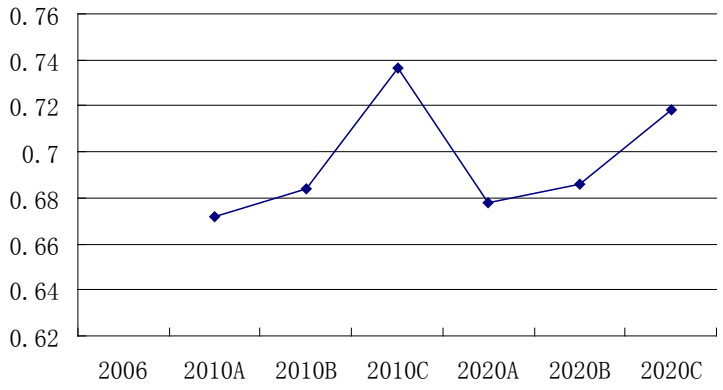

Fig. 2: Comprehensive evaluation result

Because it contains intergenerational justice index, which is without comprehensive evaluation result currently. Although the year 2020 exploitation and utilization of water resources and industrial, agricultural technology, water conservation measures have greatly improved, but under equally with water scheme by 2020 the comprehensive evaluation value relative to the comprehensive evaluation value in 2010 is lower. This is mainly because of the conditions in 2020, the water resources development and utilization growth slows down or bigger developing difficulty, this exploitation of groundwater is consistent with local situation. Meanwhile, industrial water reuse, rainwater usage and other conservation measures are difficult to improve, In these conditions, to realize the back by 2020 the sustainable development of water resources allocation is difficult. In the conditions of 2020, water supplies are no longer energetic, but also the main shackles in the limited power, under the condition of limited water resources, science4, technology and water raise the consciousness is the important link of the sustainable

development.

By 2020 and 2010 comprehensive evaluation value of C scheme are not less than 0.7, under the plan of water resources allocation can more fully realize and fix the sustainable development of regional water resources allocation, mainly under the plan, make full use of water resource, developing industrial, agricultural water saving measures, use water, mine drainage water, On the one hand, the development and utilization of water resources fully available; On the other hand, improving water efficiency by preventing waste of water. So, finally it realizes the sustainable development of water resources allocation.

Per capital GDP evaluation value doesn't increases with time, This does not explain GDP has no growth over time, but because of GDP growth, the evaluation contributions standards increased, On the other hand, population increased, just leads to the evaluation result, also explains from other side of the water resources allocation rationality of sustainable development index system. Not that the index increases with the result, but considering all kinds of factors of the social and economic development, which achieve reasonably evaluation of the sustainable development of water resources allocation. This in economic development and ecological improvement is embodied the index.

In terms of intra-generational equity, the social justice evaluation of all programs was higher, mainly because supply and demand meets the guaranteed rate life except the inadequacy of the agricultural water. Evaluation of the economic development situation is 0.6281, which shows the low current level of economic development of Qian'an City and still needs further development. Only C program development in 2020 is more reasonable, mainly because of the low development and utilization of water resources of Qian'an City at this stage, while A and B programs both are water conservation, wastewater reuse and other ineffective measures or the unreasonable programs resulting from the unclear functions, which is related with the actual situation of Qian'an City and the gentle principles of water distribution in this program, yet another embodiment of the realistic system.

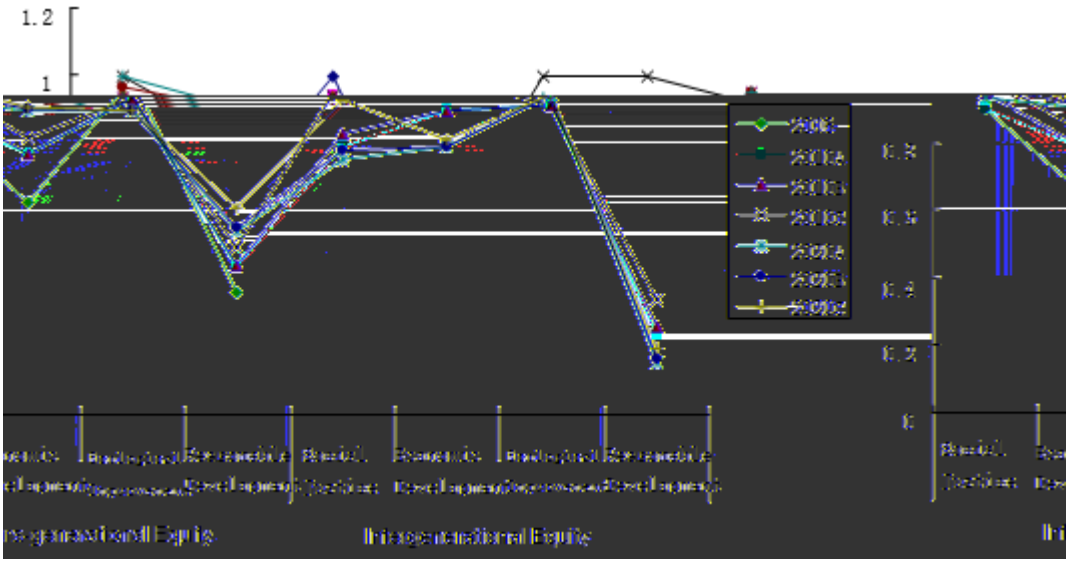

Fig. 3: Evaluation result of rule hierarchy Ⅱ

In terms of inter-generational equity, the evaluation of social justice and the rational development is lower, mainly still due to the lower level of economic development of Qian'an City at this stage and the lager difficulty of water development and utilization. But the overall increasing trend can still reflect not only the steady progress of water programs A,B,C from the side, but also the deep development of economy and water resources as time goes from now to 2020.

The results only reflect the comparison between intra-generational equity and inter-generational equity within the water resources distribution. It can be seen from the results that at the same level of water distribution in the same program, the evaluation of intra-generational equity is higher than that of intergenerational equity, which suggests the ignorance of intergenerational equity. Over time, in the same water distribution program, the evaluation value has declined possibly because of natural resources, socio-economic conditions and limits of science and technology, which explains, at the same time, why the evaluation value of intra-generational equity is higher than that of intergenerational equity. In the other words, water resources do not neglect inter-generational equity, but in the

existing natural resources and socio-economic conditions and the condition of science and technology, it is very difficult to achieve the sustainable development of water resources. We cannot find out the ideal water distribution programs and results, but we can find one in a variety of water distribution programs which is in our best interest and our future generations' interest and which is most favorable to social and economic ecology. This is the essence of water resources and the goal of sustainable water resources development.

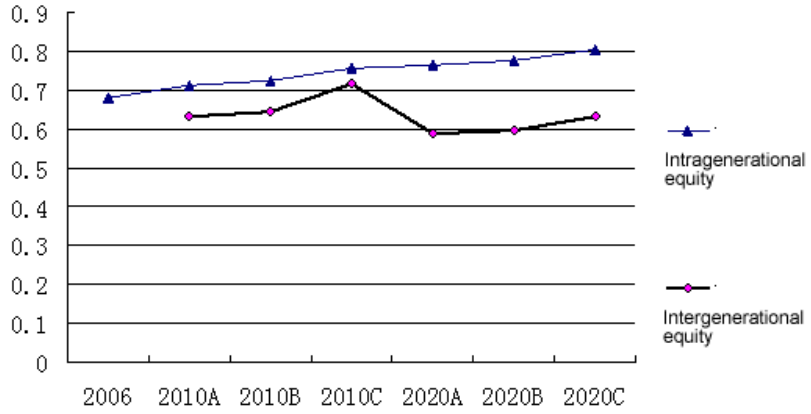

Fig. 4: Evaluation result of rule hierarchy Ⅰ

CONCLUSION

This article discusses the allocation of water resources in the region and on the basis of sustainable development, concept and content analysis of regional sustainable development of water resources allocation, summarized the researches on water allocation and sustainable development evaluation system to determine the regional water the allocation of resources for sustainable development concept and content. And by AHP, established a system of regional water resources sustainable development indicators of sustainable development as the goal, to the generation of inter-generational fairness and social justice, economic development, ecological improvement and development of rational criteria for dual-layer configuration guidelines. Determined by individual indicators and indicators of screening, the interpretation of the individual indicators, membership analysis was carried out by the method of fuzzy mathematics, which quantified, based on the individual indicators to quantify the study, re-use method to establish AHP judgment matrix to determine the weights of all levels to achieve quantified targets throughout the system. Comprehensive evaluation method using an integrated multi-weighted index. Although you can reflect the dynamic changes in the inter-generational growth structure, but the specific growth rate should be as much as appropriate, the need for a detailed analysis of the survey in order to get out of the evaluation criteria, the regional water allocation can do better and better evaluation.

Overall, the application of sustainable development indicators of regional water resources evaluation system should be configured after the study had a more extensive trial, widely accumulation configured for future sustainable development of regional water resources evaluation index system of indicators Experience.

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