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AHP Fuzzy Comprehensive Evaluation-Based Research on Coordination Between Water Resources and Urban Economic Social Development in Western China

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Abstract
Setting the effect evaluation on coordination between water resources and urban economic social development in western China as object, this thesis applies methods of literature review and on-the-spot investigation to establish evaluation index system. And by AHP and multi-level fuzzy comprehensive evaluation, this thesis conducts the empirical research on 11 provinces or regions in western China and outcomes problems as insufficient economic structure optimization, and then puts forward countermeasures and suggestions from the coordination of effective utilization of water resources to promote economic social development.

Key words: AHP fuzzy comprehensive evaluation; Western China; Urban economic social development; Water resources coordination; Effect evaluation

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INTRODUCTION

As an important natural resource, water provides support and guarantee for sustainable economic social development (Cui, 2013; Gobin, Campling, & Feyen, 2002), which is not only an important component of the external environment where human live but also related to the implementation of the strategy of urban sustainable development as well as the realization of the development goals. Based on urban water resources, the urban ecological system constitutes a social-economic-natural compound with the urban economic system. Under the background of advocating the optimal allocation of resources and establishing resource-conserving society, the hot spots of modern urban planning and construction are to scientifically plan and utilize of urban water resources, and to realize the sustainable development of urban economy (Tang, 2008) .

Along with the advancement of urbanization, the pressure of the high intensive land utilization on water environment increases, which raise scholars' concern about how to coordinate the relationship between them. Relevant scholars launched research from theoretical discussion to model methods. Xia et al. (2007) analyze the level of the sustainable development of social economy and water environment of Zhen Jiang city with the evaluation index system constructed by the PSR model; Yang et al. (2013) analyze the dynamic coupling condition and spatial distribution pattern of the economic development and water environment quality from the example of Song Hua river basin in Ji Lin province; Wu (2014) makes evaluation and expectation on China's economic development and water resource utilization by decoupling situation assessment; Lü (2014) proposes the stable concept-based security path as well as the stimulating route of sustainable development, targeting at Gan Jiang basin and based on the coupling model. As to the existing research, most studies mainly focus on coastal, circum-lake, and valley cities. It is of special importance to research such problems with the combination of analytic hierarchy process and fuzzy mathematics comprehensive evaluation, due to the following two reasons: one is that many influential factors of regional water resources optimal allocation exist as

the strong comprehensive system coordination between urban development and water environment; The other is that there is ambiguous middle transition in evaluation indexes' grade specification or fuzziness between adjacent levels' boundaries, especially in multi-level evaluation index system (Wang & Liao, 2005; Xiao, 2012; Huang, Yu, & Zhou, 2007; Li et al., 2015).

Western China is the source of the Chang Jiang and the Yellow Rivers. With the advancement of western development, the contradiction between urban development and water environment has arisen gradually so that it has become a fundamental problem urgently to be solved in social and economic development how to coordinate the relationship between them. Constructing the coordinating evaluation index system of urban economic social development and water resources on the basis of relevant research domestic and abroad, this paper, this paper sets the 11 provinces of western China (except Tibet autonomous region) as the research object, to analyze the coordinating evolution process by the combining method of analytic hierarchy process and fuzzy mathematics comprehensive evaluation with comprehensively considering the diversity of research data and sample indicators, in order to provide theoretical reference for the sustainable development of urban economy and society in western China.

1. OVERVIEW ON RESEARCH REGIONS

In China most rivers are originated in the western region. Most part of the western region is located in the first and second stairs of the mainland, whose hydroelectric potentiality accounts for 82.5% of the country's and the developed hydropower accounts for 77%. The focus of suitable economic development in western China is to realize the sustainable utilization of water resources. Western China consists of the northwest and the southwest regions, whose water resources stay deficient and the contradiction between supply and demand is sharp. The Northwest region is located in the arid and semi-arid area, where water resources distribution is uneven and ecological environment is very fragile. Meanwhile in the southwest one, the space-time distribution of the precipitation is also uneven despite its huge water resources, and along with high difficulty of water resource utilization because of large occupation of Alpine and Gorge Region, hilly area, and karst landform, so that there is a structural shortage of water resources exploitation and utilization (Li & Wang, 2014). The sustainable utilization of water resources in western China is of significance to the whole country's economic development. Since the western development, excessive and unreasonable development of water resources has generated increasing supply-demand contradiction and the deteriorating ecological environment so as to unable to meet the demand of sustainable utilization of water resources.

2. CONSTRUCTION OF EVALUATION INDEX SYSTEM

The coordination of urban development and water environment refers to the consistent and collaborative relationship between the two elements and their composition in the evolution process. Due to late start of the urban social economic development in western China and the weak overall economic foundation, the advancement of large-scale urban construction has caused problems as increasing water consumption and intemperate wastewater discharge after the western development. On the reference of relevant research, this paper combines with the characteristics of the research regions to construct the coordinating evaluation index system of urban economic social development and water resources. The growth of urban economic elements and structural evolution process are represented by population situation, economic scale, efficiency and structure. Based on water resources' pressure - state - response analysis, the consistency degree and cooperative relations of the urban construction as well as water resources consumption and pollution are quantitatively analyzed.

From seven criterion layers, population situation, economic scale, economic efficiency, economic structure, water resources pressure, water resources status and water resources response, this paper constructs the coordinating evaluation index system by selecting 25 indicators (see Table 1) on the basis of referring to relevant research and following the principles of data representation and accessibility, and improves the index system through consultation from the competent urban management and water experts to perfect validity of that in measuring the coordination of the urban economic social development and water environment level.

2.1 Population Situation

Population has great influence for social and economic development, environmental bearing capacity as well as the production and domestic water. This paper chooses year-end population and natural growth rate to reflect the situation of the local population in western 11 provinces, autonomous regions and municipalities.

2.2 Economic Scale

Since the western development, the western region is not only faced with water resources environmental protection challenges, but also with the pressure of the local economic construction. The western cities are in the middle of economic construction phase, when economic development level will affect the consumption and utilization of water resources. This paper chooses GDP indicator to represent the overall western urban economic development level, the secondary industry output indicator to the overall level of western industrial development, the tertiary industry output indicator to the overall level of western service industry and total retail sales of social

consumer goods to the improvement of people's material and culture living standard in the western region.

2.3 Economic Efficiency

The condition of economic changes in the process of urban development can be reflected through the economic efficiency. This paper selects the GDP growth rate to reflect overall economic development in the western region, the general local finance budget revenue to indirectly reflect the vitality of economic development, and fixed assets investment to reflect the inner drive in the western development.

2.4 Economic Structure

Modern urban development includes the industrial development, urbanization, and the tertiary industry development. Different economic structure has obvious different demand for water resources. This paper chooses scalable industrial output and the proportion of the secondary industry to reflect the overall industry level, and the proportion of the tertiary industry to reflect the overall level of service industry.

2.5 Water Resources Pressure

Water resources pressure can be used to measure the relative scarcity of water resources, and also to judge whether water restricts the social economic development. This paper chooses indicators as the water requirement, industrial wastewater discharge, sewage COD discharge, domestic emissions ammonia nitrogen discharge, industrial wastewater COD discharge, and industrial wastewater emissions ammonia nitrogen discharge of industrial production per ten thousand Yuan GDP to reflect the dual pressures of industrialization and urbanization that the water resources are facing with.

2.6 Water Resources Status

Water resources status means how to use water resources in the process of urban development and the present situation of water environment. This paper chooses the urban water penetration, gross industrial water consumption, water resources per capita and total annual water supply indicators to reflect the production and domestic water status.

2.7 Water Resources Response

Water resources response refers to the response caused by water consumption and production and domestic wastewater discharge in urban development needs. This paper chooses domestic wastewater, industrial wastewater and standard industrial wastewater standard discharges to reflect the open utilization of water resources in meeting the social economic development demand.

Table 1
Construction f Evaluation Index System

Target layer	Guidelines layer	Index layer	Unit
urban development	population situation (0.13)	year-end population (0.41)	Ten thousand people
		natural growth rate (0.59)	%
	economic scale (0.24)	GDP (0.22)	One hundred million yuan
		the secondary industry output (0.26)	One hundred million yuan
		the tertiary industry output (0.31)	One hundred million yuan
	economic efficiency (0.32)	total retail sales of social consumer goods (0.21)	One hundred million yuan
		the GDP growth rate (0.29)	%
		the general local finance budget revenue (0.35)	One hundred million yuan
		fixed assets investment (0.39)	One hundred million yuan
	economic structure (0.31)	scalable industrial output(0.32)	One hundred million yuan
		the proportion of the secondary industry (0.35)	%
		the proportion of the tertiary industry(0.33)	%
water resources environment	water resources pressure(0.29)	the water requirement(0.16)	T
		industrial wastewater discharge(0.15)	T
		sewage COD discharge(0.21)	T
		domestic emissions ammonia nitrogen discharge (0.18)	T
		industrial wastewater COD discharge (0.17)	T
		industrial wastewater emissions ammonia nitrogen discharge (0.13)	T
	water resources status (0.35)	the urban water penetration (0.21)	%
		gross industrial water consumption (0.26)	Ten thousand tons
		water resources per capita (0.31)	T
		total annual water supply (0.22)	Ten thousand tons
	water resources response (0.36)	domestic wastewater (0.32)	Ten thousand tons
		industrial wastewater (0.27)	Ten thousand tons
		standard industrial wastewater standard discharge s(0.41)	Ten thousand tons

The index system is established based on the AHP tool and the index weights are calculate in, the chart above-mentioned (Wang & Tu, 2005), respectively, to build and calculate the urban economic development and water environment.

3. CASE STUDY

Ten experts evaluate the coordination of economic social development and water resources in the 11 western provinces and respectively assess the urban development and water resources environment to obtain the weight of every indicator and evaluation levels, which are divided into excellent, good, medium, and poor. Multi-level fuzzy comprehensive evaluation method is used to calculate the coordination of the urban economic social development and water resources. The weights of the coordinating evaluation index system of the urban economic social development and water resources and the experts' evaluation result are shown in Table 2 (see Table 2).

Table 2
The Weights of the Coordinating Evaluation Index System of the Urban Economic Social Development and Water Resources and the Experts' Evaluation Result

Target layer	Guidelines layer	Index layer	Unit	Evaluation Structure			
				Excellent	Good	Medium	Poor
urban development	population situation(0.13)	year-end population(0.41)	Ten thousand people	2	3	4	1
		natural growth rate(0.59)	%	1	5	3	1
	economic scale(0.24)	GDP (0.22)	One hundred million yuan	3	3	4	0
		the secondary industry output(0.26)	One hundred million yuan	2	4	4	0
		the tertiary industry output(0.31)	One hundred million yuan	3	4	2	1
		total retail sales of social consumer goods(0.21)	One hundred million yuan	3	4	2	1
	economic efficiency(0.32)	the GDP growth rate(0.29)	%	4	5	1	0
		the general local finance budget revenue(0.35)	One hundred million yuan	3	4	2	1
		fixed assets investment (0.39)	One hundred million yuan	5	2	2	1
	economic structure(0.31)	scalable industrial output(0.32)	One hundred million yuan	3	2	5	0
		the proportion of the secondary industry (0.35)	%	1	3	4	2
		the proportion of the tertiary industry (0.33)	%	2	4	2	2
water resources environment	water resources pressure(0.29)	the water requirement (0.16)	T	4	3	3	0
		industrial wastewater discharge (0.15)	T	2	3	2	3
		sewage COD discharge (0.21)	T	1	3	5	1
		domestic emissions ammonia nitrogen discharge (0.18)	T	3	2	2	3
		industrial wastewater COD discharge (0.17)	T	1	3	4	2
		industrial wastewater emissions ammonia nitrogen discharge (0.13)	T	3	2	2	3
	water resources status (0.35)	the urban water penetration(0.21)	%	3	3	4	0
		gross industrial water consumption (0.26)	Ten thousand tons	2	2	5	1
		water resources per capita (0.31)	T	3	3	2	2
		total annual water supply (0.22)	Ten thousand tons	4	2	3	1
	water resources response (0.36)	domestic wastewater (0.32)	Ten thousand tons	1	3	4	2
		industrial wastewater (0.27)	Ten thousand tons	1	4	3	2
		standard industrial wastewater standard discharges (0.41)	Ten thousand tons	1	5	1	3

The multi-level evaluation on urban development is as follows:

The first level comprehensive evaluation is:

$$W_1 = (0.33\ 0.67)\begin{bmatrix}0.40.50.10\\0.30.40.20.1\\0.50.20.20.1\end{bmatrix} = (0.13\ 0.44\ 0.33\ 0.1), \quad (1)$$

$$W_2 = (0.13\ 0.25\ 0.5\ 0.12)\begin{bmatrix}0.130.440.330.1\\0.270.390.280.06\\0.430.320.180.07\\0.20.30.360.14\end{bmatrix} = (0.27\ 0.39\ 0.28\ 0.06), \quad (2)$$

$$W_3 = (0.25\ 0.25\ 0.5)\begin{bmatrix}0.40.30.40\\0.20.30.20.3\\0.10.30.50.1\\0.30.20.20.3\\0.10.30.40.2\\0.30.20.20.3\end{bmatrix} = (0.43\ 0.32\ 0.18\ 0.07), \quad (3)$$

$$W_4 = (0.32\ 0.35\ 0.33)\begin{bmatrix}0.20.30.40.1\\0.10.50.30.1\end{bmatrix} = (0.2\ 0.3\ 0.36\ 0.14). \quad (4)$$

According the calculation above, the second level comprehensive evaluation is

$$W = (0.06\ 0.19\ 0.44\ 0.31)\begin{bmatrix}0.30.30.40\\0.20.40.40\\0.30.40.20.1\\0.30.40.20.1\end{bmatrix} = (0.31\ 0.334\ 0.264\ 0.092). \quad (5)$$

The comprehensive evaluation is:

$$Z = (0.31\ 0.334\ 0.264\ 0.092)(95\ 85\ 75\ 65)^T = 83.62. \quad (6)$$

The multi-level evaluation on water resources environment is as follows:

The first level comprehensive evaluation is:

$$V_1 = (0.11\ 0.09\ 0.24\ 0.22\ 0.23\ 0.11)\begin{bmatrix}0.210.270.330.19\\0.280.260.350.1\\0.10.430.230.24\end{bmatrix} = (0.21\ 0.27\ 0.33\ 0.19), \quad (7)$$

$$V_2 = (0.28\ 0.28\ 0.28\ 0.14)\begin{bmatrix}0.30.30.40\\0.20.20.50.1\\0.30.30.20.2\\0.40.20.30.1\end{bmatrix} = (0.28\ 0.26\ 0.35\ 0.1), \quad (8)$$

$$V_3 = (0.14\ 0.44\ 0.42)\begin{bmatrix}0.10.30.40.2\\0.10.40.30.2\\0.10.50.10.3\end{bmatrix} = (0.1\ 0.43\ 0.23\ 0.24). \quad (9)$$

According the calculation above, the second level comprehensive evaluation is

$$V = (0.2\ 0.4\ 0.4)\begin{bmatrix}0.30.20.50\\0.10.30.40.2\\0.20.40.20.2\end{bmatrix} = (0.19\ 0.33\ 0.31\ 0.17). \quad (10)$$

The comprehensive evaluation is:

$$Z = (0.19\ 0.33\ 0.31\ 0.17)\ (95\ 85\ 75\ 65)^T = 80.4\ . \quad (11)$$

The evaluation results to be determined:

Those whose evaluation results of the coordination of urban economic social development and water resources are between 100-86 are rated as excellent, indicating that the relation between urban economic development and water resources environment is coordinating and in a state of health.

Those whose evaluation results of the coordination of urban economic social development and water resources are between 85-76 are rated as good, indicating that the relation between urban economic development and water resources environment is peaceful and in a state of non-mutual-damage.

Those whose evaluation results of the coordination of urban economic social development and water resources are between 75-66 are rated as medium, indicating that urban economic development and water resources environment have negative effects on each other.

Those whose evaluation results of the coordination of urban economic social development and water resources are under 65 are rated as poor, indicating that the relation between urban economic development and water resources environment is destroyed and discordant.

Results show that in this example, the city's economic development is good, and so are the economic structure, economic efficiency, etc., while its economic structure optimization is not enough and needs further reforming. However, the relative water resources environment's score is lower than economic development's, through which it is showed that the development of urban economy has begun to destroy the water resources environment and that the implementation of economic development is based on the destruction of water resources, especially the industry's.

CONCLUSION

Through above coordinating evaluation index system of urban economic and social development and water resources, we can conclude that the coordination's stand or fall is reflected through the economic efficiency and the structure of urban development, and the status and response of water resources environment. The quality of economic efficiency determines the financial support of the city for water conservation and is also protection of the economic base for water resources protection. The change of economic structure determines the pollution level of the water resources from agricultural, industrial pollutants, which mean that immoderate reliance on the first and secondary industry is bound to cause serious pollution. And at the same time, the status of water resources are related to one of urban development on

the industrial consumption, water resources per capita, urban consumption, is the important symbol that embodies the urban development degree. And domestic and industrial wastewater discharge can also estimate the urbanization and its development level. In the process of urban development, we should pay attention to the optimization of industrial structure adjustment, reduce the proportion of the first and secondary industry as well as provide adequate financial support for the rational use and protection of water resources. With strict supervision and control on industrial wastewater and sewage direct discharge, we should build a sewage treatment plant for the pollution damage of water resources, to provide protection of water resources as well as for health conditions of industrial development.

Although by using the AHP and fuzzy comprehensive evaluation method for the paper conducts research on the coordination of urban economic social development and water resources in western China and obtains some conclusion, the subjectivity is a drawback of the paper as subjective defect of the methods like AHP. In the future research, with continuous improvement of data, the author will research on follow-up studies on the basis of using the empirical method to improve the research of theoretical value and practical significance.

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