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Multi-Dimensional Factor Analysis for Assessing Region Water Resources Carrying Capacity

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Abstract:

Scientific water resource carrying capacity (WRCC) evaluations are necessary for providing guidance for the sustainable utilization of water resources. Under the background of increasing global water resources crisis, this paper takes Shandong Province of China as the research area, establishes a multi-dimensional intergration index of WRCC, and uses factor analysis to measure the WRCC from 2010 to 2019. The analysis results show that the index system of WRCC constructed by using four dimensions and 20 indicators is scientific and practical to a certain extent. Factor analysis is used to reduce the dimension of 20 indicators to 4 factors, and finally calculate the factor scores, so as to measure and rank the WRCC from 2010 to 2019.

***Keywords**: Region, Water resources carrying capacity, Sustainable development, Factor analysis.*

I. INTRODUCTION

The water resource carrying capacity (WRCC) can be defined as the maximum capacity of regional water resources to support social and economic development based on a given living standard and production technology without degrading the water environment [1]. Due to the acceleration of industrialization and urbanization, the limited capacity of regional water resources to support the growing population and economy has become a bottleneck of sustainable urban development. If WRCC cannot be matched with the economic and social needs of one country, then the development of the country or region will inevitably encounter bottlenecks, and the measurement of the carrying capacity of water resources is based on this, and only by measuring and evaluating the carrying capacity of water resources in a certain place can we use water resources more effectively according to specific conditions.

The concept of WRCC originated from resources and environmental carrying capacity. In 1995, Arrow studied the relationship between economic growth and environmental carrying capacity, which triggered a research upsurge in resource and environmental carrying capacity [2]. In 1998, URS Corporation conducted research on the carrying capacity of water resources for the first time in the United States, and defined the carrying capacity as: the maximum development level that water resources in the region can carry without causing damage to natural and artificial resources. Therefore, the term carrying capacity is widely used to evaluate the carrying capacity of various natural resources. Among them, the concept of

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WRCC is widely recognized as the research on the balance of supply and demand of water resources and the protection of ecosystems required for the sustainable development in a certain region, especially in water-scarce areas.

II. LITERATURE REVIEW

In China, many researchers have done a lot of studies on local WRCC. In 1989, first WRCC survey has been conducted by the Xinjiang Water Resources Soft Science Research Group in China. Cheng Guodong studied the evolution of the concept of WRCC and constructed the application framework of WRCC in the northwest of China [3]. Liu Jing et al.introduced the management concept and index system of WRCC [4]. Li Lijuan et al. proposed a WRCC calculation model based on system dynamics, and carried out prediction exercises [5]; Wang Mingjie, Tian Pei et al. studied the WRCC of the Yangtze River Economic Belt region [6]; Zuo Qiting et al. studied the relationship between water resources and the sustainable development [1]; Jin Juliang et al. expounded the research on the spatial balance of water resources progress [7]; Su Yangyue et al. proposed a comprehensive evaluation method for water resources management based on cloud model [8]; Chen Xiaohua, Deng Wenying et al. conducted in-depth research on the Yangtze River Delta according to land resources, WRCC and environmental capacity in order to optimize the development coordination [9].

Based on the research of the above scholars, this paper selects Shandong Province as our research area, and aim to study the regional WRCC by constructing a multi-dimensional index system. The second part of this paper describes the research method of this paper and the source of the index data. In the third part, we uses factor analysis to measure WRCC in this province. The fourth part is the conclusions and recommendations.

III. MATERIALS AND METHODS

3.1 Materials

According to the “2019 Shandong Water Resources Bulletin” issued by the Shandong Provincial Department of Water Resources, the province's average annual precipitation in 2019 was 558.9 mm, 29.2% less than the previous year's 789.5 mm, and 17.8% less than the annual average of 679.5 mm. per year. In 2019, the province's total water resources were 19.521 billion cubic meters, including 11.966 billion cubic meters of surface water resources and 7.554 billion cubic meters of groundwater resources and surface water resources. At the end of 2019, the province's large and medium-sized reservoirs had a total water storage volume of 3.815 billion cubic meters, a decrease of 632 million cubic meters from the total water storage volume of 4.447 billion cubic meters at the beginning of the year. Compared with the beginning of the year, the shallow groundwater level in the province's plains declined on the whole, with an average drop of 0.70 meters, and the groundwater storage volume decreased by 1.681 billion cubic meters. The area of the shallow groundwater level funnel area in the plain area of the province was 14,203 square kilometers and the province's total water supply was 22.526 billion cubic meters. Among them, the local surface water supply accounted for 22.18%, the inter-basin water transfer accounted for 38.66%, the

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groundwater supply accounted for 34.92%, and other water sources accounted for 4.24%. The direct utilization of seawater was 7.961 billion cubic meters. In 2019, the province's total water consumption was 22.526 billion cubic meters. Among them, farmland irrigation water accounted for 53.16%, forestry, animal husbandry, fishing and livestock water accounted for 8.20%, industrial water accounted for 14.15%, urban public water accounted for 3.55%, residential water accounted for 13.01%, and ecological environment water accounted for 7.93%.

Based on the reality of water resources in Shandong Province, our study aims to evaluate the overall WRCC of the region, analyze its main influencing factors, and propose targeted measures, which can effectively help the sustainable development of the region's economic, social and ecological environment. Regarding the research of WRCC, previous researchers have carried out a lot of important studies and achieved fruitful results. The main research methods are fuzzy comprehensive evaluation (FCE) method, simple quota estimation method, principal component analysis(PCA), grey prediction model method, multi-objective model, regression neural network and PSR model method. In this paper, factor analysis method is used to access the WRCC of Shandong Province, in order to reveal the main influencing factors of WRCC in recent years, and provide support and reference for optimal allocation of water resources in this area.

The data comes from China Statistical Yearbook, Shandong Statistical Yearbook, and Shandong Water Resources Bulletin from 2010 to 2019. Among them, social and economic data (total local population, gross regional product, investment in fixed assets, proportion of urban population, etc.) and environmental data (total wastewater discharge, industrial wastewater discharge) are collected from the "Shandong Provincial Statistics Yearbook 2010-2020". The data on water resources (total water resources, total water supply, domestic water consumption, industrial water consumption, agricultural water consumption, etc.) comes from the "Shandong Water Resources Bulletin 2010-2020", per capita water consumption , 10,000 yuan of GDP water consumption, and 10,000 yuan of industrial added value water consumption data are calculated based on the above data. Missing values were replaced by the mean of adjacent points. All collected data were analyzed using SPSS, version 22.0 (IBM SPSS).

3.2 Methodology

WRCC refers to the optimal level of development that water resources can support. Therefore, when selecting indicators that affect WRCC, we should not only focus on water resources indicators, but also care about the other factors like social, economic, ecological environment, demographic and habit. In order to precisely evaluate the WRCC of Shandong Province, this paper selected 20 representative indicators, as follows (Table I):

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TABLE I. Indicators Affecting WRCC

Element	No	Indicator	Meaning
Economic	X1	Local GDP(Bn yuan)	Overall economic status of the region
	X2	Fixed asset investment (100 million yuan)	Investment in fixed assets of the whole society
	X3	Regional fiscal revenue (100 million yuan)	Economic capacity of the local government
	X4	The tertiary industry's share of GDP	Development of the local tertiary industry
	X5	Grain output (10,000 tons)	Local agricultural development level
Social	X6	Total population (10,000 people)	Population size of the region
	X7	Proportion of urban population (%)	Degree of regional urbanization
	X8	Population natural growth rate (%)	Growth of regional population
	X9	Domestic water consumption (100 million m^3)	Demand for water resources of local residents
	X10	Industrial water consumption (100 million m^3)	Demand for water by local industry
	X11	Agricultural water consumption (100 million m^3)	Local agricultural demand for water resources
	X12	Water consumption per capita (m^3)	Per capita demand for water resources of local residents
	X13	Water consumption per ten thousand yuan GDP (m^3)	Demand for water resources for the added value of local production
	X14	Water consumption per ten thousand yuan of industrial added value (m^3)	Demand for water resources for the added value of local industrial production
Ecological	X15	Artificial ecological environment water supply (100 million m^3)	Artificial ecological environment water supply
	X16	Total wastewater	Local wastewater discharge

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		discharge (10,000 tons)	
	X17	Industrial wastewater discharge (10,000 tons)	Local industrial wastewater discharge
Water resources	X18	Total water resources (100 million m³)	Overall situation of water resources supporting the local economy
	X19	Total water supply (100 million m³)	Total water supply per year
	X20	Total precipitation (mm)	Local precipitation per year

IV. RESEARCH RESULTS AND ANALYSIS

4.1 Descriptive Statistics

The changes of each indicator from 2010 to 2019 are shown in Table II. It can be seen in Figure 1 the economic and demographic indicators, like the total population and the degree of urbanization, were basically in a continuous upward trend, while other indicators fluctuate greatly in different periods.

4.2 Factor Analysis

The factors affecting the regional WRCC level and its basic descriptive statistics are shown in Table II. Due to the complicated relationship between the divers factors, Table III confirms that there is a strong correlation among them, so that we propose to summarize them into several representative and independent factors. This paper builds a factor analysis model, extracts the main factors that affect the WRCC, and finds several influencing factors that reflect some common characteristics from many indicators.

TABLE II. Descriptive Statistics

	Mean	**Std. Deviation**	**Analysis N**
x1	52884.3646	12234.79225	10
x2	42641.9960	12365.21129	10
x3	5.0352E7	1.30301E7	10
x4	45.3700	5.18546	10
x5	5047.2100	310.00243	10
x6	9834.1410	176.96973	10
x7	0.4583	.04168	10
x8	6.5350	2.24755	10
x9	145.5090	8.96120	10

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x10	29.5640	1.72305	10
x11	33.8860	1.72762	10
x12	7.5239	1.51894	10
x13	1.4134	.18807	10
x14	3.6452	.48894	10
x15	8.5350	3.96383	10
x16	493104.8751	33427.96333	10
x17	173463.8131	20222.97558	10
x18	252.3780	71.04367	10
x19	217.4920	5.55676	10
x20	11233.9400	1468.35964	10

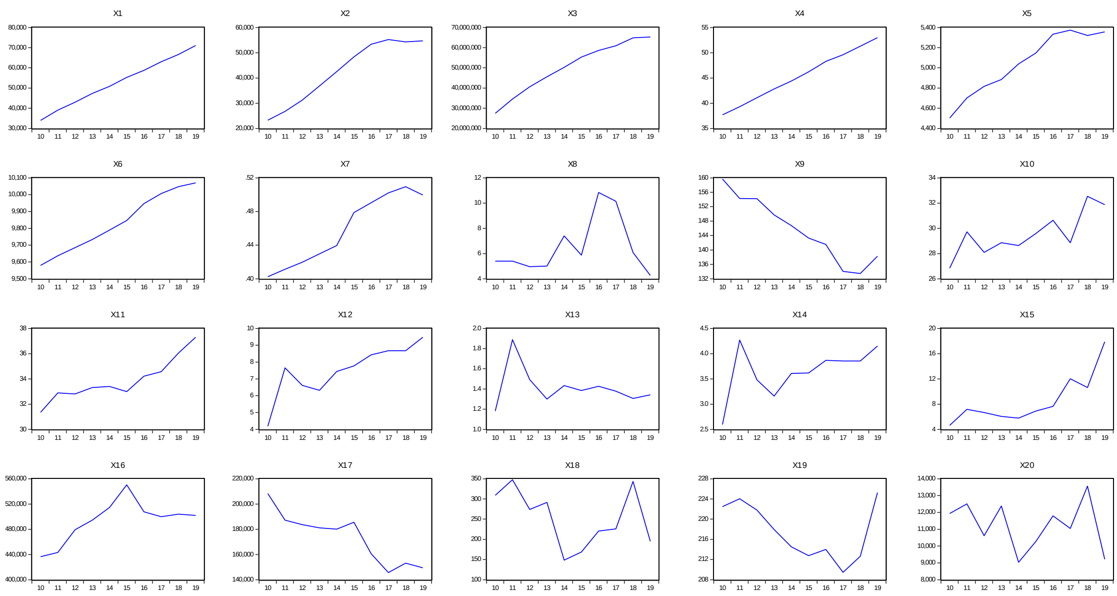

Fig 1: Line chart of indicators affecting WRCC

Mathematical model:

Assuming that there are n principal factors X_1, X_2 , $\cdots\cdots X_n$ that affect the level of WRCC, our factor analysis considers these n original variables as a linear weighted sum of k common factors(f_1, f_2 , $\cdots\cdots$ f_k)($k \leq n$)and a special factorε_i, where the common factors f_1, f_2 , $\cdots\cdots f_k$are pairwise orthogonal, and they are independent of the special factor ε_i and remain independent, so that each factor can reflect the common information of multiple variables in the same group with the greatest extent, and its matrix expression is:

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$$\begin{bmatrix} X_1 \\ X_2 \\ \cdots \\ X_n \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \cdots & \alpha_{1k} \\ \alpha_{21} & \alpha_{22} & \cdots & \alpha_{2k} \\ \cdots & \cdots & \cdots & \cdots \\ \alpha_{n1} & \alpha_{n2} & & \alpha_{nk} \end{bmatrix} \begin{bmatrix} f_1 \\ f_2 \\ \cdots \\ f_k \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \cdots \\ \varepsilon_n \end{bmatrix} \tag{1}$$

The principal components method was used to extract the common factors, the maximum variance method was used and the original factor loadings matrix was orthogonally rotated to obtain the total variance explained. Table IV shows the proportion of the total variance of all variables that can be explained by the impact factors extracted by the principal component method. According to the factor extraction standard with an eigenvalue greater than 1, four main factors are extracted, see Table III and Figure 2 , Figure 3 and Table V show the main variables included in the extracted factors.

TABLE III. Correlation Matrix

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	X16	X17	X18	X19	X20
x1	1.000	.966	.985	.999	.965	.993	.963	.293	-.958	.800	.922	.874	-.265	.577	.814	.664	-.922	-.391	-.429	-.197
x2	.966	1.000	.987	.969	.993	.971	.977	.487	-.967	.710	.802	.842	-.280	.524	.669	.760	-.889	-.489	-.613	-.196
x3	.985	.987	1.000	.984	.986	.979	.965	.368	-.967	.774	.864	.872	-.248	.567	.714	.757	-.905	-.443	-.542	-.195
x4	.999	.969	.984	1.000	.966	.996	.968	.313	-.956	.799	.919	.864	-.283	.563	.808	.654	-.921	-.386	-.432	-.186
x5	.965	.993	.986	.966	1.000	.971	.968	.501	-.964	.726	.820	.886	-.190	.598	.690	.735	-.920	-.472	-.582	-.203
x6	.993	.971	.979	.996	.971	1.000	.978	.372	-.970	.791	.907	.865	-.268	.570	.798	.622	-.940	-.347	-.468	-.134
x7	.963	.977	.965	.968	.968	.978	1.000	.441	-.973	.756	.816	.832	-.279	.530	.710	.672	-.888	-.348	-.574	-.072
x8	.293	.487	.368	.313	.501	.372	.441	1.000	-.444	.029	.057	.320	-.012	.198	-.024	.273	-.434	-.312	-.707	.035
x9	-.958	-.967	-.967	-.956	-.964	-.970	-.973	-.444	1.000	-.739	-.827	-.853	.220	-.566	-.697	-.661	.923	.316	.629	.053
x10	.800	.710	.774	.799	.726	.791	.756	.029	-.739	1.000	.871	.825	.072	.718	.678	.406	-.729	.015	-.127	.149
x11	.922	.802	.864	.919	.820	.907	.816	.057	-.827	.871	1.000	.849	-.130	.650	.908	.401	-.893	-.168	-.105	-.125
x12	.874	.842	.872	.864	.886	.865	.832	.320	-.853	.825	.849	1.000	.235	.896	.759	.560	-.884	-.332	-.314	-.199
x13	-.265	-.280	-.248	-.283	-.190	-.268	-.279	-.012	.220	.072	-.130	.235	1.000	.629	-.096	-.263	.084	.205	.270	.063
x14	.577	.524	.567	.563	.598	.570	.530	.198	-.566	.718	.650	.896	.629	1.000	.607	.264	-.663	-.126	-.055	-.114
x15	.814	.669	.714	.808	.690	.798	.710	-.024	-.697	.678	.908	.759	-.096	.607	1.000	.229	-.807	-.187	.081	-.260
X16	.664	.760	.757	.654	.735	.622	.672	.273	-.661	.406	.401	.560	-.263	.264	.229	1.000	-.454	-.720	-.652	-.407
X17	-.922	-.889	-.905	-.921	-.920	-.940	-.888	-.434	.923	-.729	-.893	-.884	.084	-.663	-.807	-.454	1.000	.217	.409	.065
X18	-.391	-.489	-.443	-.386	-.472	-.347	-.348	-.312	.316	.015	-.168	-.332	.205	-.126	-.187	-.720	.217	1.000	.328	.868
X19	-.429	-.613	-.542	-.432	-.582	-.468	-.574	-.707	.629	-.127	-.105	-.314	.270	-.055	.081	-.652	.409	.328	1.000	-.092
X20	-.197	-.196	-.195	-.186	-.203	-.134	-.072	.035	.053	.149	-.125	-.199	.063	-.114	-.260	-.407	.065	.868	-.092	1.000

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TABLE IV. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.986	64.929	64.929	12.986	64.929	64.929	11.520	57.602	57.602
2	2.626	13.129	78.057	2.626	13.129	78.057	3.081	15.405	73.007
3	1.829	9.143	87.201	1.829	9.143	87.201	2.508	12.539	85.546
4	1.555	7.773	94.974	1.555	7.773	94.974	1.886	9.428	94.974

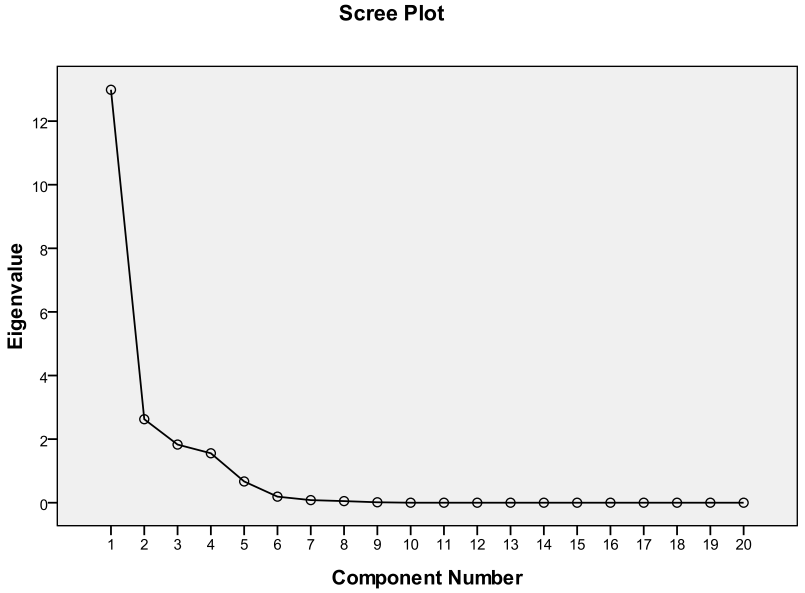

Fig 2: Screen plot

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
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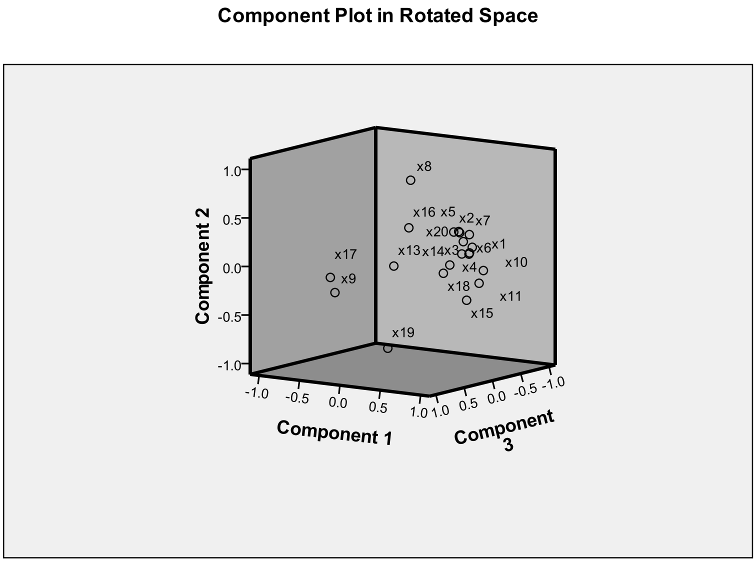

Fig 3: Component Plot in Roated Space

Generally speaking, if the variance explanation rate of each extracted factor is not very large, and the cumulative variance explained rate is above 60%, then the extraction effect of factor analysis is better. Table IV shows that when factors are extracted from the influencing factors, the cumulative variance contribution rate is above 95%. Then we can use the extraction factor scores to analyze the influencing factors of WRCC, the comprehensive evaluation model obtained is as follows:

$$f=\frac{57.602}{94.974}f_1+\frac{15.405}{94.974}f_2+\frac{12.539}{94.974}f_3+\frac{9.438}{94.974}f_4 \quad (2)$$

Table V shows the loadings of the four factors on different variables. Because our study focuses on different specific angles, it is named according to its meaning: Factor 1 has a larger load on variables $X_1-X_7, X_9-X_{12}, X_{15}, X_{17}, X_{19}$, mainly concerned with the impact of social and economic conditions on the carrying capacity of water resources, so we named it as “social and economic growth factor” according to its meaning. Factor 2 has a larger load on variables X_8, X_{19}, which concern about the pressure from population growth to the consumption of water resources, so we named it as "population growth factor". Factor 3 has a larger load in variables X_{18}, X_{20}, X_{16} which focus on the pressure of wastewater discharge, so we named it as "wastewater discharge factor". Factor 4 has a larger load on the variables X_{13}, X_{14}, these factors indicate that industrial The impact of water use on the carrying capacity of water resources, so it is named " industrial needs factor" according to its meaning. Among the four factors, social and economic development has the greatest demand for water resources, which is also the set of factors that most affect the level of WRCC. Population growth increases the water resources carrying pressure, and ecological pressure factors are also very important factors. Ineffective wastewater recycling may make regional water resources from abundant to relatively scarce, because industrial water needs become more and more important with the improvement of urbanization level.

Forest Chemicals Review
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May-June 2022 Page No. 704-715
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TABLE V Rotated Component Matrix

	Component			
	1	**2**	**3**	**4**
x1	.957	.204	.195	-.064
x2	.863	.434	.243	-.072
x3	.909	.332	.227	-.048
x4	.956	.215	.183	-.079
x5	.872	.422	.238	.022
x6	.951	.264	.129	-.062
x7	.898	.386	.104	-.083
x8	.127	.859	.041	.133
x9	-.893	-.418	-.076	.032
x10	.886	-.024	-.161	.209
x11	.980	-.115	.050	.048
x12	.862	.195	.186	.428
x13	-.177	-.076	-.096	.970
x14	.631	.041	.069	.769
x15	.889	-.286	.140	.070
x16	.467	.478	.559	-.137
x17	-.912	-.257	-.024	-.116
x18	-.155	-.270	-.940	.060
x19	-.225	-.922	-.058	.181
x20	-.046	.162	-.968	-.038

4.3 Factor Score and Ranking Analysis

The above exploratory factor analysis method reduces the dimensions of multiple indicators into four factors. These four factors can basically include the main factors affecting the WRCC of Shandong Province. The carrying capacity of water resources is indeed mainly affected by the pressure of economic growth, population growth, wastewater discharge, and industrial water use. Using these four factors to measure the WRCC of Shandong Province from 2010 to 2019, the calculation of each factor and the total factor score and the ranking results of the total factors are as follows:

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TABLE VI. The scores of each factor and ranking (2010-2019)

Year	Factor 1: Economic growth	Factor 2: Populatio n growth	Factor 3: wastewater discharge	Factor 4: industrial water use	WRCC Rating	Ranking
2010	-1.43728	-0.70794	-0.62165	-1.51894	-1.21956	10
2011	-0.68261	-0.67894	-1.01153	2.30722	-0.42839	8
2012	-0.72744	-0.64521	0.24261	0.22196	-0.49176	9
2013	-0.39583	-0.17475	-0.53392	-0.86511	-0.42487	7
2014	-0.58904	0.47663	1.50612	0.22177	-0.05905	5
2015	-0.17824	0.62121	1.13412	-0.22598	0.119934	6
2016	0.28996	1.34039	-0.14537	0.40505	0.414334	4
2017	0.58366	1.30532	0.04674	0.04796	0.576654	3
2018	1.39656	0.30326	-1.62729	-0.55079	0.626628	2
2019	1.74027	-1.83997	1.01017	-0.04314	0.886112	1

Table VI shows that from 2010 to 2019, the scores of each factor are quite different, which indicate that the factors affecting the WRCC strongly varied in different periods. According to the meaning of composite score, larger score value means smaller WRCC. Therefore, in 2010, Shandong Province had the largest WRCC and suffered the least water shortage, which was closely related to the amount of precipitation in that year. 2019 was the year with the least precipitation except 2014 in the past 10 years. However, the demand for water due to economic and social development has been increasing, which has put more pressure on water supply in this year.

V. CONCLUSION

Based on the above research, we draw the following conclusions. The carrying capacity of water resources is affected by many factors. This paper considers the economic, social, ecological, and water resources to construct an intergrated index system that affects the carrying capacity of water resources. pressure. This study selects 20 influencing factors based on the determination that "WRCC refers to the optimal level of development that water resources can support", and converts these influencing factors into 4 factors: socio-economic growth, population growth factor , wastewater discharge, and industrial water needs, they can explain about 95% of the total variance variation, indicating that these influencing factors are closely related and have strong explanatory power for the carrying capacity of water resources.

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REFERENCES

[1] Zuo Qi-ting, Zhao Heng, Ma Jun-xia (2014) Study on harmony equilibrium between water resources and economic society development. Journal of Hydraulic Engineering 45(7):785-792.
[2]Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., Jansson, B.O., Levin, S., Maler, K.-G., Perrings, C., Pimentel, D. (1995) Economic Growth, Carrying Capacity, and the Environment. Ecological Economics, Elservier, 15(2):256-289.
[3] Xinjiang Water Resources Soft Science Project Research Group (1989). Xinjiang Water Resources and Its Carrying Capacity and Development Strategy. Water Conservancy and Hydropower Technology (6):2-9.
[4] LIU Jing, Bao Zhenxin, Liu Cuishan, et al. (2019) Review of the study on the matching of regional land and water resources at home and abroad. Journal of North China university of water resources and electric power(natural science edition), 40(6): 20- 24, 74.
[5] Li Lijuan,Guo Huaicheng,Chen Bing,et al. (2000) Research on water resources carrying capacity of Qaidam Basin. Environmental Science, 21(2):20-23.
[6] Wang Mingjie, Yu Bin, Li Zhuofan, et al. (2020) Spatial and Temporal Diferentiation of the Comprehensive Carying Capacity of the Yangtze River Economic Belt and Its Influencing Factors. ournal of Xinyang Normal University Natural Science Edition, 33(2):235-243.
[7] Jin Juliang, Li Jianqiang, Wu Chengguo, et al. (2019) Research progress on spatial equilibrium of water resources. Journal of North China university of water resources and electric power (natural science edition), 40(6): 47-60.
[8] Su Yangyue, Ji Changming, Zhang Yanke, Li Rongbo (2017) Comprehensive evaluation method of water resources management based on cloud model: Taking Huizhou City as an example. China Rural Water Resources and Hydropower, (12):53-58.
[9] Chen Xiaohua, Qian Xin (2019) Evaluation of the comprehensive carrying capacity of urban agglomerations in the Yangtze River Ecological Economic Zone. Statistics and Decision-Making, 35(10):64-66.