Study on the Measurement of Water Resources Carrying Capacity Level and Spatial and Temporal Differences in Shaanxi Province

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Abstract. Reveal the state of water resources carrying capacity in Shaanxi Province, and provide thought guidance and theoretical support for enhancing the carrying capacity of water resources in various regions of Shaanxi Province. Taking Shaanxi Province as the research object, considering four dimensions of water resources, society, economy and ecological environment, we establish the evaluation index system of water resources carrying capacity, utilize the method of "entropy weight - coefficient of variation" to get the weights of each index layer, and use the TOPSIS model to get the comprehensive evaluation index of water resources carrying capacity, and then carry out the characterization of the time series and spatial distribution of the index. The results show that (1) the water resources carrying capacity index of Shaanxi Province increased steadily from 0.3933 to 0.4616 during the 10-year period from 2011 to 2020, and the carrying capacity class gradually changed from the stage of mild overload to the stage of endangered overload; (2) spatially, the water resources carrying capacity from the north and the south differed much from each other and changed to the enhancement of each region of Shaanxi Province, with a decrease in the discrepancy.

Keywords: water carrying capacity; discrepancy; indicator system

1 Introduction

Water resources are the core elements of high-quality development and ecological protection in the Yellow River Basin. Water resources carrying capacity, as a complex system subject to the interaction of water resources, the economy, society and the ecological environment, is an important measure of regional water resources security, an important aspect of evaluating the spatial equilibrium of water resources and an important indicator of the degree of sustainable utilization of regional water resources0.Clarifying the specific status of water resources carrying capacity in Shaanxi

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Province is of great significance for Shaanxi Province to actively promote the high-quality development and ecological protection of the Yellow River Basin.

Foreign water resources carrying capacity related research started early, but the research tends to be diversified, more with other resources and environmental factors combined to explore 2, mostly focusing on the theory of sustainable development. In contrast, domestic research on water resources carrying capacity is more abundant and specific, mainly focusing on the concept of water resources carrying capacity, the construction of the evaluation system and evaluation methodology research in three aspects. In terms of evaluation methods, with the development of cross-fertilization of various disciplines, the evaluation methods of water resources carrying capacity have been continuously expanded. Among them, the TOPSIS method is suitable for multiple indicators, multiple options and can give full play to the advantages of real, intuitive and reliable raw data 3, based on which, many scholars have utilized the TOPSIS method to carry out research on water resources carrying capacity[4-6].

However, most of them have a single selection method when determining the weights, which leads to bias in the final evaluation. This paper establishes a four-dimensional water resources carrying capacity evaluation index system of "water resources-social-economic-ecological environment" on the basis of the predecessors, determines the combination weights based on the entropy weight and coefficient of variation method, and then calculates the comprehensive evaluation index of water resources carrying capacity of Shaanxi Province by the TOPSIS method and analyzes the temporal and spatial evolution characteristics of water resources carrying capacity, which increases the accuracy of the evaluation of carrying capacity of the region effectively. This effectively increases the accuracy of regional carrying capacity evaluation.

2 Overview Of The Study Area and Construction of the Indicator System

2.1 Overview of the study area

Shaanxi Province is located in the middle reaches of the Yellow River in central China, with 10 prefectural-level cities under its jurisdiction, and the general characteristics of the terrain are high in the north and south, low in the center, and the distribution of annual precipitation is less in the south and north, decreasing from the south to the north, which is more significantly affected by the mountainous terrain. Overall water scarcity and uneven spatial and temporal distribution, 65% concentrated in the flood season (July and August), 71% concentrated in southern Shaanxi.

2.2 Indicator system construction

Combined with the current situation and characteristics of regional water resources and the development trend of water resources utilization in Shaanxi Province, as well as the social situation, economic characteristics and ecological environment, the

evaluation system of water resources carrying capacity in Shaanxi Province is constructed from different perspectives and in different aspects. The index system and weights for measuring the water resources carrying capacity level in Shaanxi Province are shown in Table 1.

Table 1. Indicator system and weights for measuring the water resources carrying capacity level in Shaanxi Province.

Target level	Criterion layer	Indicator layer	Attribute	Unit	Combination weight	Weight of entropy method	Weight of variation coefficient method
Water resources carrying capacity level of Shaanxi province	Water resources subsystem(0.3824)	per capita water resources	+	m^3/p	0.1424	0.1794	0.1053
		water production modulus	+	10k m^3/km^2	0.1043	0.1277	0.0809
		water resources utilization ratio	-	%	0.0529	0.0124	0.0933
		precipitation intensity	+	10k m^3/km^2	0.0426	0.0549	0.0303
		average water consumption per acre of farmland irrigation	-	m^3/acre	0.0402	0.0269	0.0535
	Social subsystem (0.2349)	urbanization rate	-	%	0.0230	0.0275	0.0186
		population density	-	p/ km^2	0.0332	0.0234	0.0430
		road network density of built-up area	+	km/ km^2	0.0479	0.0692	0.0267
		density of water supply pipeline in built-up area	+	km/ km^2	0.0291	0.0267	0.0314
		comprehensive production capacity of water supply per capita	+	10k m^3/d/p	0.1016	0.1362	0.0670
	Economy subsystem (0.1528)	per capita GDP	-	yuan/p	0.0273	0.0148	0.0399
		GDP growth rate	-	%	0.0579	0.0404	0.0754
		water consumption per ten thousand yuan GDP	-	m^3/10k	0.0387	0.0107	0.0667
		the proportion of the second and third industries	-	%	0.0289	0.0525	0.0052
	Ecological subsystem (0.2299)	centralized treatment rate of urban sewage	+	%	0.0058	0.0059	0.0056
		urban sewage discharge intensity	-	10k m^3/100 m	0.0361	0.0204	0.0518
		the proportion of ecological water consumption	+	yuan	0.1172	0.1475	0.0870
		green coverage rate of built district	+	%	0.0106	0.0117	0.0095
		chemical oxygen demand emissions	-	% t	0.0603	0.0117	0.1088

2.3 Data sources

The data for each indicator in this study come from the Shaanxi Provincial Statistical Yearbook, the Shaanxi Provincial Water Resources Bulletin, the Urban Construction Statistical Yearbook, and the statistical yearbooks of the municipalities in Shaanxi Province.

3 Research Methods

3.1 Methodology for determining indicator weights

In this paper, the entropy weight method and the coefficient of variation method are used to calculate the indicator layer weights respectively, and then the two are synthesized using the average value method to derive the comprehensive weights, which are calculated as follows:

$$w_i = \frac{a_i + b_i}{2} \tag{1}$$

Where w_i is the comprehensive weight of the i indicator in the water resources carrying capacity evaluation index system; a_i is the weight of the i indicator calculated by entropy value method; b_i is the weight of the i indicator calculated by coefficient of variation method.

3.2 Classification of evaluation ratings

Considering the actual situation of Shaanxi Province region and based on the existing research information 35, the integrated water resources evaluation index is divided into five levels, which is shown in Table 2.

Table 2. Grading Criteria for Comprehensive Evaluation Index of Water Resource Carrying Capacity.

Comprehensive evaluation index	0-0.2	0.2-0.4	0.4-0.6	0.6-0.8	0.8-1
Bearing level	Serious overloading	Mild overloading	On the verge of overload	Suitable bearing capacity	Carrying surplus
Load condition	Serious shortage of water resources	Water resource shortage	Tight water resources	Coordinated utilization of water resources	Abundant water resources

4 Characterization of spatial and temporal evolution of water resources carrying capacity in Shaanxi Province

4.1 Evaluation of the overall water resources carrying capacity of Shaanxi Province

Combined with the evaluation index system and index layer weights, the TOPSIS model was used to calculate the comprehensive evaluation value of water resources carrying capacity in Shaanxi Province. As can be seen from Figure 1, the overall water resources carrying capacity index of Shaanxi Province from 2011 to 2020 shows a

trend of gradual growth, the water resources carrying capacity index from 0.3933 in 2011 slightly fluctuating decrease to 0.3611 in 2012, a decrease of 8.19%, from 0.3611 in 2012 to 0.4616 in 2020, an increase of 21.77%, the water resources The level of carrying capacity has gradually risen from the stage of mild overload to the stage of near-overload, and the overall level has gradually improved but is still at the level of underdevelopment. From 2011 to 2016, the comprehensive index of water resources carrying capacity of Shaanxi Province ranges from [0.2,0.4], which is in the stage of mild overloading, and the water resources carrying capacity is very weak; after 2016, the comprehensive index of carrying capacity gradually climbs, and from 2016 to 2020, the comprehensive index of water resources carrying capacity of Shaanxi Province ranges from [0.4,0.6], which is elevated to the stage of verging to the overloading stage and the water resources carrying capacity obviously presents the trend of gradual enhancement.

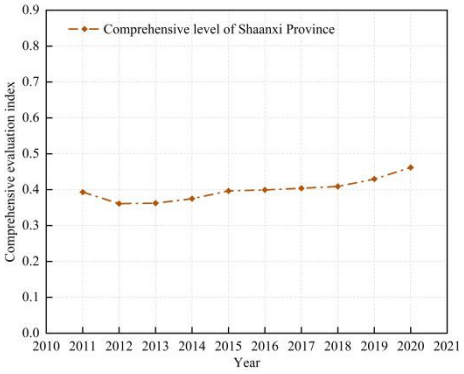

Fig. 1. Time Trend of Water Resource Carrying Capacity in Shaanxi Province, 2011-2020.

4.2 Characterization of the evolution of the spatial distribution

In this paper, the water resources carrying capacity index in 2020 is selected to analyze the spatial distribution of water resources carrying capacity in 10 prefecture-level cities in Shaanxi Province. In 2020, the water resources carrying capacity level of each prefecture-level city in Shaanxi Province was improved, and the difference in carrying capacity level between regions was significantly reduced. Xi'an City and Tongchuan City have the highest water resources carrying capacity levels, respectively 0.5750 and 0.5177, water resources carrying capacity are on the verge of overloading stage. The remaining municipalities in descending order: Shangluo (0.4967), Xianyang (0.4858), Ankang (0.4748), Hanzhong (0.4373), Baoji (0.4352), Yan'an (0.4156), Weinan (0.3977), Yulin (0.3800). Except for Weinan and Yulin, which are in the stage of mild overloading, the rest are on the verge of overloading. The spatial distribution of water resources carrying capacity in Shaanxi Province in 2020 is shown in Figure 2.

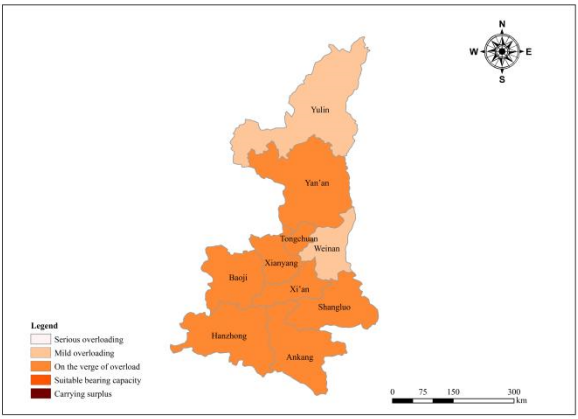

Fig. 2. Spatial Distribution of Water Resources Carrying Capacity in Shaanxi Province in 2020.

5 Conclusions

This paper measures and analyzes the level of water resources carrying capacity in Shaanxi Province from 2011 to 2020, and provides an idea orientation and theoretical support for Shaanxi Province to further improve the level of water resources carrying capacity. The main research conclusions are as follows:

(1) From 2011 to 2020, the comprehensive index of water resources carrying capacity of Shaanxi Province has been increasing, with a growth rate of 17.37%, and the carrying level has steadily entered the stage of near-overload from the stage of mild overload, and the comprehensive level of water resources carrying capacity of Shaanxi Province has been improved, and the inter-regional differences are gradually decreasing. This paper not only clarifies the current state of water resources carrying capacity in Shaanxi Province from the time series, but also lays a solid theoretical foundation for the study of water resources carrying capacity improvement in Shaanxi Province. However, this paper is limited to space, the time selected is only ten years, and related scholars can continue to collect data from this perspective for a longer period of time to strengthen the assessment of water resources carrying capacity.

(2) According to the geographic location of the division, the water resources carrying capacity level growth rate in descending order: Guanzhong > northern Shaanxi > southern Shaanxi, southern Shaanxi due to its own abundant water resources, with the continuous development of the economy and society, water resources carrying capacity level fluctuations but overall stability, Guanzhong and northern Shaanxi region itself is short of water, but with the recent years of the country to attract and transfer water projects continue to be constructed, the disadvantage of this disadvantage has a clear tendency to narrow. The future Shaanxi Provincial Government can put forward relevant measures for the regional water resources carrying capacity state according to local conditions, such as for Guanzhong region, can be constructed to the intensive and economical use of water resources, cross-basin water transfer and Yellow River diversion, the optimal allocation of water resources in and out of the

region, the northern foot of the Qinling Mountains and the Weihe River water ecological protection of water conservancy development pattern; for the north of Shaanxi, can be constructed to the intensive and economical use of water resources, Yellow River diversion and cross-basin transfer of water, For the northern Shaanxi region, it can build a water conservancy development pattern based on intensive and economical utilization of water resources, diversion of water from the Yellow River and inter-basin water transfer, optimal allocation of water resources, comprehensive management of soil erosion in sandy and coarse sandy areas, restoration and protection of water ecology of the Wuding River and along the Huanghe River, and defense against water and drought hazards; and for the southern Shaanxi region, it can build a water conservancy development pattern based on water conservation and water resources protection, flood prevention and disaster mitigation, and restoration and protection of water ecology of the Handan River.

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