Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 16, No. 1, 2024

Evaluation of Water Resources Carrying Capacity in Shandong Province Based on Entropy Weight TOPSIS Model

Jiefan Zhang

College of Xi'an International Studies University, Xi'an, China

Abstract: In order to scientifically evaluate the water resources carrying capacity of Shandong Province, this paper constructs an evaluation framework of nine key indicators, including water supply coefficient and per capita GDP, from three dimensions: hydrological resource status, economic and social development level and ecological environmental protection. Then, the entropy weight method combined with TOPSIS model was used to carry out in-depth analysis and quantitative evaluation of Shandong's water resources carrying capacity. The results show that: from 2015 to 2020, the water resources carrying capacity of Shandong Province first increased steadily, then decreased slightly, and then continued to rise sharply. From 2015 to 2020, the water resources carrying capacity of Shandong Province was always in a state of shortage; In the future work, we should pay more attention to the balanced development of economic and social development level and carrying capacity, and continue to strengthen the management of water-saving and planned water use, so as to achieve sustainable use of water resources.

Keywords: Water resources carrying capacity, Entropy weight method, TOPSIS model, Shandong Province.

1. Introduction

Water resource is an important basic resource for human survival and social development. It is an irreplaceable renewable natural resource with multiple uses [1]. Since entering the 21st century, with the rapid expansion of global economy, problems such as scarcity of water resources, degradation of water ecosystem and water pollution have become increasingly prominent, which seriously restricts the sustainable progress of regional social economy. China's water resources endowment shows a significant spatio-temporal imbalance, with sharp annual and seasonal fluctuations in water resources, and the uneven development and utilization of water resources in various regions, resulting in severe water resources pressure in many regions. At present, the existing water resources in many regions of China can no longer support the rapid pace of local social and economic growth. How to properly reconcile the contradiction between supply and demand of regional water resources and coordinate it with social and economic development has become the core issue to determine whether the region can achieve the sustainable development goals.

On the discussion of water resources carrying capacity, the academic circles at home and abroad have accumulated a wealth of research results. WIDODO and other researchers [2] integrated the concept of water resources carrying capacity with land use patterns, and determined the critical value of water resources carrying capacity in Yogyakarta city through comprehensive analysis. This study not only deepens our understanding of WCR, but also situates it in specific land use scenarios, providing empirical evidence for urban planning and water resources management. Scholars [3] such as AIT-AOUDIA proposed that water resources carrying capacity should be understood as the upper limit of human activity intensity that an ecosystem can tolerate under the premise of ensuring basic living needs and water resources security. KUSPILIC et [4] al. defined water resources carrying capacity as the maximum number of populations that a region's water resources could sustain under the premise of sustainable utilization, and analyzed the water resources carrying capacity of Cres Island based on this concept.

In carrying out the assessment of water resources carrying capacity, there have been many academic contributions on how to rationally select research approaches and quantify the relative importance of each indicator. At present, the methods of determining index weights are mainly divided into two categories: one is the subjective weighting method of subjectively specifying index weights, such as the analytic [5] hierarchy process and the relative entropy aggregation method [6] of group decision making. Although such methods can fully reflect the individual tendency of research subjects, the weights set by manual are often not robust enough due to the significant individual differences in subjective judgment. And the other category is the objective weighting method, which focuses on the direct use of the original data of indicators, with the help of statistical analysis means to automatically calculate the weight of each indicator, in order to avoid the influence of human bias. Such as principal component analysis [7], entropy weight method [8] and so on. The objective weighting method is free from the interference of subjective assumptions, and the determination of the index weight depends more on the inherent characteristics and randomness of the sample data. In view of the advantages and disadvantages of subjective and objective weighting methods, scholars have begun to carry out a series of optimization attempts, aiming at synthesizing the advantages of the two methods, in order to obtain a more accurate and comprehensive weight allocation scheme. In the evaluation index system of water resources carrying capacity, Shi Jia et al. [9] adopted the strategy of combining analytic hierarchy process (AHP) and entropy weight method to realize the comprehensive evaluation of index weights. Zhu Zhihuan [10] selected a cross-weighting technique combining coefficient of variation method and G1 method, which was successfully applied to the comprehensive evaluation of regional science and technology development level. A comprehensive review of past studies shows that the existing methods for determining the weights of indicators used to assess water resources carrying capacity fail to adequately and accurately reflect the real importance differences among indicators. Both subjective and objective weighting methods have significant limitations. Even if we try to combine subjective and objective methods and seek a compromise through the so-called combined weighting method, we often only carry out weighted average or mechanical combination at the surface level. This method not only lacks internal logic and science, but also the final weight result obtained is far from the best choice. This simple superposition of subjective and objective weights has no theoretical basis to support its rationality, nor does it have a rigorous scientific basis. More importantly, it does not really touch the core of the problem to find the optimal weight distribution scheme. The method of moment estimation can scientifically balance the ratio of subjective and objective weights, and determine the best combination of subjective and objective weights by constructing the minimum deviation function, so as to obtain the optimal synthetic weights. At present, the moment estimation method has shown its application value in many fields, such as the optimization of emergency logistics management system [11], and the research and development and evaluation [12] of micro-robot technology.

In the research field of water resources carrying capacity assessment methods, the analysis methods widely used include fuzzy comprehensive evaluation method, grey correlation analysis model and TOPSIS model. Among them, TOPSIS model has been widely adopted and applied [13] in the evaluation field of water resources carrying capacity because it has no excessive restrictions on the random distribution of sample data and indicator information, and can retain and utilize the original data details to the greatest extent while simplifying the operation process, thus significantly reducing the information distortion rate. Wang Jiang and other scholars [14] built and applied TOPSIS model to carry out a prospective prediction and analysis of water resources carrying capacity in Guanzhong area of Shaanxi Province. Xu Yang et al. [15] innovatively improved the traditional TOPSIS model by introducing grey correlation analysis method, aiming to capture the implied nonlinear correlation among indicators. However, even so, the original TOPSIS model still has a limitation, that is, the closeness value calculated by the TOPSIS lacks a clear grade division, which weakens the intuitive expression of the results to some extent. In view of this, some scholars began to explore the combination of TOPSIS model and RSR rule, which has excellent hierarchical classification ability, in order to make up for the shortcomings of TOPSIS model in the classification of results. For example, Wang Ying [16] creatively integrated the weighted TOPSIS model with RSR method and applied it to the comprehensive evaluation and classification of the influence of academic journals.

In view of the above problems, this study draws on the work of previous scholars and builds a comprehensive index system based on the theoretical framework of socio-economic-ecological coupling symbiosis. By using entropy method to scientifically measure the relative weights of each index, supplemented by TOPSIS model, the dynamic changes of water resources carrying capacity in Shandong Province from 2015 to 2020 were analyzed and comprehensively evaluated. The purpose of this study is to provide empirical basis and decision support for Shandong Province to rationally plan the development and utilization of water resources and promote its sustainable development strategy. By integrating social, economic and ecological considerations, this study tries to reveal the current situation and potential of water resources carrying capacity in Shandong Province, and provide scientific guidance for local governments to formulate water resources management policies, optimize resource allocation and balance the relationship between regional development and environmental protection.

2. General Situation and Data Source of The Research Area

2.1. Overview of the Research Area

Shandong Province is located in the warm temperate monsoon climate area, and its water resources mainly depend on natural precipitation. Therefore, the abundance and shortage of water resources in Shandong province are directly related to the amount of precipitation. The overall composition of water resources covers two parts: surface runoff and underground aquifer, and water resources can be renewed year by year through water circulation [17]. The frequent drought in Shandong Province, combined with the uneven natural distribution of water resources, serious water pollution and the lagging construction of water conservancy projects, together constitute the three causes of water resources shortage in the province. These problems not only limit the safety and stability of agricultural, industrial and urban water supply, but also have a negative impact on ecological balance and people's quality of life, becoming one of the important factors hindering the comprehensive development of Shandong Province [18]. Therefore, to solve the problem of water shortage and realize the efficient use and sustainable management of water resources is of vital significance to promote the overall economic and social progress of Shandong Province.

2.2. Data Sources

In this paper, the original data of Shandong Province in six evaluation years were obtained after sorting, analyzing and calculating the data in the Water Resources Bulletin of Shandong Province and the Environmental Status Bulletin of Shandong Province from 2015 to 2020 and the Statistical Yearbook of Shandong Province from 2016 to 2021.

3. Research Methods

3.1. Connotation of Water Resources Carrying Capacity and Index System Construction

Research on the connotation of Water Resources Carrying Capacity, after China's gradual development and improvement, its connotation can be divided into three categories: "maximum supporting scale of water resources", "maximum development capacity of water resources" and "sustainable development of water resources" theory [19]. Water resources carrying capacity essentially reflects a specific region, under the given stage of economic and social development and productivity level, its water resources system can guarantee and support, and ecological environmental protection and social and economic activities coordination, sustainable development of the appropriate capacity [20]. Therefore, in the process of carrying out the research of water resources carrying capacity, it is necessary to comprehensively consider multiple factors including ecological environment and social economy, and carry out comprehensive analysis and evaluation.

Based on the design ideas of the index system in the literature [21-22], this study followed the principles [23] of index construction including hierarchy, scientific, regional and availability. On the basis of fully considering the unique ecological system, social and economic development level and hydrological conditions of Shandong Province, and drawing reference from the index framework in relevant literature [24-26], nine key indicators were carefully selected. The three key dimensions of water resources, ecological environment and economy are taken as the evaluation criteria, and then a comprehensive evaluation system is formed to conduct a comprehensive analysis and evaluation of the water resources carrying capacity of Shandong Province from 2015 to 2020, as listed in Table 1.

Table 1. Comprehensive evaluation index system of Shandong water resources carrying capacity

Target Layer	Guideline layer	Indicators	Nature	Indicator layer	Indicator meaning
Environmental carrying capacity of water resources A	Water Resources Subsystem B1	C1	-	Per capita water resources	Total water resources/total population of the region
		C2	-	Utilization rate of water resources development	Regional water consumption/total water resources
		C3	+	Water production modulus	Total regional water resources/regional land area
		C4	+	Water supply module	Total regional water supply/regional land area
	Economic and Social subsystem B2	C5	+	GDP per capita	Total regional GDP/total regional population
		C6	+	Urbanization rate	Regional urban population/total regional population
		C7	-	Per capita daily water consumption of urban residents	Total domestic water consumption / (Number of water users x days)
	Ecological environment subsystem B3	C8	+	Sewage treatment rate	Area sewage treatment/total discharge
		C9	+	Water consumption rate for ecological environment	Regional eco-environmental water consumption/total water consumption

In the framework of comprehensive evaluation, the water resources subsystem focuses on the baseline and development and application status of water resources in Shandong Province, and selects four key indicators: per capita water resources utilization, water production coefficient, water supply coefficient and water resources development intensity. In the eco-environment subsystem, two core indexes of eco-water use ratio and wastewater treatment efficiency are included in view of the interdependence and interaction between eco-environment and water resources. In view of the economic and social subsystem, the population size and social development stage of Shandong Province have a significant impact on the carrying capacity of water resources, so three indicators such as per capita GDP and urbanization level are specially selected for consideration.

3.2. TOPSIS Model of Entropy Weight

Compared with analytic Hierarchy Process (AHP), expert score and other weight determination methods that rely on subjective judgment, entropy weight method calculates index weights based on the variation of sample data. This method can significantly reduce the uncertainty caused by human factors, so that the obtained weights are more objective and convincing, and have higher scientific reliability [27]. TOPSIS model, also known as "approximate ideal solution sorting method", is a widely used multi-criteria decision analysis method. Based on the concept of geometric distance, the method evaluates the relative merits of each option by quantifying the Euclidean distance between the decision unit and the positive ideal solution (the best case) and the negative ideal solution (the worst case). The closer the distance between DMU and the positive ideal solution, the closer its proximity index is to 1, indicating that the unit is more advantageous; On the contrary, if the distance from the negative ideal solution is smaller, the performance of the unit is relatively poor [28]. However, the entropy-TOPsis method integrates the advantages of entropy weight method in determining index weights, effectively avoiding the subjective bias that may be introduced when the traditional TOPSIS method uses expert scores or analytic hierarchy process (AHP) to calculate weights, so as to ensure the objectivity and scientificity of evaluation results [29]. At present, the entropy-TOPSIS model is gradually widely used by scholars in the fields of water resources carrying [30] capacity, market competitiveness [31], decision plan selection [32], green development evaluation [33] and other fields.

In order to ensure the consistency of the evaluation index data and eliminate the dimensional impact, the range standardization technology is used to implement the pre-processing standardization of the original data. The formula is as follows:

$$d_{ij} = \begin{cases} \frac{x_{ij}-x_{ij(min)}}{x_{ij(max)}-x_{ij(min)}} (forward\ pointer) \\ \frac{x_{ij(max)}-x_{ij}}{x_{ij(mx)}-x_{ij(min)}} (backward\ pointer). \end{cases} \quad (1)$$

Where: represents the original value of the JTH evaluation x_{ij}index of water resources carrying capacity in the i year; d_{ij}Represents the index value after standardization.

In order to test the reliability of the evaluation index system of water resources carrying capacity constructed, SPSS19.0 software was used to measure the credibility of the standardized data, and the credibility coefficient was 0.889 (see Table 2). d_{ij} It is concluded that the constructed evaluation index system of Shandong water resources carrying capacity is objective.

Table 2. Reliability analysis of the index system

Name	Cronbach'sAlpha	Sample size	Exclusions
Index system	0.889	54	0

Calculate the proportion of the JTH indicator to this indicator in year i:p_{ij}

$$p_{ij} = \frac{d_{ij}}{\sum_{i=1}^{m} d_{ij}} \quad (2)$$

Calculate the information entropy and redundancy values of the JTH indicator: (if 0, then assume 0 as well). $e_j f_j p_{ij} lnp_{ij}$ The lower the information entropy indicates that the greater the degree of variation of the index value, the more information provided, and the greater its weight, and vice versa. Redundancy, on the other hand, reflects the amount [31, 32] of information of the index.

$$e_j = -k \sum_{i=1}^{m} p_{ij} lnp_{ij} \quad (3)$$

Where: k=.$1/lnm$

Calculate the entropy weight of the JTH index:w_j

$$w_j = f_i / \sum_{j=1}^{n} f_i \quad (4)$$

Calculate the weight normalization matrix S:

$$S = (s_{ij})_{m\times n}, s_{ij} = w_j d_{ij} (i = 1,2,,3,\ldots,m; j = 1,2,3,\ldots,n) \quad (5)$$

Where: is the weight calculated by formula (4) of index w_jj; d_{ij}Is the standardized value obtained by formula (1).

Determine the positive ideal solution and negative ideal solution of each index:$s^{+}{}_{j} s^{-}{}_{j}$

$$s^{+}{}_{j} = max\{s_{1j}, s_{2j}, s_{3j}, \ldots s_{ij}\} \quad (6)$$

$$s^{-}{}_{j} = min\{s_{1j}, s_{2j}, s_{3j}, \ldots s_{ij}\} \quad (7)$$

Calculate the sum of Euclidean distance between each evaluation unit and the positive ideal solution and the negative ideal solution:$d^{+}{}_{i} d^{-}{}_{i}$

$$\text{Positive ideal distance: } d^{+}{}_{i} = \sqrt{\sum_{j=1}^{n} (s_{ij} - s^{+}{}_{j})^2} \quad (8)$$

$$\text{Negative ideal distance: } d^{-}{}_{i} = \sqrt{\sum_{j=1}^{n} (s_{ij} - s^{-}{}_{j})^2} \quad (9)$$

Calculate the closeness:C_i

$$C_i = d^{-}{}_{i} / d^{-}{}_{i} + d^{+}{}_{i} \quad (i = 1, 2, 3, \ldots m) \quad (10)$$

Where: represents the water resources carrying capacity level in year C_ii, $0 \leq C_i \leq 1$, the greater the value, the higher the carrying capacity level.C_i

By the same token, 4 criterion layers can be calculated. C_iDrawing on the research results of Tian Pei [37] and He Gang [38] et al., the comprehensive evaluation index of water resources carrying capacity is divided into 5 levels, as shown in Table 3.

Table 3. Grading standard of evaluation index of water resources carrying capacity

C	[0, 0.3)	[0.3, 0.4)	[0.4, 0.5)	[0.5, 0.6)	[0.6, 1]
Carrying class	Water scarcity	Water scarcity	Reasonable water resources	Coordination of water resources	Water abundance

4. Results & Analysis

4.1. Result Analysis of Time Change

The index weight results obtained by entropy weight method are shown in Table 4.

It can be observed from Table 4 that the weight value of the water resources subsystem occupies the first place, followed by the economic and social subsystem, and the ecological environment subsystem is at the bottom. The weight value actually reflects the influence of each subsystem on the state of water resources carrying capacity. It can be seen that the water resources subsystem plays the most critical role, which shows a significant positive promoting effect, and plays a vital positive role in improving the water resources carrying capacity.

Table 4. The index entropy weight of water resources carrying capacity

Target Layer	Guideline layer	Weights	Indicator layer	Weights
Water carrying capacity	Water resources subsystem	0.3718	C1	0.0213
			C2	0.0583
			C3	0.1382
			C4	0.1540
	Economic and Social subsystem	0.3176	C5	0.1980
			C6	0.0805
			C7	0.0391
	Eco-environmental subsystem	0.3105	C8	0.0628
			C9	0.2477

Based on the weights obtained by entropy weight method and further calculated by TOPSIS model, the proximity Ci index of the comprehensive water resources system and the three sub-systems of water resources, economic society and ecological environment in Shandong Province from 2015 to 2020 was obtained, as shown in Table 5.

Table 5. Calculation results of proximity Ci in Shandong Province

Year	Jinan	Qingdao	Zibo	Zaozhuang	Dongying	Yantai	Weifang	Jining	Tai 'an	Weihai	Rizhao	Linyi	Dezhou	Liaocheng	Binzhou	Heze	Average
2015	0.4058	0.3206	0.3853	0.2767	0.4458	0.2794	0.1938	0.3362	0.2873	0.3297	0.2051	0.1895	0.3045	0.3111	0.2854	0.2849	0.3026
2016	0.4533	0.3497	0.3830	0.2974	0.4330	0.2626	0.2005	0.3567	0.3064	0.3140	0.2370	0.2345	0.3091	0.3266	0.2940	0.3004	0.3159
2017	0.4590	0.3573	0.3705	0.3628	0.4929	0.2873	0.2199	0.3403	0.3102	0.3320	0.2450	0.2575	0.3280	0.3126	0.3144	0.2885	0.3299
2018	0.4977	0.3713	0.4167	0.3259	0.5638	0.3048	0.2947	0.3602	0.3430	0.3181	0.3690	0.2669	0.3371	0.3509	0.3315	0.3045	0.3598
2019	0.4816	0.3416	0.4027	0.3186	0.6632	0.2739	0.2500	0.3357	0.3060	0.2782	0.3012	0.2476	0.3299	0.3338	0.4527	0.2957	0.3552
2020	0.5074	0.3990	0.4386	0.3982	0.6505	0.2947	0.2865	0.3698	0.3893	0.3781	0.4507	0.3535	0.3221	0.3551	0.3694	0.3166	0.3924
Average	0.4675	0.3566	0.3995	0.3299	0.5415	0.2838	0.2409	0.3498	0.3237	0.3250	0.3013	0.2583	0.3218	0.3317	0.3413	0.2984	0.3924

As can be seen from Table 5, the overall water resources carrying capacity of Shandong Province shows a slow increase trend from 2015 to 2020, with the mean value of the evaluation index increasing from 0.3026 in 2015 to 0.3924 in 2020, and the water resources carrying capacity level has been in a state of shortage. From the perspective of time, the water resources carrying capacity of Shandong Province showed an increasing trend year by year in the past six years, and Yantai and Weifang cities were always in a state of shortage. The water resources carrying capacity of Zaozhuang City, Tai 'an City, Linyi City, Binzhou City and Heze city changed from scarcity to shortage state in the past six years; Qingdao City, Jining City, Weihai City, Dezhou City and Liaocheng City have been in the state of shortage during the six years; Jinan City and Zibo city transition from the state of water shortage in 2015 to the state of reasonable water resources in 2020; The carrying capacity of water resources in Rizhao City changed the most in 6 years, from the state of shortage to the state of reasonable; The state of water resources carrying capacity of Dongying City has always been in a good state, and the state of water resources carrying capacity has changed from reasonable to coordinated state during 2015-2020. From the perspective of spatial evolution, the evaluation index in 2015 ranked from high to low as Dongying City, Jinan City, Zibo City, Jining City, Weihai City, Qingdao City, Liaocheng City, Dezhou City, Tai 'an City, Binzhou City, Heze City, Yantai City, Zaozhuang City, Rizhao City, Weifang City, Linyi City, In 2020, the evaluation index is ranked from high to low as Dongying, Jinan, Rizhao, Zibo, Qingdao, Zaozhuang, Tai 'an, Weihai, Jining, Binzhou, Linyi, Liaocheng, Dezhou, Heze, Yantai and Weifang. It can be seen that the spatial difference of water resources carrying capacity in Shandong Province is obvious, and the level of water resources carrying capacity in Dongying and Jinan is higher. It can be seen from Table 5 that natural endowments of water resources play a promoting role in carrying capacity. From 2105 to 2020, the increase of water resources carrying capacity is small, and the change trend is gradually stable. The overall water resources are in a state of shortage, which indicates that Shandong Province still needs to take a series of measures to rationally develop and utilize water resources in order to achieve sustainable utilization of water resources.

4.2. Countermeasures and Discussion

In order to enhance the carrying capacity of water resources in Shandong Province, according to the existing constraints, the following key strategies can be adopted:

Considering that the total amount of water resources in Shandong province is limited and the water transfer quota of Yellow River is fixed, the scale of the introduction of Yangtze River water resources in the East route of South-to-North Water diversion project should be appropriately increased. At the same time, taking advantage of the concept of sponge city promoted by the State, the development and utilization of unconventional water sources such as stormwater, reclaimed water and reuse after sewage treatment should be actively promoted, and the allocation efficiency and sustainable use level of water resources in the social water circulation system should be comprehensively improved.

As a strong coastal economic province, Shandong Province should continue to promote the application and industrialization of seawater desalination technology, provide additional water security for cities in coastal arid areas, and alleviate the shortage of water resources.

Facing the position of a large province of industry and agriculture, it should comprehensively promote efficient water-saving technology, promote the transformation of traditional high-water-consuming agriculture to modern water-saving agriculture, and encourage industrial enterprises to improve the recycling rate of water and reduce the consumption of fresh water.

In addition, in view of the spatial differences in water resources carrying capacity of different cities in Shandong Province, it is suggested to optimize and adjust the Yellow River water diversion quota and allocate more index shares to Jining, Heze, Liaocheng and other water-stressed areas to ease local water resources pressure.

Through the comprehensive implementation of the above measures, Shandong Province is expected to realize the rational allocation and efficient use of water resources, and provide solid water resources support for the sustainable economic and social development of the region. At the same time, it also provides useful reference and inspiration for other regions facing similar water resources dilemma.

5. Summary

TOPSIS model was used to evaluate the water resources carrying capacity of Shandong Province from 2015 to 2020, and the results showed that the water resources carrying capacity of Shandong Province showed a fluctuating trend. Specifically, the water carrying capacity increased steadily from 2015 to 2017, then declined in 2018, but resumed its upward trend in 2019 and 2020. From the sub-system level analysis, the water resources sub-system has the most significant impact on the overall carrying capacity, followed by the economic and social sub-system. It is worth noting that the water resources subsystem plays a positive driving force, while some aspects of social development have a negative impact on the water resources carrying capacity. In view of this, Shandong Province should pay special attention to the coordinated balance between social progress and water resources carrying capacity in the subsequent development path, resolutely implement strict regulations on water resources management, and strengthen the supervision and protection measures of groundwater resources. At the same time, it is necessary to further deepen the awareness of water-saving, strengthen the management of water use plan, and ensure the long-term sustainable utilization of water resources. Through comprehensive policies, Shandong Province is expected to build a water resources management system that is compatible with social and economic development, and realize the harmonious coexistence of resources, environment and society.

References

[1] WANG Y Z. Research on evaluation of regional water resources carrying capacity [D]. Hohai University, 2005. (in Chinese with English abstract)

[2] B. Widodo, R. Lupyanto, B. Sulistiono, D.A. Harjito, J. Hamidin, E. Hapsari, M. Yasin, C. Ellinda,Analysis of Environmental Carrying Capacity for the Development of Sustainable Settlement in Yogyakarta Urban Area,Procedia Environmental Sciences,Volume 28, 2015, Pages 519-527, https://doi.org/10.1016/j.proenv.2015.07.062.

[3] Meriem Naimi Ait-Aoudia, Ewa Berezowska-Azzag,Water resources carrying capacity assessment:The case of Algeria's capital city,Habitat International,Volume 58, 2016, Pages 51-58, https://doi.org/10.1016/j.habitatint.2016.09.006.

[4] Kuspilić, M., Vuković, Ž., Halkijević, I.: Assessment of water resources carrying capacity for the Island of Cres, GRAĐEVINAR, 70 (2018) 4, pp. 305-313, doi: https://doi.org/10.14256/JCE.2167.2017

[5] Wu S X. Evaluation of comprehensive resource carrying capacity of Jiangsu city based on Analytic Hierarchy Process [J]. Journal of Economic Research, 2021, (13):48-51. (in Chinese with English abstract)

[6] Gong Zaiwu, Li Lianshui, Luo Hui, Yao Tianxiang. Relative Entropy Aggregation Method for Grey Preference Information Group Decision [J]. Systems Engineering and Electronics, 2010, 32(07):1441-1444. (in Chinese with English abstract)

[7] LI Zhijun, Jing Anlin, Huang Jiajun, Li Deliang. Water resources carrying capacity analysis of Shanxi Province based on principal component analysis [J]. Water Resources Science and Cold Area Engineering, 2022, 5(06):70-74. (in Chinese with English abstract)

[8] Chen Yu, Ding Ning, Zhao Yunxia. Dynamic evaluation of resources and environment carrying capacity in Northwest China based on entropy weight TOPSIS model [J]. Science and Technology Management of Land and Resources, 2022, 39(03):1-13. (in Chinese with English abstract)

[9] SHI Jia, XUE Lianqing, Chen Xinfang, ZHANG Luocheng, Sun Chao. Variable fuzzy comprehensive evaluation of water resources carrying capacity in Yerqiang River Basin based on comprehensive weighting method [J]. Journal of Water Resources and Water Engineering, 2017, 28(05):32-36. (in Chinese with English abstract)

[10] Zhu Zhichuan. Hybrid cross weighting method based on Covariance -G1 method. Statistics and Decision, 2017, (12):78-81. (in Chinese with English abstract)

[11] Ye Wanhong, Geng Juanjuan, Xu Dongsheng. Emergency logistics Supplier Evaluation based on Moment Estimating-Improved TOPSIS Model [J]. Gansu Journal of Science, 2022, 34(03):134-139. (in Chinese with English abstract)

[12] Wu Jianjun, Yang Yijiao, Wang Zhenfei. Research on Reliability Allocation Method of Micro-Robot based on Combined Weights [J]. Manufacturing Automation, 2022, 44(02):93-97. (in Chinese with English abstract)

[13] Duan-Liang, LI Jiuyi, Song Xiaoyan, Miao Xu, Liu Yumei. Comprehensive evaluation of water resources carrying capacity in Ordos City based on improved TOPSIS algorithm [J]. Water Resources and Hydropower Technology (Chinese and English), 2022, 53(06):101-110. (in Chinese with English abstract)

[14] Wang Jiang, Li Jing, Wei Hongyi, Tian Peng. Prediction and evaluation of regional water resources carrying capacity based on TOPSIS method: A case study of Guanzhong Area, Shaanxi Province [J]. Research of Soil and Water Conservation, 2008, (03):161-163. (in Chinese with English abstract)

[15] Xu Yang, Chen Jing, Xia Huan, Chu L L, Zhang Xin-Yuan. Evaluation of water resources carrying capacity in Huai 'an City based on DPSR-Improved TOPSIS model [J]. Journal of Water Resources and Water Engineering, 2019, 30(04):47-52+62. (in Chinese with English abstract)

[16] Wang Y. Application of Weighted TOPSIS and RSR method in Comprehensive evaluation of academic journals' influence [J]. Library and Information Work, 2013, 57(02):92-96. (in Chinese with English abstract)

[17] Zhao Qiang, Li Xiumei, Gao Qian, Xiong Dan, Zou Chunhui. Evaluation of water resources carrying capacity in Shandong Province based on fuzzy comprehensive evaluation [J]. Ecological Sciences, 2018, 37(04):188-194. (in Chinese with English abstract)

[18] Huang L, Yang P H. Research on water resources carrying capacity in Shandong Province based on fuzzy comprehensive evaluation [J]. Journal of Jiujiang University (Natural Science Edition), 2016, 31(02):12-16. (in Chinese with English abstract)

[19] Zhang L J. Evaluation of water resources carrying capacity in the Yellow River Basin [D]. Northwest A&F University, 2019. (in Chinese with English abstract)

[20] Duan Chunqing, Liu Changming, Chen Xiaonan, Liu Wenhua, Zheng Hongxing. A study on the concept and research methods of regional water resources carrying capacity [J]. Acta Geographica Sinica, 2010, 65(01):82-90. (in Chinese with English abstract)

[21] An Qiang, Wei Chuanjiang, He Huaxiang, Cui Yingjie, Nie Qianwen. Evaluation of water resources carrying capacity of Central Plains urban Agglomerations in Henan Province based on fuzzy comprehensive evaluation method [J]. Water Saving Irrigation, 2019, (12):65-71. (in Chinese with English abstract)

[22] Zhang Xifeng, Wang Xiaobo, Ding Hong. Analysis on regional water resources carrying capacity in Longjiang County [J]. Water Resources Science and Cold Area Engineering, 2021, 4(03):68-71. (in Chinese with English abstract)

[23] Xu Liangfang, Feng Guozhang, Liu Junmin. [J]. Journal of Northwest A&F University (Natural Science Edition), 2002, (02):119-122. (in Chinese with English abstract)

[24] Ma Jimin, Tuo Yunfei, Wang Qian, Wang Fei, Zheng Yang, Du Wenjuan. Evaluation and obstacle factor diagnosis of water resources carrying capacity in Yunnan Province based on GRA-TOPSIS method [J]. Journal of Water Resources and Water Engineering, 2022, 33(02):11-17+26. (in Chinese with English abstract)

[25] Wang Wenchuan, Yang Liu, Zheng Ye, Xu Dongmei. Evaluation of water resources carrying capacity in Shiyang

River Basin based on game theory and cloud model [J]. Water Resources and Hydropower Technology (English and Chinese), 2021, 52(10):35-45. (in Chinese with English abstract)

[26] Wang N, Chen Ying, Chen Xing-Wei. Construction of evaluation index system for regional water resources sustainable use[J]. Journal of Natural Resources, 2014, 29(08):1441-1452. (in Chinese with English abstract)

[27] Yuan Chengcheng, Liu Liming, Ye Jinwei, Qiu Menglong, Ren Guoping. [J]. Journal of Ecology and Rural Environment, 2017, 33(08):688-696. (in Chinese with English abstract)

[28] Liang J F, Chen S L. Evaluation and grey correlation analysis of land use performance in Fujian Province based on entropy weight TOPSIS model [J]. Journal of Fujian Normal University (Natural Science Edition), 2019, 35(03):80-87. (in Chinese with English abstract)

[29] Ke Wenjin, Wang Jun. Evaluation of carrying capacity of urban higher education resources based on entropy weight TOPSIS model [J]. Statistics and Decision, 2020, 36(18):50-53. (in Chinese with English abstract)

[30] Wei Ling. Evaluation and optimization of investment environment in overseas market of nickel resources based on entropy weight-TOPsis method [D]. China University of Geosciences (Beijing), 2020. (in Chinese with English abstract)

[31] Cheng Huixian, Yu Yang, Niu Hui, Wu Yiping, Cheng Qingqing. Analysis of coupling and coordination between ecological environment and green development in Yellow River Basin [J]. Forestry Economics, 2021, 43(06):5-20+96. (in Chinese with English abstract)

[32] Tian Pei, Zhang Zhi-hao, Xu Xin-yi, Yan Feng, Wu Yi-jin, ZHANG Hai-Lin, Liu Mu-xing. Comprehensive evaluation of water resources carrying capacity in Yangtze River Economic Belt based on variable weight TOPSIS model [J]. Journal of Central China Normal University (Natural Science Edition), 2019, 53(05):755-764. (in Chinese with English abstract)

[33] He Gang, Xia Yeling, Qin Yong, Zhu Yana, Wang Wenwen. Evaluation and spatiotemporal dynamic change of water resources carrying capacity in the Yangtze River Economic Belt [J]. Research of Soil and Water Conservation, 2019, 26(01):287-292+30. (in Chinese with English abstract)