Pol. J. Environ. Stud. Vol. 33, No. 2 (2024), 1925-1935
DOI: *10.15244/pjoes/173098*

Original Research

Evaluation and Obstacle Degree Analysis of Sustainable Utilization of Water Resources in Hotan Area

Qi Zhao*

Hydrology Bureau of Xinjiang Uygur Autonomous Region, Urumqi, Xinjiang, 830000, China

Received: 6 August 2023
Accepted: 1 October 2023

Abstract

It is of great significance to study the changes of sustainable use of water resources in arid areas to ensure the sustainable development of water resources, water resources and ecological environment. In order to fully understand the development level of sustainable utilization of water resources in Hotan area and the main obstacles to its development, this paper constructs an evaluation model of sustainable utilization of water resources in Hotan area based on "PRS" model from three aspects, such as pressure, state and response ability of water resources system. Based on TOPSIS algorithm and obstacle degree model, the evolution characteristics and obstacle factors of sustainable use of water resources were revealed. The results show that: (1) From 2000 to 2020, the sustainable utilization of water resources in Hotan area shows a fluctuating upward trend, and the calculated value is mainly 0.4-0.8; (2) From the perspective of water resources system pressure, state and response, the state, response level and pressure level of water resources in Hotan area show a fluctuating upward trend from 2000 to 2020, and their added values are 0.589, 0.400 and 0.674, respectively. Among them, the closeness degree of water resources system pressure increases the most, about 2 times. (3) The sustainable utilization of water resources in Hotan was mainly affected by evaporation change rate and vegetation coverage rate. This study believes that the industrial structure should be adjusted, the discharge of sewage and the development and utilization of water resources should be strictly controlled, the utilization rate and economic benefits of water resources should be improved, and the sustainable utilization of water resources should be improved as a whole.

Keywords: Hotan, water resources system, ttoughness evaluation, TOPSIS algorithm, obstacle degree analysis

---

*e-mail: ZhaoQi_2023@163.com

Introduction

Sustainable utilization of water resources refers to the principle of permanent utilization of water resources in order to guarantee the sustainable development of human society, economy and ecological environment [1]. Since the concept of sustainable development was put forward in the 1980s, it has attracted the attention of relevant scholars. In order to realize the sustainable development of water resources, countries and administrative regions put forward relevant measures and policies according to their own conditions [2, 3]. The basic idea is to pay attention to the balance between the adverse side effects caused by development and the expected social and economic effects in the process of water resources development and utilization. Therefore, in the development and utilization of water resources, ecological and environmental systems must not be harmed. At the same time, the water required for the rational development of society and economy should be guaranteed to meet the water requirements of various industries and provide continuous water supply [4, 5]. In addition, water will be disturbed in the natural cycle process, and countermeasures should be paid attention to to reduce the impact of such interference on the sustainable use of water resources [6, 7].

In order to ensure that the sustainable development of water resources and the level of social and economic development are compatible with the carrying capacity of water resources, since The State Council issued the Opinions on Implementing the Strictest Water Resources Management System in 2012, the state and various provinces and cities have clearly put forward the main objectives of the control of water resources development and utilization, the control of water use efficiency and the "three red lines" limiting the absorption of pollution in water functional areas [8]. Since the implementation of the strictest water resources management system, Xinjiang has adhered to the principles of "determining land, production, city and electronically controlled water according to water", and has distributed the "three red lines" control indicators to various states and cities, and has initially realized the control of total water use and water use efficiency[9, 10]. In order to realize the general goal of "three red lines", Hotan region actively carries out the construction of water-saving society, and implements a series of measures: perfect and perfect water resources management system [11]; The industrial structure and water supply structure should be established according to local water resources endowment and spatial and temporal distribution characteristics. In order to ensure the water quality standard, the water resources monitoring system has been improved. Improve residents' awareness of water-saving and the popularization rate of efficient water-saving technologies. However, due to the low level of industrial and agricultural development and relatively backward industrial development in Hotan, its water economic benefits are low, which is not conducive to the construction of a water-saving society, and is also a major factor hindering the realization of the overall goal of "three red lines" and the sustainable utilization of water resources [12, 13].

The distribution of water resources in Hotan is uneven in time and space, and water resources are scarce. However, with the development of industrialization and modernization, the social and economic water demand is increasing, the contradiction between supply and demand of water resources is becoming increasingly prominent, and water pollution is becoming increasingly serious, which has become an important "bottleneck" restricting its sustainable development. The main influencing factors of water resources sustainable development in different periods are also different. With the help of obstacle degree model, the influence of each factor on the sustainable development of water resources system can be quantitatively expressed from the aspects of index deviation degree, obstacle degree and contribution degree. Therefore, the study on the sustainable utilization of water resources in Hotan and the analysis of its main influencing factors are of great guiding significance to the realization of the overall goal of "three red lines" and the sustainable utilization of water resources in local and Xinjiang. The specific arrangement of this work is as follows:

Research Data and Methods

Overview of the Study Area

Hotan (77°31'E~84°55'E, 34°22'N~39°38'E) is located in the southernmost part of Xinjiang Uygur Autonomous Region (Fig. 2) [14]. By 2018, the per capita disposable income of urban residents in Hotan was 29,046 yuan, and the per capita net income of farmers and herdsmen was 8,882 yuan [15]. It is bounded by the Kunlun Mountains in the south, Aksu in the north by the Taklimakan Desert, Bayingoleng Mongolian Autonomous Prefecture in the east, and Kashgar Prefecture in the west. The area of the prefecture is 247,800 square kilometers; The area is rich in light and heat resources, which is not only the habitat of rare wild animals such as wild yaks and snow leopards, but also the distribution of wild plants with high economic value. The region is rich in mineral resources, with rich reserves of oil, natural gas and other mineral resources; Due to its location in a warm continental climate, it is characterized by strong evaporation and drought, low annual precipitation and frequent wind and sand [16-18].

Data Sources

This study chooses 2000-2020 as the research year with relatively complete data. The original data of total population, wastewater discharge, GDP, vegetation area and other indicators were derived from Xinjiang Statistical Yearbook (2000-2020). The original data

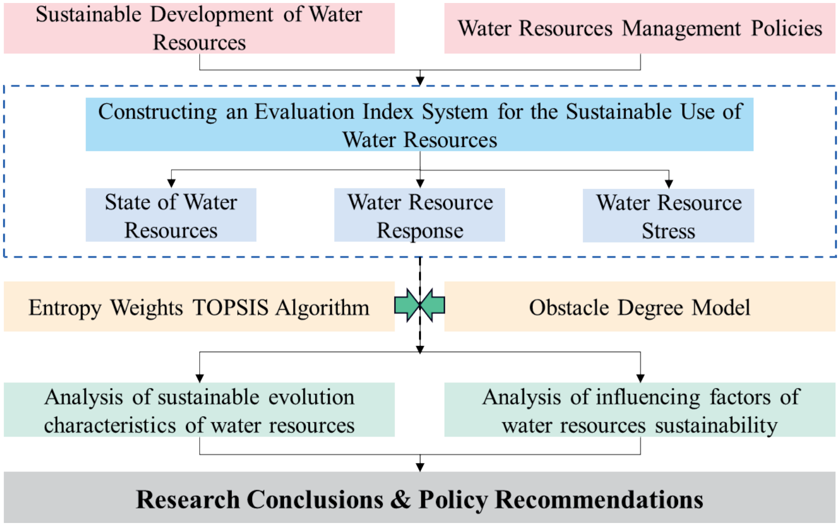

Fig. 1. Flowchart of specific work arrangement.

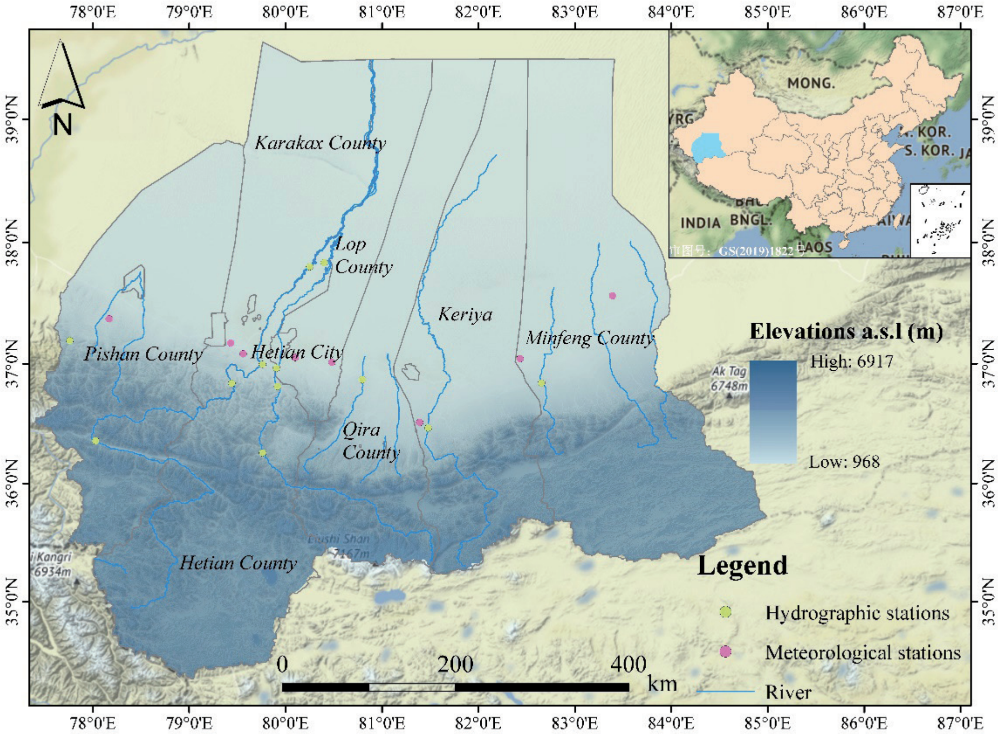

Fig. 2. Geographical location map of Hotan area.

of annual average precipitation, total water consumption, annual precipitation, evaporation change rate, surface water quantity, underground water quantity and total water resource were obtained from Xinjiang Water Resources Bulletin (2001-2020).

Research Methodology

Construct Evaluation Framework and Index System

For the sustainable utilization of water resources, according to the concept of resilience and the logical idea of pressure-state-response, an index system was constructed from three aspects: system pressure, state and response, as shown in Table 2-1. For the sustainable use of water resources, water system pressure: 5 indicators were selected from the aspects of sewage discharge, resource development and utilization intensity; Water system status: considering the amount of resources, water production capacity and surface/water conversion capacity, a total of 3 indicators; Water system response: three indicators were selected based on changes in green cover, rainfall and evaporation. (Table 1).

Table 1. Evaluation index system of sustainable utilization of water resources in Hotan area

Target layer	Attribute layer	Index level	Stats
Sustainable utilization of water resources	Status indicator	Coefficient of water production (X1)	+
		Surface water/groundwater conversion capacity (X2)	+
		Water resources quantity (X3)	+
	Response index	Precipitation change rate (X4)	+
		Evaporation rate (X5)	-
		Vegetation area change rate (X6)	+
	Pressure index	Population density (X7)	-
		Natural rate of population growth (X8)	-
		Water consumption for 10,000 yuan of GDP (X9)	-
		Per capita wastewater discharge (X10)	-
		Utilization rate of water resources development (X11)	-

Note: "(+)" is a positive index; The higher the index value, the higher the toughness development of the system. "(−)" is a negative exponent; The smaller the target value, the lower the toughness development of the system.

Indicator Weight

In this paper, entropy based method is used to assign the index. Entropy weighting overcomes the shortcoming of subjective weighting and has higher credibility [19, 20]. Due to the different information contained by each index on system changes, the weight of different indicators is different: the greater the weight of a specific indicator, the greater the impact on system changes, and vice versa [21].

Data Standardization

Because the dimensions of each index are different, it is necessary to carry out standardization processing, so that different data can be compared. Based on the core idea of TOPSIS algorithm, this paper adopts deviation standardization, and the calculation formulas according to the characteristics of indicators are as follows:

(1) Positive indicators:

$$x'_{ij} = \frac{x_{ij} - min\{x_{ij}\}}{max\{x_{ij}\} - min\{x_{ij}\}} + 1 \tag{1}$$

(2) Negative indicator:

$$x'_{ij} = \frac{max\{x_{ij}\} - x_{ij}}{max\{x_{ij}\} - min\{x_{ij}\}} + 1 \tag{2}$$

where: x_{ij} is the jth index in the year of sample i, and x_{ij}' represents the jth index in the year of sample i after standardization. Where 1≤i≤m, 1≤j≤n.

Entropy Weighting

The basic idea of entropy weighting method is to calculate the information entropy among indicators, and the index weight of the measure has strong objectivity and credibility [22]. The specific steps are as follows:

(1) Calculate the specific gravity matrix of the index system:

$$(P_{ij})_{(m,n)} = \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ P_{m1} & P_{m2} & \cdots & P_{mn} \end{bmatrix} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}} \tag{3}$$

where: $(P_{ij})_{(m,n)}$ is the specific gravity matrix of evaluation indicators, $0 \le P_{ij} \le 1$, where m represents the number of sample years; n represents the number of evaluation indicators; x_{ij}' represents the jth index in the standardized sample year i.

(2) Calculate the entropy of each index:

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} \left(P_{ij} \ln P_{ij}\right) \tag{4}$$

where e_j is the entropy value of each index, $0 \le e_j \le 1$.

(3) Calculate index weight:

$$g_j = 1 - e_j \tag{5}$$

$$W_j^{sz} = \frac{g_j}{\sum_{j=1}^{n} g_j} \tag{6}$$

where: g_j is the difference coefficient of the jth index; W_j^{sz} is the entropy weight of the jth item.

TOPSIS Algorithm

In order to fully show the development and change of evaluation targets, TOPSIS algorithm is adopted to evaluate the development status of evaluation targets by measuring the relative distance between each sample scheme and the optimal (or inferior) solution [23]. For specific calculation, refer to relevant studies [24].

$$H(x)_i = \frac{sep(x)_i^-}{sep(x)_i^+ + sep(x)_i^-} \tag{7}$$

where $H(x)_i$ ranges from [0,1], $H(w)_i$ represents the index of sustainable utilization of water resources, and $H(s)_i$ represents the index of sustainable utilization of water resources. $sep(x)_i^+$ is the distance between the i^th^ sample scheme and the optimal solution; $sep(x)_i^-$ is the distance between each sample scheme and the worst solution. Where 1≤i≤m, m is the number of sample years.

Obstacle Degree Model

In order to further reveal the main factors hindering the improvement of the sustainable utilization level of water resources in Hotan area, this paper adopts the obstacle degree model to conduct a quantitative analysis of the obstacle factors and the degree of obstacles affecting the sustainable utilization of water resources in the basin, based on the analysis of the obstacle degree of a single index to the overall goal. This paper refers to the methods provided by relevant literature for calculation:

$$Z_{ij} = \frac{L_{ij} W_j}{\sum_{j=1}^{n} L_{ij} W_j} \times 100\% \tag{8}$$

$$L_{ij} = 1 - x'_{ij} \tag{9}$$

where: z_{ij} is the obstacle degree of the j^th^ index to the sustainable utilization of water resources in the basin in the year i; L_{ij} is the difference between the single factor and the target condition, and W_j is the weight of the j^th^ indicator. Where 1≤i≤m, 1≤j≤n, m is the number of sample years, n is the number of evaluation indicators.

Results and Analysis

Evaluation Index Weight Determination

Based on the data standardization results, the entropy weighting method was used to assign weights to the selected indicators, and the indicators were sorted according to their weights (Table 2). The ratio weight of evaporation change is the largest (0.149), the weight of water production coefficient is the smallest (0.046), and the weight difference is 0.103. The top five indexes ranked by weight were evaporation change rate (0.149), precipitation change rate (0.117), water consumption per 10,000 yuan GDP (0.114), population density (0.111), surface water/groundwater conversion capacity (0.083), and the weight difference was small. From the attribute level, the weight ranking is stress index (0.436), response index (0.335) and state index (0.229).

Changes in the Sustainable Use of Water Resources in Hotan

The raw data is standardized according to the data standardization method described in 2.3.2.1. According to the different index systems corresponding to each criterion layer and factor layer, TOPSIS algorithm is used to calculate the relative distance between each sample scheme and the optimal (or inferior) solution of different evaluation objectives from 2000 to 2020. Finally, the sustainable utilization of water resources in the study area and the close degree of each index of the factor layer are obtained.

In the past 20 years, the sustainable utilization of water resources in Hotan showed a fluctuating upward

Table 2 .Weights of indicators in Hotan area.

Target layer	Attribute layer	Weight	Index level	Weight
Sustainable utilization of water resources	Status indicator	0.229	Coefficient of water production (X1)	0.046
			Surface water/groundwater conversion capacity (X2)	0.083
			Water resources quantity (X3)	0.100
	Response index	0.335	Precipitation change rate (X4)	0.117
			Evaporation rate (X5)	0.149
			Vegetation area change rate (X6)	0.069
	Pressure index	0.436	Population density (X7)	0.111
			Natural rate of population growth (X8)	0.062
			Water consumption for 10,000 yuan of GDP (X9)	0.114
			Per capita wastewater discharge (X10)	0.081
			Utilization rate of water resources development (X11)	0.069

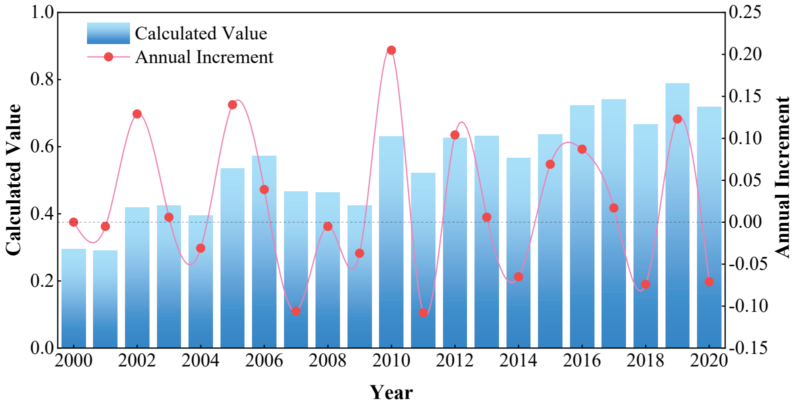

Fig. 3. Sustainable utilization of water resources in Hotan area.

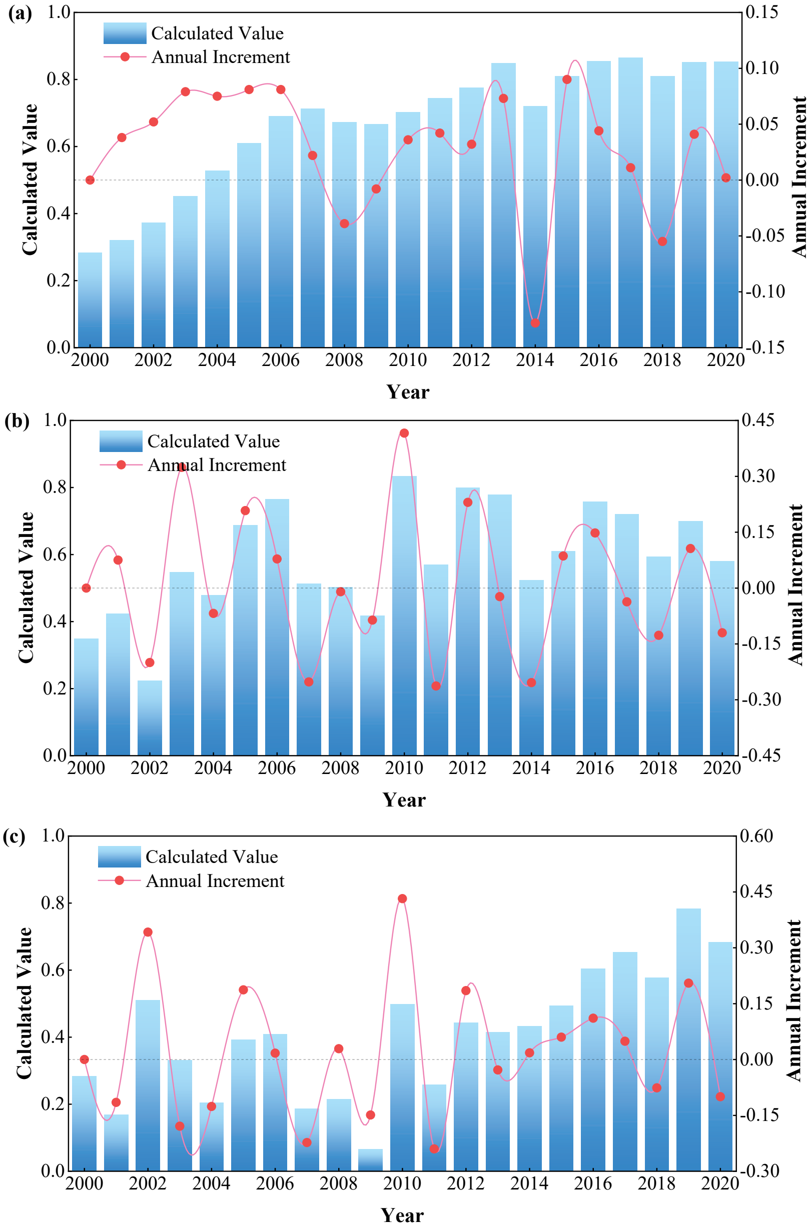

Fig. 4 Calculated values of each index.

trend (Fig. 3), with a variation of 0.423. Taking 2006 as the cut-off point, the index of sustainable water resources utilization from 2000 to 2006 showed a trend of rapid increase, and the change was obvious, with a amplitude of 0.278; From 2007 to 2020, the sustainable water resources use index showed an upward trend, among which the change of the sustainable water resources use index from 2007 to 2009 was relatively slow, and the change of the sustainable water resources use index was only -0.042, and the change of the sustainable water resources use index from 2017 to 2020 was 0.251, and the change was obvious but tended to be stable.

In addition to the obvious upward trend of the water resource pressure index, the overall change trend of the status and response indicators is the same, showing a fluctuating trend (Fig. 4), and the specific changes are different in different periods: (1) Before 2007, the water resource pressure index showed an overall upward trend with obvious changes, and after 2008, it showed a slow fluctuating upward trend with a small increase (Fig. 4a); (2) Taking 2006 and 2010 as the demarcation points, the water resources status index showed an obvious upward trend at first, a relatively stable trend from 2007 to 2009, and an overall fluctuating downward trend from 2010 to 2020 (Fig. 4b); (3) The change trend of water resources response index can be divided into two sections: the fluctuation trend from 2000 to 2008, and the change and increase from 2009 to 2020, with an increment of 0.570 (Fig. 4c).

Obstacle Degree Analysis of Sustainable Use of Water Resources

According to the obstacle degree model, the obstacle degree of each index to the sustainable use of water resources in different years was calculated, and

Table 3. Main obstacles to sustainable utilization of water resources in Hotan area

Obstacle factor	X5	X6	X1	X3	X4	X10	X11	X8	X9	X7
Frequency	20	20	19	19	19	17	14	12	12	9
Frequency	0.952	0.952	0.905	0.905	0.905	0.810	0.667	0.571	0.571	0.429

Table 4. Main obstacle factors and obstacle degree of sustainable utilization of water resources.

Year	1		2		3		4		5		od
	of	od	of	od	of	od	of	od	of	od	
2000	X2	0.136	X7	0.136	X9	0.136	X10	0.136	X5	0.130	0.676
2001	X4	0.144	X5	0.135	X7	0.131	X9	0.128	X10	0.119	0.657
2002	X1	0.154	X3	0.124	X5	0.122	X9	0.121	X7	0.116	0.638
2003	X5	0.135	X9	0.120	X7	0.117	X4	0.117	X3	0.106	0.595
2004	X5	0.178	X3	0.157	X4	0.154	X9	0.108	X11	0.101	0.698
2005	X5	0.183	X8	0.133	X9	0.122	X1	0.118	X4	0.108	0.664
2006	X5	0.249	X4	0.165	X9	0.142	X1	0.117	X7	0.094	0.767
2007	X5	0.198	X4	0.189	X3	0.175	X11	0.104	X6	0.099	0.766
2008	X5	0.164	X4	0.155	X3	0.144	X11	0.102	X6	0.101	0.666
2009	X4	0.169	X3	0.169	X11	0.169	X5	0.168	X6	0.135	0.811
2010	X8	0.282	X5	0.205	X6	0.198	X1	0.152	X9	0.070	0.907
2011	X5	0.178	X6	0.151	X4	0.149	X3	0.135	X10	0.120	0.733
2012	X6	0.218	X5	0.175	X8	0.135	X1	0.111	X10	0.091	0.730
2013	X5	0.229	X6	0.142	X4	0.137	X1	0.133	X10	0.088	0.728
2014	X4	0.189	X3	0.170	X6	0.137	X11	0.136	X10	0.133	0.765
2015	X4	0.167	X3	0.136	X5	0.123	X6	0.115	X1	0.113	0.653
2016	X6	0.184	X1	0.160	X5	0.131	X4	0.130	X8	0.125	0.730
2017	X1	0.172	X4	0.169	X6	0.133	X3	0.127	X5	0.100	0.701
2018	X6	0.184	X1	0.165	X3	0.164	X4	0.145	X10	0.114	0.771
2019	X1	0.242	X8	0.151	X3	0.139	X4	0.130	X6	0.105	0.767
2020	X6	0.291	X1	0.191	X3	0.119	X2	0.104	X10	0.097	0.801

Note: “of” stands for “Obstacle factor”; “od” stands for “Obstacle degree”

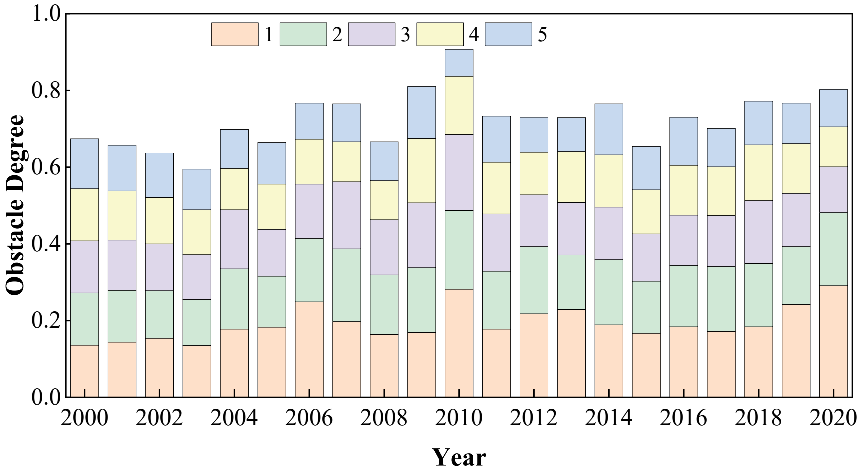

Fig. 5 Obstacle degree of the top 5 influencing factors.

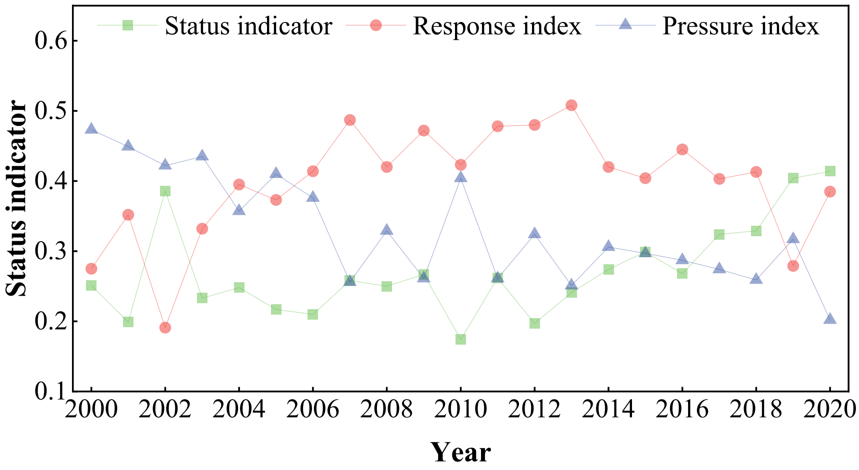

Fig. 6. Change trend of obstacle degree in attribute layer of sustainable water resources utilization.

the obstacle degree of each index was analyzed from the index level, attribute level and criterion level, and the main obstacle factors were determined. Obstacle degree of each index was ranked in order of magnitude, and obstacle factors were screened according to the criterion of obstacle degree Zi≥4.0% [25], and the diagnostic results of major obstacle factors for sustainable utilization of water resources in Hotan area were obtained (Table 3). The top five obstacle factors of this year were selected to analyze the changes in the main obstacle factors of sustainable water resources use (Table 4).

As can be seen from Table 3, among the obstacles to the sustainable use of water resources in Hotan area from 2000 to 2020, the rate of change of evaporation (X5) and the rate of change of vegetation area (X6) have the highest frequency, both of which are 95.24%. Followed by water production coefficient (X1), water resources amount (X3) and precipitation change rate (X4), the frequency is 90.48%. From the perspective of attribute level indicators, there are 5, 2 and 3 indicators belonging to water resources pressure index, state index and response index respectively.

As can be seen from Table 4 and Fig. 5, the cumulative obstacle degree of the top 5 obstacle degrees in the index layer gradually increases. In 2020, it even reached 80.1%, while in 2003, the cumulative handicap was the lowest at 59.5%. Among the obstacle factors of sustainable water resources utilization this year, the obstacle factors with the obstacle degree greater than 5% are mainly: evaporation change rate (X5), vegetation area change rate (X6), precipitation change rate (X4), water production coefficient (X1), water resources volume (X3), population density (X7) and water consumption of 10,000 yuan GDP (X9).

As can be seen from Fig. 6, water resource pressure, state and response index obstacle degree change are also different. During the study period, the obstacle degree of water resource stress index showed a decreasing trend as a whole, but its changing trend could be divided into two periods: starting from 2010, the overall fluctuation decreased before 2015, and the change was relatively stable after 2015, mainly within the range of (0.300,0.200); The overall change of obstacle degree of state index showed a fluctuating upward trend, which can be divided into two stages: from 2000 to 2010, the increase rate was only 0.015, and after 2011, it showed a significant upward trend, with a amplitude of 138.3%; The barrier degree of response index took 2013 as the demarcation point, which experienced rapid growth and fluctuation decline successively.

Discussion

The changes of indicators and evaluation objectives show that (Fig. 3 and 4) : In the past 20 years, the sustainable utilization capacity of water resources in Hotan region has been mainly affected by water resources pressure and response capacity, and after 2018, the change of water resources status has a significant impact on the development of sustainable utilization capacity of water resources in Hotan region. (1) Although with the implementation of many policies such as returning farmland to forest and pasture, the overall vegetation area shows a trend of fluctuation and decline due to the influence of social and economic activities, which limits the sustainable development of water resources in this region [26, 27]. (2) The precipitation in Hotan area increased steadily, the local conditions of water resources were improved, and the state capacity of local water resources was enhanced [28, 29]. (3) With the adjustment of industrial structure and the iteration of industrial technology, the economic benefits of water resources have been improved, and the sustainable development of water-socio-economic multiple system in Hotan has been promoted. (4) During the study period, the natural population growth rate showed an overall upward trend and the population increased, but due to the gradual expansion of human activity space and influence scope, the population density showed an overall downward trend, which reduced the local water resources pressure. At the same time, due to the gradual increase of social economy and agricultural irrigation demand, the development and utilization rate of water resources gradually increased, and the global water resources pressure increased.

From the attribute level indicators, there are 5, 2 and 3 indicators of water resources pressure, state and response indicators respectively. On the one hand, it shows that the sustainable utilization of water resources in Hotan area is affected by the combined effects of water resources pressure, state and response ability. On the other hand, it also shows that the obstacle factors affecting the sustainable development of water resources mainly come from the factor layer of water resources pressure and water resources response ability [30-32]. In the past 20 years, the vegetation area of water resources in Hotan has fluctuated and declined, the intensity of water resources development and utilization has increased [33, 34], the water environment has deteriorated, the social and economic benefits of water resources have improved, and the local conditions of water resources in the region have improved , so it is urgent to strengthen the protection of water resources in the region for sustainable development of water resources in the region.

Conclusion

On the basis of constructing the index system of sustainable water resources utilization in Hotan area, this paper analyzes the evolution characteristics and main obstacle factors of sustainable water resources utilization in Hotan area by using the entropy-weighted TOPSIS model and the obstacle degree diagnosis model. The conclusions of this paper are as follows:

(1) The comprehensive weights of each evaluation index in Hotan were determined based on entropy weighting and random weighting.

(2) From 2000 to 2020, the sustainable utilization of water resources in Hotan region showed an overall upward trend, and its development tended to be stable.

(3) The main obstacles to the sustainable use of water resources in Wada area were different at different time periods. Overall, the rate of evaporation change (X5) and the rate of vegetation area change (X6) are the main obstacles to the sustainable utilization of water resources. Water yield coefficient (X1) and vegetation area change rate (X6) are gradually becoming the main obstacle factors.

Acknowledgments

The authors sincerely thank all anonymous reviewers who provided detailed and valuable comments or suggestions to improve this manuscript.

Conflict of Interest

The authors declare no conflict of interest.

References

1. MENHUI B.W., MINGMING L., CANJUN L HUANLONG. Evaluation on sustainable utilization of water resources in Beijing City based on knowledgegranularity and attribute importance. Yangtze River. **54** (5), 47-52+60, **2023**.
2. COCKLIN C., BLUNDEN G. Sustainability, water resources and regulation. Geoforum. **29** (1), 51-68, **1998**.
3. HERMANOWICZ S.W. Sustainability in water resources management: changes in meaning and perception. Sustainability Science. **3** (2), 181, **2008**.

4. RONG G.L., YINI Y., FENG Z., YONG. Assessment of sustainable utilization level of water resources in HenanProvince based on a three-dimensional water footprint model. Journal of Water and Water Engineering. **34** (1), 30, **2023**.
5. PETERSON H.M., NIEBER J.L., KANIVETSKY R., SHMAGIN B. Water Resources Sustainability Indicator: Application of the Watershed Characteristics Approach. Water Resources Management. **27** (5), 1221, **2013**.
6. YOUGUANG L., YULIANG Y., ZHUOCHENG L., XI G. Evaluation of Sustainable Utilization of Water Resources in Henan Province Based on Spatia.Temporal Variation of Energy Water Ecological Footprint. Yellow River, **44** (6), 100-104+162, **2022**.
7. KAZAPOE R.W., ADDAI M.O., AMUAH E.E.Y., DANKWA P. Hydrogeochemical characterization of groundwater in the Wassa Amenfi East and Prestea-Huni Valley areas of southern Ghana using GIS-based and multivariate statistical techniques. Sustainable Water Resources Management, **9** (5), **2023**.
8. LI GUOYING Chaired a ministerial meeting of the Ministry of Water Resources to study the assessment of the implementation of the strictest water resources management system at the end of the 13th Five-Year Plan to review the guidance on strengthening the supervision of the water conservancy industry. China Water Resource, **920** (14), 6, **2021**.
9. LONG T. Some reflections on the assessment of implementing the strictest water resources management system in Xinjiang. Inner Mongolia Water Resources, **202** (6), 42, **2019**.
10. BO L. Analysis on the supervision mechanism of the strictest water resources management system in Xinjiang. Water Resources Planning and Design, **156** (10), 1-3+16, **2016**.
11. SALAZAR D., ESCOBAR M., YATES D., ALJANAHI M.Y. , ALQATTAN A.K. Advancing water sustainability in Bahrain through water resource management knowledge platforms. Desalination and Water Treatment, **263**, 265, **2022**.
12. CHENGJUN Y. Research on optimal allocation of water resources in Hotan area. Ground Water, **45** (1), 225, **2023**.
13. LILI Z., XIAOYA D., AIHUA L., HAIFENG G., CAI R., ZHIYUN L. Spatial-temporal assessment of water resource security based on theagricultural water footprint: A case in the Hotan Prefecture of Xinjiang. Arid Zone Research, **39** (2), 436, **2022**.
14. QIONG S. Thinking about the success of poverty alleviation in southern Xinjiang and the continuation of rural revitalization – taking Hotan as an example. Shanxi Agricultural Economy, **314** (2), 93, **2022**.
15. WANYUN L., MINGQIAN R., FUBO W., XUE H., HUI S. Multidimensional identifcation of relative povertvy in arid regions:An analvsis from the perspective of sustainable ivelihoods. Journal of Arid Land Resources and Environment, **36** (6), 15, **2022**.
16. WENWEN S., JINLONG Z., YANYAN Z., YING S. Distribution characteristics and formation of fluorinein groundwater inHotan Prefecture. Arid Zone Research, **39** (1), 155, **2022**.
17. ZHANG Y., LONG A., LV T., DENG X., WANG Y., PANG N., LAI X., GU X. Trends, Cycles, and Spatial Distribution of the Precipitation, Potential Evapotranspiration and Aridity Index in Xinjiang, China. Water, **15** (1), 62, **2023**.
18. GU X., ZHANG P., ZHANG W., LIU Y., JIANG P., WANG S., LAI X., LONG A. A Study of Drought and Flood Cycles in Xinyang, China, Using the Wavelet Transform and M-K Test. Atmosphere, **14** (8), 1196, **2023**.
19. NA W., ZHAO Z.C. The comprehensive evaluation method of low-carbon campus based on analytic hierarchy process and weights of entropy. Environment Development and Sustainability, **23** (6), 9308, **2021**.
20. WANG S., LAI X., GU X. Analysis of Spatial and Temporal Evolution Characteristics and Influencing Factors of the Water Footprint in Xinjiang from 2000 to 2020. Systems, **11** (7), 349, **2023**.
21. WEI J., QINGZHENG X., JINHUAN S., YONG H., JINGJING X., BOWEN Z., DONGDONG Y. Prediction of asphalt pavement performance based on entropyweighted grey Markov method. China Sciencepaper, **17** (6), 595, **2022**.
22. LI Y.G., SUN M.H., YUAN G.H., ZHOU Q., LIU J.Y. Study on Development Sustainability of Atmospheric Environment in Northeast China by Rough Set and Entropy Weight Method. Sustainability, **11** (14), **2019**.
23. JIN Y., ZHONGWEI W., YAN P. Performance evaluation of camellia industry development based on entropy TOPSIS method. Journal of Central South University of Forestry & Technology, **41** (12), 168, **2021**.
24. UNVAN Y.A. Financial Performance Analysis of Banks with Topsis and Fuzzy Topsis Approaches. Gazi University Journal of Science, **33** (4), 904, **2020**.
25. LI Z., HU Y., LIU Q., LIU S. Early Warning Evaluation and Simulation Analysis of Resources and Environmental Carrying Capacity in Inland Arid Regions:An Empirical Analysis from Ningxia. Ecological Economy, **37** (11), 209-215+229, **2021**.
26. YAN L., QINGQING Z., XINFENG Z., XINGHONG L., HAILIANG X., AILI A. Dynamics of natural vegetation on the banks of Hetian river in recent 17 years and their driving forces. Journal of Arid Land Resources and Environment, **34** (10), 153, **2020**.
27. YU H., GU X., LIU G., FAN X., ZHAO Q., ZHANG Q. Construction of Regional Ecological Security Patterns Based on Multi-Criteria Decision Making and Circuit Theory. Remote Sensing, **14** (3), 527, **2022**.
28. HAIHUA L., YUE M., ANBEI L., RUQI L. Comparative analysis of on water vapor characteristics of two extreme rainstorms in the north slope of Kunlun Mountains. Arid Land Geography, **45** (3), 715, **2022**.
29. GU X., XIAO S., YANG G., HE X., ZHAO Q., ZHANG L., LI D. Hydrological process simulation of Manas River Basin based on CMADS and SWAT model. Journal of Water Resources and Water Engineering, **32**, 116, **2021**.
30. SUN C.J., CHEN Y.N., LI J., CHEN W., LI X.G. Stable isotope variations in precipitation in the northwesternmost Tibetan Plateau related to various meteorological controlling factors. Atmospheric Research, **227**, 66, **2019**.
31. SUN L.X., YU Y., GAO Y.T., HE J., YU X., MALIK I., WISTUBA M., YU R.D. Remote Sensing Monitoring and Evaluation of the Temporal and Spatial Changes in the Eco-Environment of a Typical Arid Land of the Tarim Basin in Western China. Land, **10** (8), **2021**.

32. GU X., LONG A., LIU G., YU J., WANG H., YANG Y., ZHANG P. Changes in Ecosystem Service Value in the 1 km Lakeshore Zone of Poyang Lake from 1980 to 2020. Land, **10** (9), 951, **2021**.
33. LIU L., XUE J., MAO D.L., CHANG J.J., WANG S.K., LI X.X. An integrative socio-hydrological resilience assessment and management implications for oasis sustainability in arid regions, Northwest China. Journal of Hydrology-Regional Studies, **47**, **2023**.
34. PANG N., DENG X., LONG A., ZHANG L., GU X. Evaluation of the Resilience of the Socio-Hydrological System of the Tarim River Basin in China and Analysis of the Degree of Barriers. Sustainability, **14** (13), 7571, **2022**..