Construction of Evaluation System of Water Resources Environmental Carrying Capacity in Island Tourism based on Frequency Analysis Method

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Abstract: Most evaluation systems don't consider the problem of evaluation index selection, so the evaluation delay increases, and the evaluation results are not ideal, in order to solve the above problems effectively, a system to evaluate the water resources environmental carrying capacity in island tourism based on frequency analysis method is proposed and constructed. Through the study of the concept and connotation of water resources environmental carrying capacity in island tourism, combined with the system analysis theory, the principle of comprehensive evaluation indicator selection is established; the basic indicators are screened by frequency analysis method, and the evaluation system of water resources environmental carrying capacity in island tourism is established. According to the established system, a comprehensive evaluation model is set up to evaluate the environmental carrying capacity of water resources in island tourism. The simulation results show that the proposed system can effectively reduce the delay and improve the accuracy of the results to evaluate the environmental carrying capacity of water resources in island tourism.

Keywords: frequency analysis method; island tourism; water resources; environmental carrying capacity; evaluation system construction

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1. Introduction

Water is not only a kind of precious natural resources, but also a part of the natural environment. It is also one of the material bases and supporting conditions for the sustainable development of human

society. In addition to the indispensable survival needs of human life, water resources have the potential capacity to support social and economic development to a greater extent. In other words, water resources not only have the carrying capacity of population, but also have the carrying capacity of economy (including industrial development scale and agricultural irrigation scale). With the development of population, industrialization and urbanization, the problems of environmental pollution and resource shortage have become increasingly prominent [1]. The core problem of sustainable development of human society is how to control human activities within the tolerance of resources, environment and ecology. Therefore, the concept of carrying capacity has been gradually accepted and applied to relevant aspects, and the research on water resources carrying capacity has emerged as the times require.

Water resources carrying capacity is an important part of natural resources carrying capacity [2], and it is a "bottleneck" indicator whether the water resources shortage areas can support the coordinated development of population, economy and environment. The research on water resources carrying capacity is of great significance to the ecological environment protection and sustainable utilization of water resources in national economic development planning. As a basic subject of sustainable development research and sustainable utilization of water resources, the research on water resources carrying capacity has attracted great attention of academic circles, and has become an important and hot research issue in current water resources science. For example, Lu Qing et al. [3] constructed an evaluation system of regional environmental carrying capacity by using “Cannikin Law” based on the sub-systems of land resources, water resources, water environment, atmospheric environment and so on. Based on the DPSIR model system framework, Liu Zhiming et al. [4] constructed the carrying capacity evaluation indicator system of the "Water resources- Social economy-Ecological environment" composite system; determined the weight of each evaluation indicator by using AHP method; proposed the Logistic logarithm bearing model based on the Logistic logarithmic growth equation; and at the same time, introduced the comprehensive indicator of sustainable development to judge the sustainable development of social economy and the benign development conditions of social economy and ecological environment. Finally, the carrying capacity of water resources and the level of sustainable development were comprehensively evaluated. Jia Zimu et al. [5] divided the sub units according to the national control unit, and carried out the zoning research of water environment carrying capacity from three aspects: carrying state of water environment, vulnerability of water system and development and utilization potential of water environmental carrying capacity, on the basis of comprehensive evaluation of water environmental carrying capacity based on catastrophe progression method.

Although the above methods have

achieved satisfactory research results at this stage, the evaluation delay is increased and the accuracy of evaluation results is reduced due to the failure to consider the selection of evaluation indicators. Therefore, this paper designs and proposes an evaluation system of water resources environmental carrying capacity in island tourism based on frequency analysis method. Simulation results show that the proposed system can improve the accuracy of evaluation results and effectively reduce the evaluation delay.

2. Construction of evaluation system for water resources environmental carrying capacity in island tourism based on frequency analysis method

2.1 Construction principles of evaluation indicator system

Through the analysis of the original data, the indicators can help people to judge and understand the degree of change of something or phenomenon with time. Indicator system refers to the set of measurable parameters describing and evaluating something. The establishment of a complete set of evaluation indicator system can objectively and accurately reflect the water resources and environmental carrying capacity of tourism areas. The indicator system of water resources environmental carrying capacity of tourism is the basis for the study of water resources environmental carrying capacity of tourism, and also the main basis for tourism environmental management. It is an organic whole composed of a series of independent indicator factors which complement and restrict each other. It is a kind of quantitative form to express the environmental carrying capacity of tourism water resources.

The water resources and environment of island tourism is a complex and comprehensive system [6-7], which involves a wide range of indicators. Due to the large number of islands in China, the geographical environment and natural conditions of different regions are different. In order to select the evaluation indicator of tourism water resources environmental carrying capacity of islands, we should refer to some common characteristics of islands. When we use the research area, we should also take into account the significant characteristics of each region. At the same time, combined with the theory of system analysis, on the basis of screening and adjusting the indicators, we should establish a suitable for the region. The establishment of the indicator system of environmental carrying capacity of tourism water resources should follow the following basic principles:

(1) Scientific principle:

The evaluation indicator system of environmental carrying capacity of tourism water resources should be established on the basis of science. The selected evaluation indicators should have clear meaning, keep high dynamic consistency with the tourism water resources and environment system [8], accurately grasp the connotation of the research object, and reflect the essential characteristics of things scientifically and objectively.

(2) Systematic principle:

The environmental carrying capacity system of tourism water resources covers a wide range of fields, which involves many

aspects such as nature, environment, society, etc. Therefore, it is necessary to conduct a comprehensive analysis on their structure, level and interaction. In order to comprehensively reflect the comprehensive level of environmental carrying capacity of tourism water resources, the evaluation system should be composed of different levels and different subsystems [9].

(3) Principle of representativeness:

There are differences in the connotation of water resources in each subsystem. The selection of indicators should fully reflect the characteristics of a thing, that is, not to generalize the whole, but to highlight the impact of the main factors. Therefore, in the selection of indicators, selecting some representative important indicators according to the research object, and truly reflect the objective attributes of specific research objects.

(4) Operability principle:

The establishment of indicator system should combine simplicity and complexity, and fully consider the difficulty of quantifiable indicators and the availability of data. At the same time, the practical, easy to operate and feasible evaluation indicators should be selected according to the available data [10].

(5) The combination of qualitative and quantitative principles:

Indicator selection should consider quantifiable indicators as far as possible, such indicators can usually accurately reflect the state and change degree of things with numbers; things that are difficult to quantify can use qualitative indicators, which usually reflect the state and change degree of things in words.

2.2 Construction of evaluation system for water resources environmental carrying capacity in island tourism

According to the characteristics of complexity and comprehensiveness of tourism water resources and environment system, the environmental carrying capacity of tourism water resources from different levels should be studied, and analyze the comprehensive carrying capacity of tourism destinations on the basis of in-depth study of single carrying capacity. On the basis of ecology, environmental science and sustainable development theory, focusing on the protection of island water resources and environment [11-12], and according to the analytic hierarchy process (AHP), the evaluation indicator system of island tourism environmental carrying capacity with corresponding levels is constructed from three aspects of nature, economy and society. Its structure is shown in Figure 1.

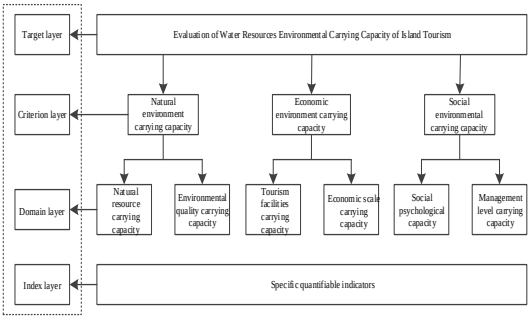


Figure 1 Evaluation system structure of water resources environmental carrying capacity in island tourism

When using analytic hierarchy process (AHP) to establish the hierarchical structure model, it is necessary to form different levels of various influencing

factors according to the relationship of mutual correlation and subordination. The factors of the same level play a dominant role in the factors of the next level, and at the same time, they are dominated by the factors of the upper level. The following hierarchical structure chart is divided into four layers, namely target layer, criterion layer, domain layer and indicator layer.

(1) Target layer:

The goal layer represents the general goal of the research problem, which contains only one factor. The target layer of the indicator system is the environmental carrying capacity of water resources in island tourism.

(2) Criterion layer:

The criterion layer is the intermediate link involved in the realization of the target, and it is the next sub objective layer of the target level control [13]. The criterion layer consists of three components, which are

① Carrying capacity of natural environment;

②Carrying capacity of economic environment;

③Carrying capacity of social environment.

The difference of water carrying capacity of islands is the symbol of their internal tourism capacity.

(3) Domain level:

Domain level is the further decomposition and description of the criteria in the criterion level. Each criterion includes a series of subsystems, and each subsystem can be composed of different domains. This paper establishes six areas, namely, natural resources carrying capacity, environmental quality carrying capacity, tourism facilities carrying capacity, economic scale carrying capacity, social psychological carrying capacity and management level carrying capacity.

(4) Indicator layer:

The indicator layer is a quantitative factor that can be dynamically controlled in real time. It uses a series of statistical and quantitative indicators to reflect the requirements of the domain level and evaluate whether the system can achieve the final goal. Each domain can be represented by a certain number of indicators, and quantifiable data should be used as far as possible to reflect the specific indicators of attributes.

The research on the environmental carrying capacity of water resources in island tourism is based on the establishment of an evaluation indicator system. The scientific rationality of the indicator system is directly related to the accuracy of the evaluation results of the water resources environmental carrying capacity in island tourism. While constructing the evaluation index in accordance with the above basic principles, it is necessary to select the evaluation index according to the actual situation and determine the research method, so as to accurately and comprehensively describe and evaluate the island tourism environment carrying capacity.

The selection of indicators can mainly adopt theoretical analysis method, frequency analysis method, expert consultation method and so on. Frequency analysis method is mainly through the analysis of the theoretical concept of tourism environmental carrying capacity,

its basic meaning, characteristics, elements and other issues of comprehensive comparative analysis to select targeted indicators for research issues; frequency statistics method mainly extracts the relevant evaluation indicator system from the existing research results for statistical analysis, and selects the indicators with higher use frequency from the existing research results [14-15]. Expert survey method is to collect the experience and opinions of experts through multiple rounds of anonymous surveys, and get more accurate evaluation indicators through continuous feedback and modification; expert consultation method is to consult relevant experts and adjust the indicators on the basis of preliminary evaluation indicators. This study comprehensively uses the above-mentioned evaluation indicator system.

By referring to the research literature on the evaluation index of island tourism, ecological tourism and environmental carrying capacity, the index with high frequency in the literature was selected. According to the construction principle of evaluation index, based on the characteristics of the island tourism water resource environment system and the problems existing in the island tourism development at present, 60 indexes are selected on the basis of consulting experts

Due to the large number of initially selected indicators and the overlapping of the meanings of the indicators, it is necessary to further reorganize the indicators to exclude the relevant indicators. The primary indicators were made into consultation representations, and the opinions of operators, managers, experts and professors of island tourism scenic spots were asked to score the importance of the primary indicators with a 5-point system, and put forward suggestions and suggestions for modification. According to the experts' selection of the indicator importance degree, the indicator category is classified and optimized [16], and finally the evaluation index system of environmental carrying capacity of island tourism composed of 30 indexes is formed.

The environmental carrying capacity of water resources in tourism environment is a comprehensive concept, which is determined by different component carrying capacity indicators. Each evaluation indicator reflects the impact of human tourism activities on the tourism environment system from different aspects. Therefore, the selected indicators should reflect whether the natural resources in the tourism environment system are reasonably used, whether the ecosystem is benign development, whether the economic system is operating efficiently, and whether the social system is healthy and safe.

(1) Carrying capacity of natural environment:

A good natural ecological environment is the basic material condition for the development of tourism. The natural environment itself has a certain capacity to absorb pollutants, such as air, water, soil and so on. However, this ability is limited. If it exceeds a certain limit, it will inevitably lead to a significant decline in environmental quality. The overload of

tourism economic activities causes environmental pollution and ecological damage. Therefore, the intensity of self-purification determines the ability of tourism natural environment to withstand pollution damage. The carrying capacity of natural environment refers to the intensity that the natural environment can bear the effect of human tourism activities under the premise of keeping the internal system in normal operation. The elements restricting tourism activities in the natural environment can be divided into tangible and intangible. The carrying capacity of natural environment can also be divided into the corresponding hard resource carrying capacity and soft resource carrying capacity. The hard resource refers to the tangible physical resource [17], while the soft resource refers to the intangible quality resource. The natural environment carrying capacity can be divided into the natural resource carrying capacity and the environmental quality carrying capacity.

① Carrying capacity of natural resources:

Natural resources are the material basis of tourism development, and its ability to meet the needs of human social and economic development is limited. The carrying capacity of natural resources refers to the supporting capacity of natural element resources (such as land resources, water resources, biological resources, energy resources, etc.) to people's tourism economic activities under certain socio-economic and technological conditions. The carrying capacity of natural resources depends on the quantity, types and utilization of resources.

②Carrying capacity of environmental quality:

Environmental quality carrying capacity refers to the restriction degree of environmental quality of tourist destination on tourism activities under the premise of maintaining ecological virtuous cycle and sustainable development under specific spatial conditions. The main factors affecting the environmental quality of tourist destinations include air quality, water quality, environmental noise, natural disasters, etc. The carrying capacity of environmental quality depends on the mode of human production and environmental quality standards to a great extent. It is an effective way to improve the carrying capacity of environmental quality by controlling the way of people's production activities.

(2) Economic and environmental carrying capacity:

The economic environment of a tourist destination is the fundamental guarantee for the development of tourism, which directly determines the income and cost of tourism activities. A mature and perfect economic structure can better cope with various changes in the tourism environment, so as to improve the carrying capacity of tourist destinations for tourism activities, and help to maximize the income and minimize the cost of tourism activities. The carrying capacity of economic environment refers to the intensity of tourism activities that the economic development level of a tourist destination can bear in a certain period of time [18]. It mainly includes the carrying capacity of

tourism facilities and economic scale.

①Carrying capacity of tourism facilities:

The carrying capacity of tourism facilities includes tourism infrastructure and tourism service facilities. The carrying capacity of tourism infrastructure mainly involves the capacity of power supply, water supply and gas supply as well as the supply capacity of communication facilities; the carrying capacity of tourism service facilities is the reception capacity of tourism service industry in accommodation, catering, transportation, shopping, culture and entertainment. The improvement of infrastructure and service facilities directly affects the quality of tourism services, the satisfaction of tourists and the accessibility of tourist destinations.

② Carrying capacity of economic scale:

The carrying capacity of economic scale refers to the limited intensity of the social and economic development degree of a tourist destination on tourism activities in a certain region. The direct factors related to the economic development conditions of tourist destinations include investment in tourism projects, tourism output, GDP level of tourist destinations, proportion of tourism industry, driving coefficient of tourism industry, etc.

(3) Carrying capacity of social environment:

The social environment of a tourist destination mainly refers to its customs and culture, residents' attitude towards tourism, tourist satisfaction, the management level of tourist destination and the perfection of policies and laws. The carrying capacity of social environment refers to the maximum intensity of tourism activities that the tourist destination can bear before the occurrence of unacceptable negative social impact. It includes the carrying capacity of social psychology and the level of tourism management.

① Social psychological carrying capacity:

Social psychological carrying capacity can be divided into tourist psychological carrying capacity and local residents' psychological carrying capacity. Tourist psychological carrying capacity refers to the development intensity that a certain area maintains a certain level for tourists to use in a certain period of time without damaging the environment or affecting the tourists' recreation experience. It is mainly determined by the tourists' social and cultural background (such as age, gender, race, socio-economic status, educational background, etc.) and the tourists' sensory satisfaction; the psychological carrying capacity of the residents in the tourist destination refers to the maximum degree of tourism development acceptable to the residents of the tourist destination for the environmental and lifestyle changes caused by tourism activities. It is determined by the main characteristics of the residents (such as age, gender, education level, income) and the close degree of residents' participation in tourism. It is difficult to calculate the social psychological carrying capacity by quantitative method in practice [19-20], so it can be obtained through questionnaire survey and on-the-spot interview.

② Carrying capacity of management

level:

The carrying capacity of management level refers to the ability of a tourist destination to achieve the goal of tourism economic development by its management level. If the intensity of tourism activities exceeds the capacity of tourist destination management, it leads to chaos in the tourism system and directly affect the environmental, economic and social benefits of tourism. The level of management is closely related to the socio-economic factors and management methods of the tourist destination, which is mainly reflected in whether the management system, methods and objectives are consistent with the actual development level of the tourist destination.

According to the principle of indicator construction, 30 specific statistical and monitoring indicators are selected from six subsystems to form a scientific and reasonable evaluation indicator system. Some of the indicators can be directly obtained from the statistical yearbook of the island area over the years, while some indicators can only be obtained through calculation or questionnaire. The specific meaning and calculation of indicators at each level are briefly explained here.

(1) Plant coverage rate:

Plant coverage rate is an indicator reflecting the richness and Greening Status of existing vegetation in tourist areas. Plant coverage rate = vegetation coverage area / total land area × 100%.

(2) Biodiversity indicator:

The biodiversity indicator mainly reflects the overall diversity and variability of the ecosystem. It refers to the proportion of the number of species within the ecosystem to the total number of species in the whole region. The higher the biodiversity indicator is, the more stable the ecosystem of a tourist destination is, and the greater the intensity of tourism activities it can bear [21]. The following mainly uses the marine biological species in the island area as the specific indicators to measure the species of biological species.

(3) Water resources utilization efficiency:

Water resources utilization efficiency is a measure indicator reflecting the degree of water resources development and utilization. Water resources utilization efficiency = water consumption of tourism area / total water resources × 100%.

(4) Tourism land use intensity:

Tourism land use intensity is an indicator reflecting the scale and space of tourism activities. Tourism land use intensity = tourism development and construction land / residential land area. Specific data can be obtained through the statistical data of tourism administration.

(5) Ratio of available time to the whole year:

The ratio of available time to the whole year refers to the ratio between the number of days suitable for tourism and the total number of days in the whole year.

(6) Air quality:

Air quality is an indicator to reflect the air pollution of tourist destinations. According to the national ambient air quality standard (GB3095-1996), the environmental air quality evaluation standard of tourist area can be obtained.

(7) Water quality:

Water quality mainly reflects the situation of water pollution. The surface water quality can be obtained according to the requirements of China's surface water environmental quality standard (GHZBI-1999-1999).

(8) Noise environmental quality:

Noise environmental quality is the main indicator to measure the noise pollution of tourist destinations, which can be obtained by the environmental noise standard of urban region (GB3096-1996).

(9) Land pollution indicator:

Land pollution indicator (LPI) is a quality parameter of soil environment, which mainly represents the degree of soil environmental pollution or the grade of soil environmental quality.

(10) Frequency of natural disasters:

The frequency of natural disasters refers to the number of events that cause casualties and human social property losses due to natural events or forces.

(11) Treatment rate of solid waste:

The treatment rate of solid waste mainly reflects the capacity of the tourist destination to treat the solid waste generated by tourists in the process of tourism activities.

(12) Water supply capacity:

The water supply capacity mainly reflects the supply capacity of water resources in tourist destinations, and the main indicators include annual total water supply and per capita water supply.

(13) Carrying capacity of vehicles:

The carrying capacity of vehicles mainly measures the traffic condition of tourist underpass and the types and quantity of vehicles. It is mainly determined by the road grade, the number of tourist cars and boats and the number of flights.

(14) Reception capacity of catering institutions:

The reception capacity of catering institutions mainly measures the ability of a tourist destination to receive tourists' daily diet, which can be reflected by the number of catering institutions and service personnel and the quality of food hygiene in the island tourism area.

(15) Reception capacity of accommodation institutions:

The reception capacity of accommodation institutions mainly measures the capacity of the tourist destination to provide accommodation for tourists, which can be determined by the number of hotels, total number of beds and facilities and equipment in the region.

(16) Reception capacity of shopping institutions:

The reception capacity of shopping institutions is an indicator reflecting the purchasing ability of tourist destinations [22].

(17) Reception capacity of medical facilities:

Medical and health conditions are used as indicators to reflect the status of service facilities in tourist destinations. It is measured according to the number and level of medical institutions.

(18) Island per capita GDP:

The per capita GDP of islands is an indicator to measure the economic development of island areas, and its data may be obtained from the statistical data of tourism administration.

(19) Growth rate of island GDP:

The growth rate of island GDP is an indicator to measure the level of island economic development. Data from the Bureau of statistics are mainly used.

(20) Proportion of tourism revenue in GDP:

The proportion of tourism income in GDP mainly reflects the development level and status of tourism in national production. The proportion of tourism income in GDP= total tourism income / GDP × 100%.

(21) Input-output ratio of tourism industry:

The input-output ratio of tourism industry is an indicator reflecting the level of tourism benefit.

(22) Ratio of tourists to local residents:

The ratio of tourists to local residents mainly reflects the number of tourists that local residents can bear. The higher the ratio of tourists to local residents is, the greater the impact on local social culture is. Ratio of tourists to local residents = total number of tourists / total number of local residents × 100%.

(23) Density of visitors per unit area:

Tourist density per unit area is an indicator to measure the psychological satisfaction of tourists, which directly affects the quality of tourists in the tourist destination. The higher the density of visitors per unit area is, the lower the psychological satisfaction of tourists is, otherwise, it will improve the psychological satisfaction of tourists.

(24) Access convenience:

Access convenience is an indicator used to reflect the connectivity between tourist destinations and the outside world. It is mainly determined by the traffic routes and the use of vehicles in the tourism area.

(25) Sensory satisfaction of tourists:

Sensory satisfaction of tourists is an important indicator to measure tourists' psychological satisfaction, which can be obtained through tourist satisfaction survey.

(26) Degree of community residents' participation

The degree of community residents' participation reflects the degree of local residents' participation in tourism activities. The degree of community residents' participation = the number of residents participating in tourism activities / the total number of local residents × 100%.

(27) Tourism complaints rate:

Tourism complaint rate is an indicator reflecting the level of tourism management or tourists' satisfaction with the service quality of tourist areas. The lower the complaint rate of tourists is, the higher the management level of tourism is.

(28) The average education level of tourism employees:

The average education level of tourism practitioners is an indicator to reflect the cultural quality of local residents. The indicator value can be obtained by weighting and quantifying the population with different educational background.

(29) Proportion of investment in environmental protection construction:

The proportion of investment in environmental protection construction mainly reflects the importance of tourism destinations to environmental protection. Investment ratio of environmental protection construction = financial investment of environmental protection /

GDP × 100%. (1)

(30) The government's policy support for tourist destinations

The government's policy support to the tourism destination is a token of the importance and support of the local tourism industry, which can be obtained through the comprehensive analysis of the statistical data of the Tourism Bureau.

3. Evaluation method for water resources environmental carrying capacity of island tourism

At present, the evaluation method of water resources carrying capacity is still in the exploratory stage, and there are often large differences in the actual evaluation results. On the one hand, the regional water resources carrying capacity system is a dynamic system composed of water resources, social economy and ecological environment, and its complexity determines the difficulty of comprehensive evaluation. On the other hand, it is due to the different principles and research emphasis of various evaluation methods.

The criterion layer indicator judgment matrix is established by frequency analysis method, and the eigenvector corresponding to the maximum eigenvalue is solved by MATLAB software. The specific expression forms are as follows[23]:

$$A_{\text{Criterion layer}} = \begin{bmatrix} 1,2,2,2,2 \\ \frac{1}{2},1,1,1,1 \\ \frac{1}{2},1,1,1,1 \\ \frac{1}{2},1,1,1,1 \\ \frac{1}{2},1,1,1,1 \end{bmatrix}$$

All eigenvalues of matrix A are solved to form diagonal matrix

$$V = \begin{bmatrix} -0.9701, 0.7071, 0.0000, 0.0000, 0.0000 \\ 0.1213, 0.3536, 0.8660, -0.0000, -0.0000 \\ 0.1213, 0.3536, -0.2887, 0.7887, -0.2113 \\ 0.1213, 0.3536, -0.2887, -0.2113, 0.7887 \end{bmatrix}$$

(2)

The eigenvectors corresponding to the maximum eigenvalue $\lambda = 5$ are as follows:

$$\omega = (0.7071, 0.3536, 0.3536, 0.3536, 0.3536)^T$$

(3)

After normalization, the weight vector is obtained, that is

$$\omega = (0.7071, 0.167, 0.167, 0.167, 0.167)^T$$

(4)

According to the weight of each subsystem and the basic indicator weight, the comprehensive evaluation indicator weight of regional water resources carrying capacity is finally established.

According to the above-mentioned comprehensive evaluation indicator system, the indicator layer indicators are divided into two types: positive indicators and reverse indicators. The higher the score value, the better is the positive indicator, and the smaller the better, the reverse indicator. In order to reflect the carrying capacity of water resources in island tourism more accurately and objectively, referring to the international and national recognized standards and the national development plan, the indicator evaluation standard is divided into five levels: I, II, III, IV and V, and the corresponding score range is obtained.

Let y be the indicator score value and x be the actual value of the indicator [24-25], and the calculation method of each indicator score is designed as follows:

(1) The level I indicator:

$$y=\begin{cases}1, when\ x(positive)\le a_1\\ 1, when\ x(positive)\ge a_1\end{cases} \tag{5}$$

(2) The level II indicator:

$$y=\begin{cases}1+\left(\dfrac{x-a_1}{a_2-a_1}\right), x \text{ is a forward indicator}\\ 1+\left(\dfrac{a_1-x}{a_1-a_2}\right), x \text{ is a reverse indicator}\end{cases} \tag{6}$$

(3) The level III indicator:

$$y=\begin{cases}2+\left(\dfrac{x-a_1}{a_2-a_1}\right), x \text{ is a forward indicator}\\ 2+\left(\dfrac{a_1-x}{a_1-a_2}\right), x \text{ is a reverse indicator}\end{cases} \tag{7}$$

(4) The level IV indicator:

$$y=\begin{cases}3+\left(\dfrac{x-a_1}{a_2-a_1}\right), x \text{ is a forward indicator}\\ 3+\left(\dfrac{a_1-x}{a_1-a_2}\right), x \text{ is a reverse indicator}\end{cases} \tag{8}$$

(5) The level V indicator:

$$y=\begin{cases}4, when\ \ x(positive)\ge a_1\\ 4, when\ \ x(positive)\le a_1\end{cases} \tag{9}$$

According to formula (5) ~ (9), the score value y of each indicator such as water resources is calculated. The calculation formula of the score value q and comprehensive evaluation value p of each subsystem is as follows:

$$q_i=y_{i1}w_{i1}+y_{i2}w_{i2}+y_{i3}w_{i3} \tag{10}$$

$$p=q_1w_1+q_2w_2+\mathrm{L}\ q_iw_i \tag{11}$$

In the formula, i represents the standard serial number of quasi lateral layer; y represents the score value of indicator layer; w represents the weight of indicator layer; w_i represents the weight of criterion layer.

The full bearing state indicates that the carrying capacity of water resources in island tourism can well support the regional development and realize the sustainable utilization of water resources; the bearable state indicates that the carrying capacity of water resources in island tourism adapts to the regional development and presents a coordinated development trend; the light overload state indicates that the carrying capacity of water resources in island tourism can no longer bear the regional development, but it is overloaded. The results show that the carrying capacity of water resources in island tourism cannot support the sustainable development of the region, which has become the "bottleneck" of regional development, and the serious overload state shows that the regional development has completely exceeded the carrying range of water resources in island tourism and entered into a vicious circle.

The comprehensive score p calculated by the above comprehensive evaluation model can accurately and objectively reflect the size and status of regional water resources carrying capacity; according to the score q of each indicator in the criterion layer, the influence of each subsystem on the regional water resources carrying capacity can be analyzed from a macro perspective, so as to point out the direction for improving the regional water resources carrying capacity; and according to the index score y of each index layer, the limiting factors of regional water resources carrying capacity can be analyzed, so as to provide scientific basis for formulating regional water resources development and utilization policies.

4. Simulation experiment

In order to verify the comprehensive effectiveness of the evaluation system of water resources environmental carrying capacity in island tourism based on frequency analysis method, the island tourism city G is set as the research object, which is composed of 32 islands of different sizes.

(1) Geomorphic features:

The island tourism city G has the typical geomorphic characteristics of bedrock Island, that is, the terrain is steep, the fluctuation is large, the loose accumulation is not developed, the bedrock exposed or thin soil accounts for a large proportion of the island area. The main geomorphic type of City G is with low altitude, 50 ~ 200m. Due to the development of geological structure and strong marine erosion, this is mainly manifested in the coastal geomorphic types of each island. Various marine erosion landforms and related deposits formed are relatively complete and typical. Many coastal zones form sea erosion caves, and cliffs are strongly eroded by sea water. Loess slope, loess gully and loess platform can be seen in most of the islands, and the coastal low-lying areas are mostly marine plain.

(2) Climate features:

The island tourism city G is located in the East Asia warm temperate monsoon area, with marine climate in summer and continental climate in winter half year. Due to the influence of the alternating action of cold and warm air and the temperature regulation of sea water, there is less severe heat in summer and less severe cold in winter, and the temperature change is mild, which is characterized by warm winter and cool summer. The air of City G is fresh and the content of negative oxygen ion is much higher than that of city, so it belongs to the tourism climate advantage area. The annual average temperature of Changdao is between 11.0 ℃ and - 12.0 ℃, the annual average maximum temperature is 14.3 ℃~ 15.3 ℃, and the minimum temperature is 8.6 ℃ ~ 9.20 ℃. The average annual exposure time of City G is 2674 ~ 2771h, and the annual average percentage is 60 ~ 62%.

In the above experimental environment, the simulation test is carried out, and the experiment is divided into two stages. The first step is to compare the evaluation delay of water resources

environmental carrying capacity in island tourism by different evaluation system; the second step is to compare the evaluation accuracy of different evaluation systems, and set the evaluation deviation and average error as evaluation indicators. The following are the specific experimental results:

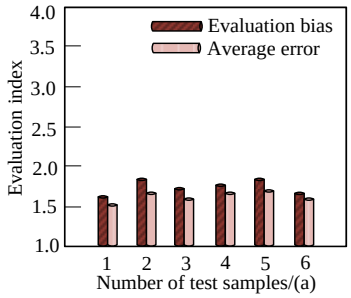
(1) Table 1 shows the time delay comparison results of four different evaluation systems of water resources environmental carrying capacity in island tourism.

Table 1 Delay comparison results of water resources environmental carrying capacity in island tourism evaluation of different evaluation systems

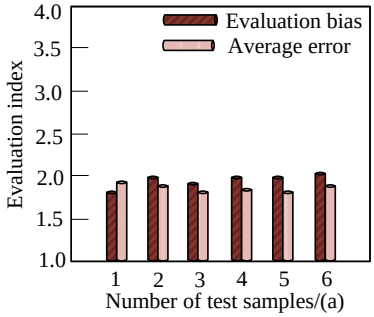
Number of experiments / (Times)	Evaluation delay of water resources environmental carrying capacity of island tourism / (ms)			
	The proposed evaluation system	The evaluation system in reference [3]	The evaluation system in reference [4]	The evaluation system in reference [5]
10	10	12	14	15
20	11	13	16	18
30	13	16	18	21
40	14	18	22	25
50	16	21	26	27
60	17	23	28	30
70	19	25	31	33
80	21	27	34	36
90	23	30	37	38

Analysis of the experimental data in Table 1 shows that with the continuous increase of experimental tests, the evaluation delay of water resources environmental carrying capacity in island tourism of each evaluation system will also increase. However, the evaluation delay of the whole evaluation system is significantly lower than that of the other three evaluation systems because the basic indicators are screened by the frequency analysis method, which effectively simplifies the operation process.

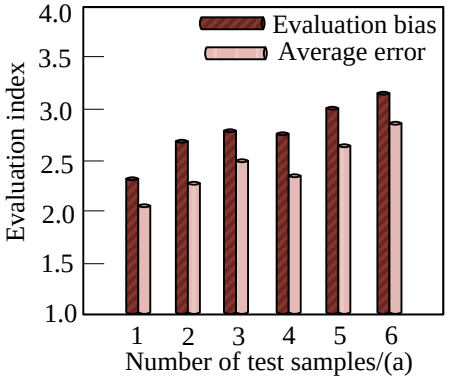
(2) The accuracy comparison results of four different evaluation systems for water resources environmental carrying capacity in island tourism are given, as shown in Figure 2.



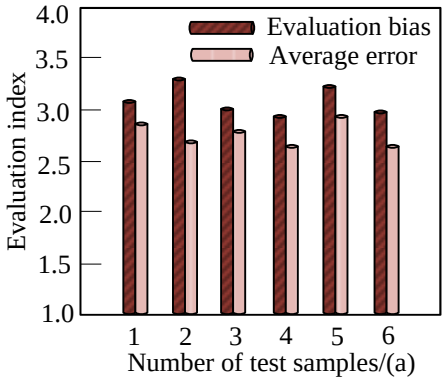
(a) Accuracy of the evaluation results of the proposed system on the water resource environmental carrying capacity in island tourism



(b) Accuracy of evaluation results of water resources environmental carrying capacity in island tourism based on reference [3]



(c) Accuracy of evaluation results of water resources environmental carrying capacity in island tourism based on reference [4]



(d) Accuracy of evaluation results of water resources environmental carrying capacity in island tourism based on reference [5]

Figure 2 Accuracy comparison of evaluation results of water resources environmental carrying capacity in island tourism in different systems

Analysis of the experimental data in Figure 2 shows that the smaller the values of the two test indicators are, the higher the accuracy of the evaluation results is. In the actual operation process, the proposed evaluation system using the frequency analysis method to screen the evaluation indicator and select the valuable evaluation indicator, so as to eliminate the non-use value indicator. On this basis, the evaluation indicator system of water resources environmental carrying capacity in island tourism is built, to improve the accuracy of the evaluation results. Failure to pay attention to the issue of water will cause drought and will have serious effects [26-34]

5. Conclusion

This study designs and puts forward the evaluation system for water resources environmental carrying capacity in island tourism based on frequency analysis

method. The simulation results show that the proposed method can effectively improve the accuracy of the evaluation results and reduce the evaluation delay to evaluate the water resources environmental carrying capacity in island tourism.

However, due to the limitation of time and various factors, the proposed method still has some deficiencies. In the future, we will focus on the following aspects:

(1) According to the established comprehensive evaluation system of water resources carrying capacity, a comprehensive evaluation is carried out for island city G. There is a lack of application research in other typical areas of China, and there is certain uncertainty in whether it has universal applicability, which needs further verification.

(2) The comprehensive evaluation indicator system of water resources carrying capacity is very complex and huge. To build a scientific indicator system needs rich experience accumulation and research, and the rationality and comprehensiveness of the comprehensive evaluation indicator system need to be further improved.

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