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Modelling and analysis of the impact of renewable energy on mitigating ecological pollution of marine environment

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ABSTRACT

In order to study the ecological pollution of marine environment, the modelling analysis of the impact of renewable energy on marine environmental ecological pollution is proposed. The evaluation index of the carrying capacity of renewable energy to alleviate the ecological pollution of the marine environment is established. The weight of the evaluation index of the ecological pollution bearing capacity of the marine environment is calculated by using the analytic hierarchy process, and the sustainable development model is established. The evaluation index is combined with the sustainable development model to complete the research on the impact of renewable energy on the mitigation of marine environmental ecological pollution. Taking a certain sea area as the analysis object, this paper evaluates the ecological pollution carrying capacity of marine environment, and analyse the evaluation results, which has certain practical significance.

Keywords: Renewable energy; Marine environmental ecological pollution; Impact modelling analysis; Evaluation index; Analytic hierarchy process

1. Introduction

Renewable energy refers to the energy that can be continuously regenerated and used in nature. It has the characteristics of inexhaustible and inexhaustible. It mainly includes solar energy, wind energy, water energy, biomass energy, tidal energy, geothermal energy and ocean energy [1]. Renewable energy is harmless to the environment or has little harm, and the resources are widely distributed, so it is suitable for local development and utilization. Compared with the exhausted fossil energy, renewable energy can be recycled in nature [2,3]. Renewable energy belongs to the primary energy in the process of energy development and utilization. Renewable energy does not include fossil fuels and nuclear energy [4,5]. However, the current research on the modelling of the impact of renewable energy on the mitigation of marine environmental ecological pollution is relatively scattered, which is usually focused on a specific problem. Although it involves a wide range of aspects, there is no universally recognized theoretical system. Qualitative research is relatively more, and the discussion of some problems remains in descriptive analysis, while quantitative research is less, lacking empirical (pre and post analysis) research, quasi empirical research and comparative research [6]. Therefore, this paper analyses the impact of renewable energy on marine environmental ecological pollution modelling. This paper mainly designs the overall framework of the marine environmental ecological pollution impact model, designs the model data resource database, and stores all the related information in the same node, which is convenient for big data analysis and management. The ecological footprint method is used to calculate the ecological pollution carrying capacity of marine environment, control the ecological pollution within the scope of automatic recovery of the environment, calculate the environmental ecological footprint of soil environment, water resources environment, biological environment and pollutants, and get the impact modelling of marine environmental ecological pollution mitigation. The results show that the study has a certain reference significance to alleviate the impact of marine environmental ecological pollution.

2. Modelling the impact of renewable energy on marine environmental ecological pollution mitigation

2.1. Establishment of evaluation system for carrying capacity of renewable energy to alleviate ecological pollution of marine environment

The establishment of scientific and reasonable evaluation index system is the key to the study of marine environmental ecological pollution carrying capacity, which is related to the correctness of the evaluation results [7]. In the selection of indicators, we should not only follow the above principles, but also consider the particularity of each principle and the differences in understanding in current research, so as to accurately and comprehensively describe and measure the ecological environment carrying capacity. The frequency analysis method is used to screen the indicators. The frequency analysis method is to carry out frequency statistics on the evaluation research or related research index system of marine environmental ecological pollution carrying capacity, and select the indicators with higher frequency [8]. The preliminary evaluation indexes of ecological pollution carrying capacity of marine environment are shown in Table 1.

Due to the problems of too many indicators, overlapping and repetition between indicators, it is necessary to select or reorganize the indicators to exclude the closely related indicators. In order to fully and accurately describe the characteristics of the system, the evaluation index system of marine environmental ecological pollution is divided into three levels [9]. The first level is decomposed into three criteria, namely natural environment, economic environment and social environment, which is called “criterion layer”, which marks the difference of internal criteria of ecological pollution of marine environment. The second level is the further decomposition of the first level of natural, economic and social criteria. The third level is the index synthesis of the domain level described in the second level, which is the unit and element for scaling, quantification and dynamic real-time control, and also the most effective, direct and lowest level element for measuring the ecological pollution level of the marine environment [10]. Therefore, according to the effect reflected by the indicators and the relationship among the factors in the index system, a hierarchical evaluation index system of marine environmental ecological pollution is constructed.

2.2. Determination of evaluation index weight

Based on the above analysis, analytic hierarchy process (AHP) is used to set the index weight. AHP is a multi-objective decision-making method proposed by American Operational Research Experts in the S. by decomposing complex problems into several levels and several factors, simple comparison and calculation are carried out among various factors, so as to obtain the weight of different scheme importance degree, which provides the selection of the best proportion [11]. This method can be called as a simple method to make decisions on some complicated and fuzzy problems. AHP has the characteristics of combining qualitative and quantitative, which can provide a new, concise and practical modelling method for decision-making and sequencing, and greatly improve the scientificity and applicability of decision-making results [12].

According to the structure of evaluation index system, it is easy to construct the judgment matrix. Each element with downward membership is in the upper left corner as the first element of judgment matrix, and the elements that belong to it are arranged in the first row and the first column. Meanwhile, the two elements are compared to determine the importance [13]. The numbers 1–9 and its reciprocal are used as the scale, as shown in Table 2.

In addition, it should be noted that it is very important to make only two judgments. The comparison of two judgments can provide more information. Through repeated comparison, a reasonable ranking can be derived [14].

According to the criteria, the judgment matrix based on pairwise comparison is constructed, which is usually called judgment matrix for short, as shown in Table 3.

The third is hierarchical single arrangement and consistency test. That is to say, the relative importance of all elements in the same level for a factor at the upper level is ranked in the evaluation order [15]. The commonly used methods include least square method, logarithmic least

Table 1
Evaluation index of ecological pollution carrying capacity of marine environment

Index name	Relevant contents	Index name	Relevant contents
Biodiversity of marine environment	Abundance of marine resources	Types of marine living resources	Diversity of marine landscape
Shore vegetation structure	Marine resources landscape aesthetic degree	Marine climate comfortable period	Marine resources utilization rate
Relationship between ocean and related industries	Air anion concentration	Seawater resource utilization efficiency	Economic development level
Comprehensive water pollution index	Natural disaster rate	Water quality standard rate	Solid waste treatment
Tourism industry policy	Environmental protection awareness of nearby residents	Government investment in marine environmental resources protection	Management system

Table 2
Importance scale of judgment matrix and its meaning

Serial number	Importance scale	Meaning
1	1	Indicator B_i and indicator B_j is equally important
2	3	B_i is more important than B_j
3	5	B_i is evidently more important than B_j
4	7	Index B_i is much more important than B_j
5	9	Index B_i is extremely more important than B_j
6	2, 4, 6, 8	Median value of adjacent judgments
7	Reciprocal	If the comparison between target *i* and target *j* is judged as a_{ij}, then the comparison between target *j* and target *i* is judged as $a_{ji} = 1/a$

Table 3
Judgment matrix

A	B1	B2	B3	C1	C2	C3	C4	C5	C6
B1	1	1/3	1/2	1	2	1	5	3	1
B2	3	1	1	1/2	1	1/5	1	1/3	2
B3	2	1	1	1	1	1/3	3	1	

square method, sum method, root method, geometric average method and characteristic root method. In this paper, the root method is adopted to calculate the weight value of the factor index in the second layer. That is the weight of natural environment, economic environment and social environment on the evaluation system:

$$W = \prod_{j=1}^{n} \left(a_{ij}\right) \frac{1}{n} \tag{1}$$

where W represents the weight value. n denotes the number of columns in judgment matrix.

The fourth is consistency test. In order to ensure the strictness of the value of pairwise comparison of judgment matrices, it is necessary to conduct the consistency test of matrix. The expression is:

$$C = \frac{Q_{\max} - n}{n-1} \tag{2}$$

where $Q_{\max}$ represents the average value of the maximum eigenvalue. C represents the consistency value.

When $C < 0.10$, it was considered that the consistency of judgment matrices was acceptable, otherwise the judgment matrix should be modified appropriately. After the consistency test, the judgment matrix composed of the indexes of each layer in the evaluation index system had complete consistency. Therefore, the judgment matrix has satisfactory consistency and the calculated weight value was credible. On this basis, the weight of the index in the same level was obtained.

3. Results

Based on the calculation of the total ecological footprint in 1995, 2000, 2005 and 2013, the ecological trends of the four periods are shown in Table 4.

As shown in Table 4, the total ecological footprint of all types of land is on the rise with the passage of time. The growth trend of ecological footprint of grassland is the most obvious, which is caused by human factors. According to the survey results, the main factors affecting the experimental ecological footprint include: the increase of population, the intensity of grassland utilization, the improvement of residents' living standards, and the improvement of energy consumption ecological footprint.

The average composition of per capita land ecological carrying capacity in Yushu city is shown in Fig. 1.

As shown in Fig. 1, obviously, the per capita land ecological carrying capacity of the city showed a downward trend with the passage of time. It decreased from 11.7323 hm^2/person in 1995 to 6.9689 hm^2/person in 2013, with an average annual decrease of 0.2820 hm^2. The reduction rates of bearing capacity in the fourth stage were 17.96%, 12.83%

Table 4
Total ecological footprint near the experimental sea area from 1995 to 2013

Particular year	Total ecological footprint in 1995 (hm^2)	Total ecological footprint in 2000 (hm^2)	Total ecological footprint in 2005 (hm^2)	Total ecological footprint in 2013 (hm^2)
Cultivated land	15,889.8414	19,969.5510	17,370.6005	19,163.5600
Grassland	41,805.3378	59,573.8808	76,671.7765	111,484.3600
Woodland	1,788.1824	2,413.4740	3,107.9532	4,981.8800
Construction land	105.1872	155.7080	276.8579	559.5200
Fossil energy land	13,943.8782	17,649.5018	21,559.1926	25,339.8000
Total	73,532.4270	99,762.1156	118,986.3807	161,529.1200

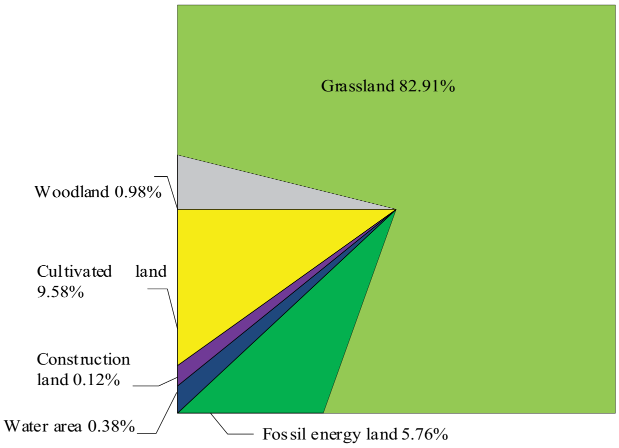

Fig. 1. The average composition of per capita land ecological carrying capacity.

and 16.94%, respectively, and the average annual reduction rate was 2.76%. The change range of per capita land ecological carrying capacity of cultivated land is small, showing a trend of first rising and then decreasing. The proportion of land ecological carrying capacity per capita was 0.71%, 1.08%, 1.08% and 1.04%, respectively.

4. Conclusions

This paper mainly discusses the modelling and conceptual framework of the impact of renewable energy on the mitigation of marine environmental ecological pollution, as well as the application of the combination of the establishment of evaluation index system, evaluation standards and evaluation model in the study of marine environmental ecological pollution. In the theory, method, technology and the combination of the three, the research of renewable energy to alleviate the ecological pollution of marine environment has been carried out, and some progress has been made in this field.

Data availability statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest

It is declared by the authors that this article is free of conflict of interest.

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