Big Data Evaluation on Marine Ecological Civilization in Guangdong Province

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Abstract: In this paper, entropy method and coupling coordination degree model were used to evaluate the level of marine ecological civilization construction in Guangdong Province from 2009 to 2018. Fourteen indicators were selected from four aspects, including economy, society, ecology, environment and ecology. A performance evaluation system was established for marine ecological civilization construction in Guangdong Province. The results show that the comprehensive development index of society and the environment is low. Thus, in the future construction process, we need to pay more attention to the quality of life and strive to improve living standards. At the same time, we need to strengthen the protection and governance of the environment. The coupling coordination of the performance evaluation system of marine ecological civilization shows a slow growth, which transitions from the basic coordination stage to the good coordination stage. This indicates that the construction level has been improved but still needs to be strengthened.

Keywords: Marine Ecological Civilization, Entropy Value Method, Coupling Coordination Degree Model, Guangdong Province.

1 INTRODUCTION

In 2019, the fourth Plenary Session of the 19th CPC Central Committee required improving the exploitation and protection of the marine resources system and strengthening the protection of Marine natural ecology from the perspective of "adhering to and improving the system of ecological civilization" [1]. Marine ecological civilization construction is an important part of ecological civilization construction and coastal economy.According to preliminary calculation, China's Marine GDP in 2019 was 8941.5 billion yuan with an increase of 6.2% over the previous year, and the proportion of marine industry in GDP was 9.0%[2]. While providing various means of production, the ocean is also facing increasingly serious environmental problems [3,4]. In recent years, Chinese scholars have mainly studied the connotation definition, evaluation system construction and practice of marine ecological civilization construction.

In terms of the connotation of marine ecological civilization construction, Zhu(2017)[5] believes that the connotation includes three aspects. First, consciousness, civilized behavior, and systematic civilization of marine ecological civilization. Second, marine ecological civilization behavior. Third, marine ecological system civilization. In terms of the construction of its evaluation system, Feng and Ye (2021)[6] studied the construction of marine ecological civilization in Zhejiang Province and selected 34 indicators to construct an evaluation system

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from six aspects of community, economy, governance, culture, resources, and ecology to analyze the construction level of Zhejiang Province. In terms of practice, Gao(2016)[7] studied the advantages, existing problems, and future work direction of Shengsi City's marine ecological civilization construction and put forward suggestions for the existing problems. This is conducive to the development of Shengsi City and provides a reference for other coastal cities.

2 DATA SOURCES AND RESEARCH METHODS

For Guangdong Province, we propose a set of objectives and a comprehensive performance evaluation index system from the perspectives of economy, society, environment and science, and technology to supplement the existing achievements and provide relevant basis for the construction of other regions.

2.1 Evaluation Index System of Marine Ecological Civilization Development

Based on the research of Feng and Ye(2021)[6], Miao and Wang(2020)[8], and the principles of quantification, timeliness, representativeness and feasibility, we constructed an evaluation index system (Table 1) comprising target layer, criterion layer and index layer. The construction process was combined with the actual situation to be representative and feasible.

2.2 Data Sources

In order to explore and evaluate the development of Marine ecological civilization in Guangdong Province, economic, social, resource, scientific and technological data were collected from China Marine Statistical Yearbook, China Statistical Yearbook, Guangdong Statistical Yearbook, as well as statistical bulletins and work reports of relevant departments of Guangdong Province from 2009 to 2018. The study covers Guangdong Province. Individual missing data are filled in with exponential smoothing method on the basis of previous years' data.

Table 1: TABLE I. EVALUATION INDEX SYSTEM.

The target layer	Rule layer	Index layer	Index of the unit	Index attribute	The weight
Performance level of Marine ecological civilization construction in Guangdong Province	economic (0.2709)	Gross Marine product	One hundred million yuan	+	0.067
		Proportion of GROSS Marine product in gross regional product	%	+	0.0633
		The proportion of Marine tertiary industry in gross Marine product	%	+	0.0819
		Direct economic losses caused by Marine disasters	One hundred million yuan	-	0.0587
	social	GDP per capita	yuan	+	0.0666

The target layer	Rule layer	Index layer	Index of the unit	Index attribute	The weight
	(0.1799)	Number of employed persons	Ten thousand people	+	0.0591
		Proportion of urban population	%	+	0.0542
	The environment (0.2255)	Proportion of Marine area of first and second class water quality in nearshore area	%	+	0.0532
		Investment in environmental pollution control as a proportion of GDP	%	+	0.0775
		Discharge of sewage from the sea	One hundred million tons of	-	0.0948
	Science and technology (0.3237)	Number of Marine scientific research institutions	a	+	0.0702
		Number of Marine science and technology patents granted	item	+	0.1014
		Marine science and Technology activists	people	+	0.0863
		The number of graduates with master's degree and doctor's degree in oceanography	people	+	0.0658

2.3 Index Weight of Evaluation System

The weight of indicators can reflect the importance of indicators to the construction of ecological civilization. In order to avoid the influence caused by subjective factors, objective weighting method is adopted in this paper. The larger X_{ij} is, the better the evaluation is, which indicates that X_{ij} is a positive indicator, and vice versa.In order to eliminate the influence of different dimensions and orders of evaluation indicators, the evaluation indicators need to be standardized before analysis. After standardizing, the part of the result is 0, which makes the subsequent logarithmic calculation meaningless. Therefore, a positive number slightly greater than zero is added to the result of all calculations.

Standardizing is carried out by following equations.

$$X_{ij}{}^{*} = \frac{X_{ij} - X_{j\,min}}{X_{j\,max} - X_{j\,min}} + 0.0001 \tag{1}$$

$$X_{ij}{}^{*} = \frac{X_{j\,max} - X_{ij}}{X_{j\,max} - X_{j\,min}} + 0.0001 \tag{2}$$

The proportion of *J* in *I* is

$$Y_{ij} = \frac{X_{ij*}}{\sum_{i=1}^{m} X_{ij*}} \tag{3}$$

The following equation is used to calculate the information entropy of *j*.

$$e_j = -k \sum_{i=1}^{n} (Y_{ij} \times lnY_{ij}) \tag{4}$$

Information entropy was used to calculate the different coefficients of *j*.

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

The difference coefficient is used to calculate the weight of *j*.

$$W_j = \frac{d_j}{\sum_{i=1}^{n} d_j} \tag{6}$$

2.4 Coupling Coordination Degree Model

After determining the index weight, calculate the comprehensive score of the ecological civilization index:

$$D_i = \sum_{i=1}^{n} (W_j \times X_{IJ}^{*}) \tag{7}$$

D_i Is the comprehensive evaluation score, and n is the number of indicators.

2.5 Coupling Coordination Degree Model

The coupling degree means the degree of interaction between two or more systems. The smaller value indicates that the system develops in the direction of disorder and conversely in the direction of order. The degree of coupling among economic, social, environmental and technological subsystems reflects the degree of interaction among each system. Since the number of subsystems is four, the equation is as follows.

$$C = 4 \times \left[\frac{U_1 \times U_2 \times U_3 \times U_4}{\prod(U_1 + U_2 + U_3 + U_4)}\right]^{\frac{1}{4}} \tag{8}$$

where *C* represents the coupling degree and ranges from 0 to 1, *U*1, *U*2, *U*3 and *U*4 represent the comprehensive development indicators of the four subsystems: economy, society, environment and science and technology. In this paper, the coupling degree is divided into four sub-values: 0−0.30, 0.30−0.50, 0.50−0.80, and 0.80−1, which respectively represent four stages: low level coupling, antagonism, run-in, and high-level coupling[9].

The indexes in the evaluation system are dynamic and unbalanced, and errors may be generated only depending on the coupling degree. Therefore, to avoid such errors, the following coupling coordination function is used.

$$D = \sqrt{C \times T} \tag{9}$$

$$T = aU_1 + bU_2 + cU_3 + dU_4 \tag{10}$$

where D is the coupling coordination degree, T is the comprehensive coordination index of economy, society, environment and science and technology subsystems, A, B, C, and D are undetermined parameters, and $A + B + C + D = 1$. Since the coordination effects of the four subsystems are the same, 1/4 of A, B, C, and D are selected in this paper. Based on relevant research results [10][11] and the actual situation, we divided the coupling coordination degree into the following five types. When D is greater than 0 and less than or equal to 0.1, it represents serious disorder. When D is greater than 0.1 and less than or equal to 0.2, it is moderate disorder. When D is greater than 0.2 and less than or equal to 0.3, it represents basic coordination. When D is greater than 0.3 and less than or equal to 0.4, it indicates intermediate coordination. Good coordination is indicated when D is greater than 0.4 and equal to 0.7. When D is greater than 0.7 and equal to or equal to 1, the coordination is good.

3 RESULTS AND ANALYSIS

3.1 Comprehensive Evaluation Index Analysis

According to the real data of Guangdong province from 2009 to 2018 and Eqs. (1)-(7), the comprehensive development index of the four subsystems of economy, society, environment and science and technology is calculated as shown in Table 2 and Figure 1.

Table 2: Performance level of marine ecological civilization construction and comprehensive development index of each subsystem in Guangdong Province from 2009 to 2018

Year	Economics	Society	The environment	Science and technology	Construction level of marine ecological civilization
2009	0.04286	0.00002	0.11724	0.09327	0.25338
2010	0.06421	0.03739	0.14034	0.07410	0.31603
2011	0.07413	0.05296	0.11701	0.08411	0.32821
2012	0.08987	0.06389	0.08125	0.08476	0.31977
2013	0.04944	0.08226	0.09158	0.07470	0.29799
2014	0.10274	0.09350	0.08468	0.05746	0.33838
2015	0.14832	0.10586	0.09458	0.12144	0.47020
2016	0.18139	0.11961	0.00689	0.07312	0.38101
2017	0.16300	0.13666	0.05682	0.06751	0.42400
2018	0.20196	0.16022	0.10212	0.16487	0.62917

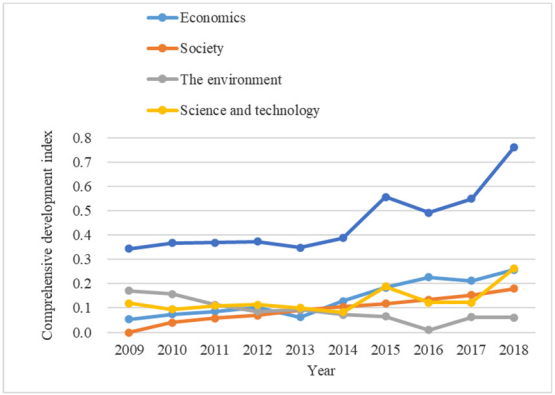

Figure 1: Performance level of marine ecological civilization construction and comprehensive development index of each subsystem in Guangdong Province from 2009 to 2018

As can be seen from Table 2 and Figure 1, the performance level of Marine ecological civilization construction in Guangdong Province showed an overall upward trend from 2009 to 2018, increasing from 0.25338 in 2009 to 0.62917 in 2018, which increased by two times. This data reflects that Marine ecological civilization construction in Guangdong Province is developing in a sustainable and healthy direction.The overall development level of economic, social and scientific subsystems has been on the rise in the past decade. Guangdong Province attaches great importance to the development of economy, society and science and technology, but ignores the importance of the environment. Thus, it has made progress in economy, society, and science and technology. However, the development of the environment is gradually ignored, which leads to the imbalance of the overall development. Compared with the economic and technological subsystem, the overall development index of the social and environmental subsystem is slightly lower. Therefore, Guangdong province needs to pay attention to improving people's quality of life and strengthening environmental protection and management in the future construction process.

3.2 Coupling Coordination Analysis

According to the real data of Guangdong Province from 2009 to 2018 and Eqs. (8)-(10), the coupling coordination degree of the four subsystems of economy, society, environment and science and technology is calculated. The results are shown in Fig. 2 and Table 3.

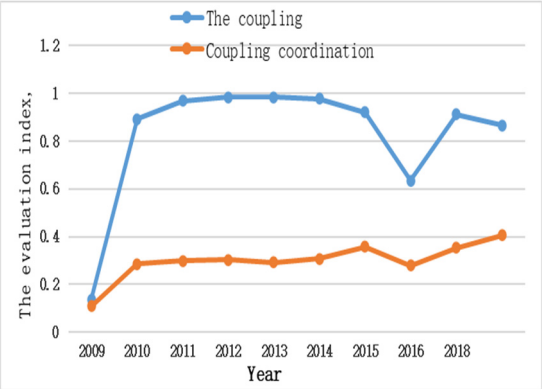

Figure 2: Coupling coordination index.

Table 3: TABLE II. PERFORMANCE COUPLING TYPES.

Year	Coupling coordination	Coordination type
2009	0.10878	The basic coordinate
2010	0.28615	
2011	0.29845	
2012	0.30288	Intermediate coordinate
2013	0.29251	The basic coordinate
2014	0.30780	Intermediate coordinate
2015	0.35802	
2016	0.27917	The basic coordinate
2017	0.35373	Intermediate coordinate
2018	0.40613	Good coordination

The degree of coupling and coordination of marine civilization construction in Guangdong Province has increased in the past ten years. From 0.13770 in 2009 to 0.86639 in 2018. From 2011 to 2014, the coupling degree is relatively stable, from low coupling stage to high coupling stage. And the coupling degree is relatively stable from 2012 to 2015, which shows that in the past four years, there is a strong correlation between the economic, social, environmental and scientific subsystems.From 2015 to 2016, the direct economic loss index of marine disasters decreased from 2.877 billion yuan to 963 million yuan, and there was a gap between the speed of economic development and the other three systems. The correlation between the four subsystems weakened, and the coupling degree decreased from 0.92099 in 2015 to 0.63375 in 2011.

The degree of coupling coordination increased from 0.10878 in 2009 to 0.40613 in 2018, and the type of coupling coordination increased from basic imbalance to good coordination. Among them, 2009−2011 is the basic coordination stage, 2012 is the intermediate coordination stage, 2013 is the basic coordination stage, 2014−2015 is the intermediate coordination stage, 2016 is the basic coordination stage, 2017 is the intermediate coordination stage, and 2018 is the good

coordination stage. Figure 2 shows that the coupling coordination degree of the performance evaluation system of marine ecological civilization construction in Guangdong Province is low. There are differences among the four subsystems of economic, social, environmental and scientific, and technological development. On the whole, the coupling coordination degree shows a slow upward trend, that is, the difference between subsystems in the construction process decreases, showing a general direction of development.

4 CONCLUSIONS

We select 14 indicators for evaluation and analysis from four aspects: economy, society, environment, science and technology. The conclusions are as follows.

From 2009 to 2018, the marine economy of Guangdong Province showed an increase, and the industrial structure continued to be optimized. The marine GDP showed linear growth, and the economy continued to develop. With regard to marine scientific research institutions, more experts are engaged in marine research, and the ability of marine scientific research is increasing. In the follow-up process, it is necessary to pay attention to environmental protection and restoration and strive to improve people's living standards and quality of life.

The overall performance level of marine ecological civilization construction in Guangdong Province shows an increase but the comprehensive development index of social environment is low. Therefore, Guangdong Province needs to pay attention to improving people's quality of life and strengthening environmental protection and governance in the process of marine ecological civilization construction in the future.

From 2009 to 2018, the coupling coordination degree of Guangdong marine ecological civilization showed a slight increase from 0.10878 in 2009 to 0.40613 in 2018 from the basic coordination stage to the good coordination stage. The coupling degree increased from 0.13770 in 2009 to 0.86639 in 2018. The increase from low level coupling stage to high level coupling stage indicates that the differences among the four subsystems of economic, social, environmental and scientific development are decreasing and developing in a right direction on the whole.

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