Evaluation of green development level of Marine economy in Guangdong province based on entropy method

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Abstract. Based on the concept of green development, this paper analyzes the green development level of Marine economy in 14 coastal cities of Guangdong province with the help of the entropy method, and boosts the green development of Marine economy in Guangdong Province according to the research results. Starting from the status quo of Marine economy, the paper summarizes the current Marine economic development and ecological environment development in Guangdong province, selects two dimensions of economic development and ecological environment protection to build a green ocean economy development index evaluation system in Guangdong province, uses entropy method to calculate the index weight, scores for the ocean economy green development level of coastal cities of Guangdong province, and analyses differences of green development level among every cities according to the scoring.

1. Introduction

1.1. Scale of Marine economy and current industrial situation of Guangdong province
During the period of the 13th Five-Year Plan, the scale of whole province's Marine economy increased from 1.44 trillion to 2.1 trillion, and the annual average growth rate of the Marine GDP was 9.76%, higher than the growth rate of the GDP in the same period. In the past five years, the proportion of provincial Marine economy in the national Marine economy has been increasing year by year, ranking first in the country for 25 years [4]. The industrial structure of the Marine economy of the province has been continuously optimized, the primary industry has remained basically stable, the proportion of the secondary industry has gradually decreased, and the proportion of the tertiary industry has gradually increased. By 2019, the proportion of the three industries is 1.9%: 36.4%: 61.7%, and the provincial Marine economy has basically realized the "321" industrial structure mode.

1.2. Status quo of Marine ecological environment in Guangdong province
According to the monitoring data of the Department of Ocean and Fisheries of Guangdong Province in 2017, the coastal water quality of Guangdong province from 2013 to 2017 maintained an overall good level, with the proportion of high-quality waters accounting for 84.6% on average, and the coastal water quality gradually improved. The coastal biodiversity monitoring showed that the phytoplankton diversity level was good, the large-scale benthic biodiversity level was poor, but the overall ecological status remained stable. The ecological status of Marine reserves is basically stable, and the growth of
animals and plants in the region is good, with the population increasing year by year. In 2017, the over-standard rate of all typical sewage outlets into the sea was 28.8%, which was slightly lower than that in 2016. The ecological environment of some sewage outlets to the sea was poor, mainly manifested as poor water quality and poor biodiversity, such as the estuary of The Xiaodongjiang River. In recent ten years, about 10 red tide events were found annually in the province, but the number of large-scale red tides was relatively small, and none of the 10 red tides in 2017 caused direct economic losses.

2. Indicator system for the green development of Guangdong's Marine economy

2.1. The evolution of green development ideas
The term "green development" was first coined by economist Stuart Pearce in blue Book on the Green Economy [5], published in 1989. In the following three decades, more and more countries began to attach importance to the relationship between economic development and ecological environment. Since the 18th National Congress of the CPC, China's economic development has entered a new era, and the economic development has paid more attention to the impact on the ecological environment. President Xi once pointed out that "adhering to green development is a profound revolution of the concept of development". Green development is gradually becoming the main melody of China's economic development [2]. As an important part of China's national economy, the Marine economy should implement the concept of green development, realize the coordinated development of economic society and ecological environment, and make the sky bluer, the land greener and the water cleaner.

2.2. Marine economy Green Evaluation System
By analyzing the data of 14 coastal cities in Guangdong province in 2017, this paper constructs the evaluation system for the green development of Marine economy in Guangdong Province. By comparing the different development situations of various regions, we can analyze the green development level of the marine economy in the coastal cities of Guangdong Province and analyze the reasons for the differences. The article starts from two perspectives of economic development and ecological environment, takes the green development of Marine economy in Guangdong province as the overall goal, and selects two first-level indicators and nine second-level indicators [1]. The first-level index includes two systems -- economic development system and ecological environment system. The second-level index takes into full consideration the representativeness, authenticity and feasibility of the index, and selects a total of nine evaluation indexes to establish the indicator system of green development of Marine economy, as shown in Table 1:

![Table 1. Indicator system for the green development of Marine economy.](image-url)

| The total goal | The first indicators | The secondary indicators | Units | Direction |
|---------------|----------------------|--------------------------|-------|-----------|
| Green development of Marine economy in Guangdong Province | Economic development system | The secondary indicators | % | positive |
| | | Reduction rate of energy consumption per unit of GDP | % | positive |
| | | Annual GDP growth rate | % | positive |
| | Tertiary industry ratio | 100 million tons | negative |
| | Industrial wastewater discharge | 100 million cubic meters | negative |
| | Industrial exhaust emission | 10 thousand tons | negative |
| | Industrial solid waste production | % | positive |
| | Urban sewage treatment rate | % | positive |
| | The proportion of energy conservation and environmental protection expenditure | 10 thousand mu | positive |
2.3. Empowerment approach

(1) Data standardization

Due to the different index units, it is very hard to directly compare. In order to solve the problem, the original data needs to be processed, which is standardization. In this paper, range method is selected to dimensionless the data. The calculation formula is as follows:

Definition \( x_{ij} \) is the \( j \)th index value of the \( i \)th region, \( z_{ij} \) is the \( j \)th index value of the \( i \)th area after standardization, \( \min_{i=1,m} x_{ij} \) is the minimum value in the \( j \)th index in the \( i \)th region, and \( \max_{i=1,m} x_{ij} \) is the maximum value in the \( j \)th index in the \( i \)th region, \( i = 1, 2, 3 \ldots m, j = 1, 2, 3 \ldots n \).

For the forward indicator, the standardized formula is as follows:

\[
Z_{ij} = \frac{x_{ij} - \min_{i=1,m} x_{ij}}{\max_{i=1,m} x_{ij} - \min_{i=1,m} x_{ij}} \tag{1}
\]

For negative indicators, the standardized formula is as follows:

\[
Z_{ij} = \frac{\max_{i=1,m} x_{ij} - x_{ij}}{\max_{i=1,m} x_{ij} - \min_{i=1,m} x_{ij}} \tag{2}
\]

(2) To calculate the ratio of the index in the \( i \)th region of the \( j \)th index, the formula is as follows:

\[
p_{ij} = \frac{z_{ij}}{\sum_{i=1,m} z_{ij}} \tag{3}
\]

(3) To calculate the entropy of the \( j \)th index. Entropy is used to reflect the degree of dispersion of various indicators. The larger the entropy of the indicator, the more information the indicator contains, which increases the uncertainty. The formula is as follows:

\[
e_j = \frac{1}{\ln m} \sum_{i=1}^{m} p_{ij} \times \ln p_{ij}, \quad 0 \leq e_j \leq 1 \tag{4}
\]

(4) To calculate the coefficient of difference. The difference coefficient and the weight are linearly negatively correlated, and the sum of the two is 1, the formula is as follows:

\[
g_j = 1 - e_j \tag{5}
\]

(5) To calculate the weight of the \( j \)th index. The weight is used to reflect the importance of the indicator, the larger the weight value, the higher the importance of the indicator, the formula is as follows:

\[
w_j = \frac{g_j}{\sum_{j=1}^{n} g_j} \tag{6}
\]

(6) To calculate the integrated score of each regional indicator. The integrated score of each area is obtained by calculating the sum of the product of the weight of each indicator and the proportion of each area indicator value, the formula is as follows:

\[
s_i = \sum_{j=1}^{n} (w_j \times p_{ij}) \tag{7}
\]

3. Evaluating the green development level of Marine economy in Guangdong province based on entropy value method

3.1. Data sources and data standardization

This paper selects 2017 data for analysis and all the data in this paper are from the authoritative data released by China Marine Statistical Yearbook and Statistical Yearbook of Guangdong Province couple with other authorities. With the help of the above method, the weight of each index is calculated, as shown in Table 2:

**Table 2. Evaluation index weight system of Green development of Guangdong Marine economy.**

| The first indicators          | The secondary indicators                          | Weight |
|------------------------------|--------------------------------------------------|--------|
| Economic development         | Reduction rate of energy consumption per unit of GDP | 6.17%  |
From the table 2 above, it is clear that the index weight of artificial afforestation area is the highest, indicating that the ecological protection policy of afforestation, returning forest, grassland and lake has a significant impact on the level of green development. At the same time, the ratio of the tertiary industry and the expenditure on energy conservation and environmental protection act as a positive part in promoting green development: the higher the ratio of the tertiary industry and the proportion of the expenditure on environmental protection, the less the ecological environment is subject to industrial and domestic pollution, which is good to improving the level of local green development. In addition, the higher the emissions of the three wastes, the greater the environmental pressure will be, which will restrict the green development of economy. Finally, the sewage treatment capacity and reduction of GDP unit energy consumption will also promote the green development of regional economy.

3.2. Coastal cities green development level of Marine economy comprehensive ranking

After the weight of each index is calculated, the green development level of each region needs to be scored in the end. According to formula (7), the index weight is multiplied by the value of the ith region on the JTH index and added together, and the comprehensive score of the green development of Marine economy of 14 coastal cities is calculated and ranked. The results are shown in Table 3:

**Table 3. Comprehensive score and ranking of green development of Marine economy in 14 coastal cities of Guangdong province.**

| City    | Score | Ranking |
|---------|-------|---------|
| Shanwei | 0.1939| 1       |
| Maoming | 0.0970| 2       |
| Jieyang | 0.0817| 3       |
| Shantou | 0.0731| 4       |
| Shantou | 0.0727| 5       |
| Shenzhen| 0.0710| 6       |
| Chaozhou| 0.0674| 7       |
| Yangjiang| 0.0594| 8       |
| Zhuhai  | 0.0589| 9       |
| Guangzhou| 0.0545| 10      |
| Zhongshan| 0.0483| 11      |
| Huizhou | 0.0477| 12      |
| Dongguan| 0.0430| 13      |
| Jiangmen| 0.0316| 14      |

With the aid of the above-mentioned index system and calculation method, the comprehensive score and ranking of the green development level of the marine economy of the 14 coastal cities in Guangdong Province are finally obtained, which further analyze the reasons for the differences between cities on this basis. In general, the level of green development of the marine economy of coastal cities in Guangdong Province shows an unbalanced law, which is reflected in the lower level of green development in areas with higher levels of economic development, but higher levels of green
development in areas with higher levels of economic backwardness. This reflects the incoordination between economy and ecology. The reason for this phenomenon is worthy of further discussion.

4. Conclusions
According to the above results, Shanwei has the highest level of green development of Marine economy and Zhanjiang has the lowest level. Shanwei ranks the first in artificial afforestation area in the province with its comprehensive score being the highest. Maoming city and Jieyang City also rank high due to their high afforestation area. The tertiary industry in Guangzhou accounts for as high as 71.02%, ranking the first in the whole province. However, due to the high urbanization rate of Guangzhou, the available area land is tight, and the artificial afforestation area is 0, which reduces the overall green development level of Guangzhou. Shenzhen has the highest proportion of environmental protection expenditure, but like Guangzhou, its urbanization rate has reached 100% and the area of artificial afforestation is 0, which also drags down the overall green development level of the city. Moreover, Guangzhou and Shenzhen have a large population and a large amount of various wastes, which further affects the green development level of the two cities. In addition, such as the zhujiang, zhongshan, dongguan and other cities of high regional economic development level, the green ocean economy development level are low, and some of the economic development is relatively backward area, such as shanwei, chaozhou, yangjiang, Marine economic green development level is higher, indicating that these regions of coordination between economic development and ecological environment is bad, the future shall formulate corresponding measures to solve the problems. Based on this, the coastal cities of Guangdong Province should formulate corresponding measures according to their own conditions to improve the level of green development of Marine economy. For example, guangzhou and Shenzhen, two super cities, can not only increase the rate of urban green land but also improve people living conditions by expanding the area of urban parks and intensifying pollution control measures. Other cities may, according to their own conditions, delimit and establish nature reserves, actively plant trees and trees, increasing the proportion of tertiary industry, to raise the green development level of Marine economy in the whole province.

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References
[1] Liu Bo, Long Ruyin, ZHU Chuangeng, Sun Xiaoxiang, Pan Kunyou. (in Chinese) Evaluation of high quality development level of Marine economy in jiangsu province [J]. Economic geography,2020,40(08):104-113.
[2] Guan Hongjun, Sun Zhenzhen, Gao Haonan, Zhao Aiwu. Spatial and temporal Evolution of green Total factor Productivity in China’s Marine economy and its Influencing Factors [J]. Journal of Ocean University of China (Social Science edition),2019(06):40-53.
[3] Editorial Committee of China Marine Statistical Yearbook. Wang Hong, Xian Zude, editor-in-chief, China Marine Statistical Yearbook, Ocean Press,2017,4-5, Yearbook.
[4] Liang Huagang. Comprehensive Measurement of green Development Level of China’s Marine Economy and Research on Spatio-temporal Evolution [J]. Ocean development and management,2019,36(05):73-83.
[5] Shao Wenhui, Liang Zhenlin. Practice of green transformation of Marine economy abroad and its enlightenment to China [J]. China fishery economy,2016,34(02):98-104.
[6] Liu Xiaofeng, Chen Sizeng. Research on implementation effect evaluation of green development of fujian Marine economy [J]. Journal of fujian jiangxia university,2014,4(06):9-14.