The Coordination Effect of Marine and Land Resources Carrying Capacity of Coastal Areas in China

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Abstract: The carrying capacity of marine and land resources is one of the indicators to measure the sustainable development level of coastal areas, reflecting the supporting capacity of the ecological environment for human activities and the impact of human activities on the regional environment. This paper establishes an evaluation index system to determine the evaluation value of the carrying capacity of marine and land resources in China's coastal areas, the evaluation index of marine and land resources supply capacity (economic and social development demand) subsystem, and the degree of coordinated development of the subsystems in 11 coastal areas from 2006 to 2017. The results showed that the average supply and demand capacity of the two subsystems in each region is not high; the average demand level of economic and social development is higher than the supply capacity of marine and land resources; the carrying capacity of marine and land resources is slightly overloaded in most areas; the collaborative development between the supply and demand subsystems is barely coordinated with moderate imbalance; most regions need to move in the direction of green development to ensure the supply capacity of marine and land resources.

Keywords: Marine and land resources; Carrying capacity; Sustainable and coordinated development

1. Introduction

The environment and its resources are the carriers of ecological civilization and an essential material basis for the survival and development of the human society. With the rapid development of the economy and society, as well as the rapid growth of people and the gradual depletion of land resources, the supply and demand for resources has become more apparent [1]. As the frontier of China's economic and social development, it is necessary to evaluate the carrying capacity of marine and land resources to avoid the excessive development and utilization of these resources [2], so as to provide research support for the sustainable development of marine and land resources in China's coastal areas. The marine system provides human, capital, science and technology, as well as other resources for the development of land economy, while the land system provides space, environmental cost, and other resources for the development of marine economy. The two subsystems are connected and coupled, utilizing complementary advantages and factor flow to realize the coordinated evolution of the two subsystems. Therefore, controlling the economic and social functions of the marine system and land system maximizes the potential of the marine and land system as well as improve the overall economic benefits, which is of great practical significance to social

and economic development [3].

Although China is a huge country with both marine and land resources, its marine consciousness started late. There are uncoordinated problems in resources and environment, planning and layout, as well as the economic development between the marine and land systems. Therefore, it is also an inevitable trend of China's economic development to realize the mutual promotion and symbiosis of marine and land resources [4]. This paper aims to establish an evaluation index system based on the characteristics of marine and land resources in China's coastal areas, determine the evaluation value of their carrying capacity, the comprehensive evaluation index of marine and land resources supply capacity (economic and social development demand) subsystem, and the degree of coordinated development of the subsystems in 11 coastal regions of China from 2006 to 2017, measure the maximum supply and pollution carrying capacity of marine and land resources and the environment, as well as to determine the maximum support capacity for the socio-economic development scale and corresponding population of coastal areas, with the condition of meeting specific living standards, environmental quality requirements, and not exceeding the elastic limit of the marine and land ecosystem.

2. Literature review

In regard to resource carrying capacity, Arrow and other scholars studied the relationship between economic development and environmental carrying capacity. They combined social production, life, and carrying capacity and proved the inevitable impact of economic growth on the environment. Carrying capacity has been used in sustainable urban development and applied to study the sustainable development of urban settlements in Indonesia [5]. There are also several scholars in China who have conducted research on tourism environmental carrying capacity, ecological carrying capacity, and resource environmental carrying capacity from various perspectives [6-8].

Marine carrying capacity includes four domains: society, economy, resources, and marine carrying capacity [9]. From the perspective of resources and environmental economics, the key to evaluating marine carrying capacity lies in the market value and nonmarket value of marine resources and the environment. The resource allocation and socio-economic development system can be combined to evaluate the carrying capacity of resources and the environment to find a path suitable for the coordinated development of China's natural resource system and socio-economic system [10].

At present, the research on marine resources and environmental carrying capacity is relatively limited, especially in regard to the overall planning of marine and land resources. As a result, more technical frameworks and support are required in this field [11]. Other scholars have looked into the development of marine environmental carrying capacity of other countries and cities. For example, the coupling development trend and coordinated development trend of marine environmental carrying capacity in Liaoning have been studied [12]. Researchers have also taken an interest in Bohai sea, studying the relationship between marine economy and marine carrying capacity in 17 cities as well as analyzing the development network according to its coupling development [13]. Imane has examined the marine carrying capacity in Morocco and put forward suggestions conducive to the long-term development of marine resources in Morocco [14]. Based on Yantai City and the relevant contents of marine resources, suggestions for the scientific construction and management of marine resources have been put forward [15]. The characteristics of China's marine resource carrying capacity have evolved, and the influencing variables of the carrying capacity of marine resources in various provinces and cities have been summarized [16].

From the perspective of the entire country, the carrying capacity of China's marine resources, environment, and economic system as well as the temporal and spatial evolution of coordinated development provide a reference basis for the sustainable development of China's marine resources and economy. Sun has put forward an ecological protection supervision mechanism based on the carrying

capacity of marine ecological development as well as Wenzhou's marine resource environment and land resource environment [17]. Overall, China's marine carrying capacity needs to be enhanced because marine resources are vital economic and ecological goals for the country, and its growth must be coordinated [18]. Several studies by other researchers have stressed the importance of coordinated land and marine economy development to China's economic and social development [19-21].

In terms of research methods, there are two commonly used evaluation methods to determine the carrying capacity of marine areas: state-space method and fuzzy comprehensive evaluation method [22]. In earlier studies, there are also single factor evaluation methods, system dynamics models, etc. The methods to determine the weight of evaluation indexes include the analytic hierarchy process (AHP), Delphi, and other subjective weighting methods. Objective weighting methods include entropy, principal component analysis, coefficient of variation weighting, and mean square deviation method.

Based on the aforementioned literature, scholars worldwide still focus on the single factor natural resources, such as land resources (population carrying capacity of land resources) and marine resources. There is still little quantitative synthesis evaluation of the carrying capacity of marine and land resources. From the perspective of research content, most of them focus on evaluating resource carrying capacity and spatial difference analysis. At present, there is limited research from the standpoint of mutual coordination among internal subsystems, which provides direction for further research in this paper.

This paper establishes an evaluation index system according to the characteristics of marine and land resources in China's coastal areas, determines the evaluation value of the carrying capacity of marine and land resources, the subsystem index, and the degree of coordinated development of the subsystems of 11 coastal regions in China by constructing a subsystem comprehensive index evaluation model, a carrying capacity evaluation model, and a coordinated development degree evaluation model. This paper reveals the state of the carrying capacity of marine and land resources in China's coastal areas at the present stage.

3. Research methods
3.1. Subsystem comprehensive index evaluation model
This paper adopts the subsystem comprehensive index evaluation model to further evaluate the supply-demand level of marine and land resources in coastal areas. It solves the regional carrying capacity subsystem (B1 and B2) through multi-objective linear weighting function.

$$P_{1i(2i)} = \sum_{j=1}^{m(n)} w_j \, r_{ij} \tag{1}$$

In formula (1), $i = 1, 2, \ldots, 11$; $P_{1i(2i)}$ refers to the evaluation index of marine and land resources supply capacity (demand for economic and social development) subsystem, in area i; m refers to the index number of marine and land resources supply capability subsystem; n refers to the index number of the economic and social development demand subsystem; w_j refers to the index weight of j; $\sum_{j=1}^{m(n)} w_j = 1$. In area i, r_{ij} is the standardized value of the evaluation index of j.

3.2. Marine and land resources carrying capacity evaluation model
From the perspective of resource supply and demand, this paper defines the calculation of the carrying capacity of marine and land resources into the formula below:

$$B_i = \frac{P_{1i}}{P_{2i}} \tag{2}$$

In formula (2), B_i refers to the evaluation value of marine and land resources carrying capacity; P_{1i} refers to the supply capacity of land and marine resources; P_{2i} stands for the economic and social development demand. When $B_i \geq 1$, the carrying capacity of marine and land resources is in a reasonable state; when $0.55 \leq B_i < 1$, the carrying capacity of marine and land resources is in a mild overload condition; when $B_i < 0.55$, the carrying capacity of marine and land resources is in a severe overload condition.

3.3. Coordinated development degree evaluation model

The coordinated development degree of marine and land resources carrying capacity system can fully reflect the degree of interaction between the two subsystems of marine and land resources supply and economic and social development demand as well as reflect the development state of the whole system. This paper provides a coordinated development degree evaluation model of marine and land resources carrying capacity system at coastal areas based on relevant literatures. The formulas are as follows:

$$LC_i = \left[\frac{4P_{1i}P_{2i}}{(P_{1i} + P_{2i})^2} \right]^k \tag{3}$$

$$LCD_i = \sqrt{LC_i \cdot S_i} \tag{4}$$

$$S_i = \alpha P_{1i} + \beta P_{2i} \tag{5}$$

In formula (3), $LC_i \in (0,1)$; LC_i is the coordination degree of the two subsystems of the regional marine and land resources supply capacity as well as the social and economic development demand in area i; P_{1i} and (P_{2i}) are the synthesis evaluation index of the two subsystems in area i; k refers to the adjustment coefficient, where $k \geq 2$; in this paper, $k = 2$. In formula (4), LCD_i is the coordinated development degree of the two subsystems of the marine and land resources supply capacity as well as the social and economic development demand in area i. In formula (5), S_i refers to the evaluation index of the overall effect of the system in area i. Since both two subsystems are essential to marine and land resources carrying capacity systems, $\alpha = \beta = 0.5$.

According to existing research [23], in order to accurately characterize the cooperative development relationship, the stage of the two subsystems of the supply capacity of marine and land resources, as well as the demand for economic and social development in coastal areas based on the coefficient of LCD, the classification and discrimination standard of coordinated development of the supply-demand subsystem are shown.

4. Construction of the index system
4.1. Index selection

The construction principle of the marine and land resources carrying capacity indicators is that the composition should not be too complex. The selection of indicators should be scientific, available, operable, etc.

The carrying capacity of marine and land resources is affected by natural, environmental, economic, and social systems. The target layer is the carrying capacity of marine and land resources in coastal areas. It can be divided into two criteria: marine and land resources supply capacity as well as economic and social development demand. Marine and land resources supply capacity include 4 elements: land resources (with index layer: per capita urban construction land area, km²/person); water resources (with index layer: water resources per capita, ton/person); marine resources (with index layer: marine area, thousands of hectares);

environment protection (with index layer: green space per capita, square meters). Economic and social development demand include three elements: environment pollution (with index layer: sulfur dioxide emissions, tons); economic development (with index layer: gross regional product, ten thousand RMB; the ratio of marine output value to GDP, %); investment completed in real estate development, ten thousand RMB.

4.2. Data source
This paper chose 11 coastal areas in China as the research subjects: Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, and Hainan. The data from 2006 to 2017 have been downloaded from Wind database. This study uses the mean interpolation method and regression analysis method to analyze the data as some years' statistical data are absent when collecting the index's original data.

4.3. Data processing
In this paper, the indicators are divided into "benefit-type" and "cost-type." The "benefit-type" indicator indicates that the attribute value is positively correlated with the carrying capacity of marine and land resources, whereas the "cost-type" indicator indicates that the attribute value is negatively correlated with the carrying capacity of marine and land resources. As the indicators' data have different orders of magnitude and dimensions, the indicators should be standardized using the deviation standardization method to eliminate these effects.

5. Analysis
5.1. Subsystem comprehensive index evaluation
According to the statistical index data and the subsystem synthesis index evaluation model, the evaluation indexes of the subsystem of marine and land resources supply (demand for economic and social development) in coastal regions from 2006 to 2017 are calculated. The results are shown in **Table 1**.

Table 1. Evaluation index of the supply-demand subsystem in coastal areas (2006-2017)

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tianjin	P_1	0.004	0.006	0.010	0.022	0.028	0.051	0.052	0.053	0.033	0.035	0.037	0.079
	P_2	0.211	0.224	0.234	0.283	0.287	0.304	0.306	0.282	0.274	0.226	0.230	0.252
Hebei	P_1	0.092	0.072	0.075	0.072	0.117	0.166	0.103	0.095	0.126	0.123	0.103	0.087
	P_2	0.652	0.671	0.676	0.679	0.711	0.742	0.701	0.677	0.703	0.649	0.596	0.579
Liaoning	P_1	0.226	0.186	0.243	0.250	0.315	0.278	0.326	0.317	0.220	0.285	0.301	0.264
	P_2	0.458	0.477	0.493	0.552	0.539	0.561	0.566	0.581	0.508	0.414	0.337	0.305
Shanghai	P_1	0.160	0.150	0.142	0.138	0.134	0.132	0.137	0.128	0.133	0.124	0.107	0.110
	P_2	0.509	0.505	0.455	0.452	0.431	0.418	0.484	0.426	0.404	0.410	0.418	0.373
Jiangsu	P_1	0.266	0.327	0.295	0.204	0.196	0.233	0.196	0.200	0.184	0.206	0.207	0.178
	P_2	0.844	0.842	0.859	0.879	0.901	0.916	0.908	0.898	0.892	0.902	0.886	0.850
Zhejiang	P_1	0.114	0.170	0.146	0.155	0.165	0.155	0.189	0.152	0.181	0.183	0.178	0.161
	P_2	0.746	0.709	0.681	0.712	0.720	0.720	0.776	0.775	0.789	0.811	0.755	0.760

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		2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Fujian	P_1	0.214	0.223	0.201	0.136	0.204	0.151	0.218	0.177	0.205	0.202	0.252	0.191
	P_2	0.595	0.608	0.595	0.593	0.593	0.611	0.633	0.625	0.702	0.742	0.676	0.682
Shandong	P_1	0.286	0.272	0.290	0.214	0.195	0.186	0.249	0.324	0.343	0.291	0.376	0.384
	P_2	1.013	0.982	0.993	1.048	1.042	1.048	1.034	1.023	1.097	1.055	1.132	1.083
Guangdong	P_1	0.185	0.185	0.206	0.182	0.187	0.185	0.212	0.200	0.201	0.214	0.237	0.229
	P_2	1.178	1.189	1.182	1.157	1.139	1.098	1.119	1.094	1.112	1.204	1.195	1.252
Guangxi	P_1	0.165	0.171	0.183	0.123	0.151	0.155	0.211	0.187	0.218	0.224	0.190	0.223
	P_2	0.610	0.609	0.617	0.610	0.608	0.527	0.519	0.503	0.499	0.493	0.438	0.481
Hainan	P_1	0.218	0.253	0.224	0.212	0.230	0.256	0.215	0.245	0.241	0.162	0.222	0.188
	P_2	0.440	0.451	0.437	0.458	0.429	0.426	0.421	0.423	0.415	0.438	0.375	0.391

From the perspective of spatial sequence, the comprehensive evaluation index of the supply subsystem fluctuates in the range of 0.079-0.384. During the study period, the average supply capacity of marine and land resources is not high, which is 0.223, and there are differences among regions. The supply capacity of Shandong is the strongest, and that of Tianjin is the weakest. Only three areas (Liaoning, Jiangsu, and Shandong) have an average supply capacity of more than 0.3, accounting for 27% of the region. In contrast, the supply capacity of other areas is weak. The evaluation index of the demand subsystem ranges from 0.306 to 1.252. From 2006 to 2017, the average demand level for economic and social development is 0.776, with the highest in Guangdong and the lowest in Tianjin. However, the moderate demand pressure in 11 regions exceeds 0.3. This result reflects a consistency between the supply index of marine and land resources of each part and the demand index of economic and social development, showing a relatively balanced state. However, the imbalance between supply and demand among regions is prominent. The gap between the maximum and minimum evaluation index of marine and land resources supply capacity among different areas is 0.305. The gap between the maximum and minimum demand index for economic and social development is 0.946.

From the perspective of time, the supply capacity of marine and land resources in Tianjin, Shandong, Guangdong, and Guangxi showed a upward trend. The supply capacity of marine and land resources in Hebei initially rose and then fell, with a small overall change in its level. The supply capacity of marine and land resources in Liaoning and Zhejiang showed a slight upward trend. The supply capacity of marine and land resources in Shanghai, Jiangsu, Fujian, and Hainan showed a gradual downward trend, with slight fluctuations and small changes in the overall level.

From 2006 to 2017, the demand for economic and social development in Tianjin, Zhejiang, Fujian, Shandong, and Guangdong showed an upward trend. The demand for economic and social development in Hebei, Shanghai, Guangxi, and Hainan showed a slight downward trend, with a small range. The demand for economic and social development in Liaoning showed a downward trend, whereas Jiangsu showed an upward and downward trend, with a slight decline. This means that there is a reverse development trend between supply capacity and development demand in certain regions. Resource supply promotes economic and social development. Excessive economic and social development inevitably harms the environment, and resource scarcity will inevitably create certain roadblocks to economic and social development.

5.2. Degree of coordinated development
The coordinated development degree evaluation model of marine and land resources supply capacity

(economic and social development demand) subsystem tallies the coordination degree and coordinated development degree between the two subsystems in China's coastal areas from 2006 to 2017. The results are shown in **Table 2**.

Table 2. Coordination degree and coordinated development degree between the two subsystems in coastal areas (2006-2017)

|		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tianjin	LC	0.261	0.308	0.390	0.514	0.565	0.703	0.706	0.729	0.621	0.680	0.689	0.851
	LCD	0.168	0.188	0.218	0.280	0.298	0.354	0.355	0.349	0.309	0.298	0.303	0.375
Hebei	LC	0.658	0.590	0.600	0.589	0.697	0.773	0.669	0.658	0.718	0.731	0.708	0.673
	LCD	0.495	0.468	0.475	0.471	0.537	0.592	0.519	0.504	0.546	0.531	0.497	0.473
Liaoning	LC	0.940	0.898	0.940	0.927	0.965	0.942	0.963	0.956	0.918	0.983	0.998	0.997
	LCD	0.567	0.546	0.588	0.610	0.642	0.629	0.656	0.655	0.578	0.586	0.565	0.533
Shanghai	LC	0.854	0.840	0.851	0.846	0.850	0.854	0.830	0.842	0.863	0.845	0.805	0.838
	LCD	0.534	0.525	0.504	0.499	0.490	0.485	0.507	0.483	0.481	0.475	0.460	0.450
Jiangsu	LC	0.854	0.898	0.873	0.783	0.766	0.804	0.765	0.771	0.752	0.778	0.784	0.757
	LCD	0.689	0.724	0.710	0.651	0.649	0.679	0.650	0.651	0.636	0.657	0.654	0.624
Zhejiang	LC	0.679	0.790	0.763	0.766	0.779	0.763	0.793	0.740	0.780	0.775	0.786	0.760
	LCD	0.540	0.589	0.562	0.576	0.587	0.578	0.619	0.586	0.615	0.620	0.606	0.592
Fujian	LC	0.883	0.886	0.869	0.780	0.872	0.796	0.873	0.829	0.837	0.821	0.889	0.828
	LCD	0.597	0.606	0.588	0.533	0.590	0.551	0.610	0.577	0.616	0.623	0.643	0.601
Shandong	LC	0.829	0.824	0.837	0.750	0.729	0.716	0.791	0.855	0.852	0.823	0.865	0.879
	LCD	0.734	0.719	0.733	0.688	0.671	0.665	0.712	0.759	0.783	0.745	0.808	0.803
Guangdong	LC	0.686	0.682	0.711	0.686	0.696	0.702	0.731	0.722	0.720	0.716	0.743	0.723
	LCD	0.684	0.685	0.703	0.678	0.679	0.671	0.697	0.684	0.687	0.713	0.730	0.732
Guangxi	LC	0.818	0.827	0.840	0.747	0.799	0.838	0.907	0.888	0.920	0.927	0.919	0.930
	LCD	0.563	0.568	0.579	0.523	0.551	0.534	0.576	0.554	0.575	0.576	0.537	0.572
Hainan	LC	0.942	0.959	0.946	0.931	0.953	0.968	0.946	0.964	0.964	0.888	0.967	0.937
	LCD	0.557	0.581	0.559	0.558	0.560	0.575	0.548	0.567	0.562	0.517	0.537	0.521

(1) During the study period, the coordinated development degree of the supply-demand subsystem in 11 coastal areas of China is consistent, in which the coordinated development degree is between 0.261 and 0.998. Liaoning has the highest degree of coordinated development, with an average evaluation value of 0.952, whereas Tianjin has the lowest value, with an intermediate evaluation value of 0.5848. According to the discriminant criteria of the degree of coordinated development, 11 coastal areas are making efforts to progress from moderate imbalance to well-coordinated development between the year of 2006 to 2017. Although the coordinated development level of 11 coastal areas requires further improvement, the trend is moving towards a positive direction. Overall, it shows that the supply and demand of marine and land resources in 11 coastal areas do not correspond to the level of demand. The demand for marine and land resources is relatively ahead, but the supply of subsystems is relatively backward.

(2) The evaluation index of the overall effect of the supply and demand systems is the relationship between the degree of coordinated development and the carrying capacity of marine and land resources. The coefficient of coordinated development degree of Shandong and Guangdong is large, with an average value of more than 0.6, and its carrying capacity level is also high, with an average evaluation value of more than 0.6. The coefficient of coordinated development degree of Tianjin is small, and its carrying

capacity level is also low, with an average evaluation value of below 0.2. The average evaluation values in other regions are above 0.1 or below 0.6. This shows that once a well-coordinated development mechanism has been formed between the supply capacity of marine and land resources and the demand for economic and social development, the carrying capacity of regional marine and land resources can be improved.

(3) During the study period, the average value of the coordinated development degree of 11 coastal areas is 0.5707. From 2006 to 2017, the coordinated development degree of 11 coastal areas is greater than 0.5. There are great differences between the coordinated development degree and coordination degree in the 11 coastal areas, but the bending degree is the same from the time trend. The higher the coefficient of coordinated development between the two subsystems, the more harmonious the coordination relationship between them. In line with the actual situation, the coordination relationship between the two subsystems is also more harmonious in regions with higher economic development level. Areas of lower economic development level have many restrictions, so it is necessary to pay more attention to the coordination and consistency of promoting growth and benefits.

5.3. Spatial evolution of coordinated development

In order to analyze the spatial evolution of the coordinated development of marine and land resources supply capacity (economic and social development demand) subsystem in coastal areas, the ArcGIS software is used to draw the spatial evolution state of the marine and land subsystems, as shown in **Figure 1**.

| (a) Year 2006 | (b) Year 2017 |
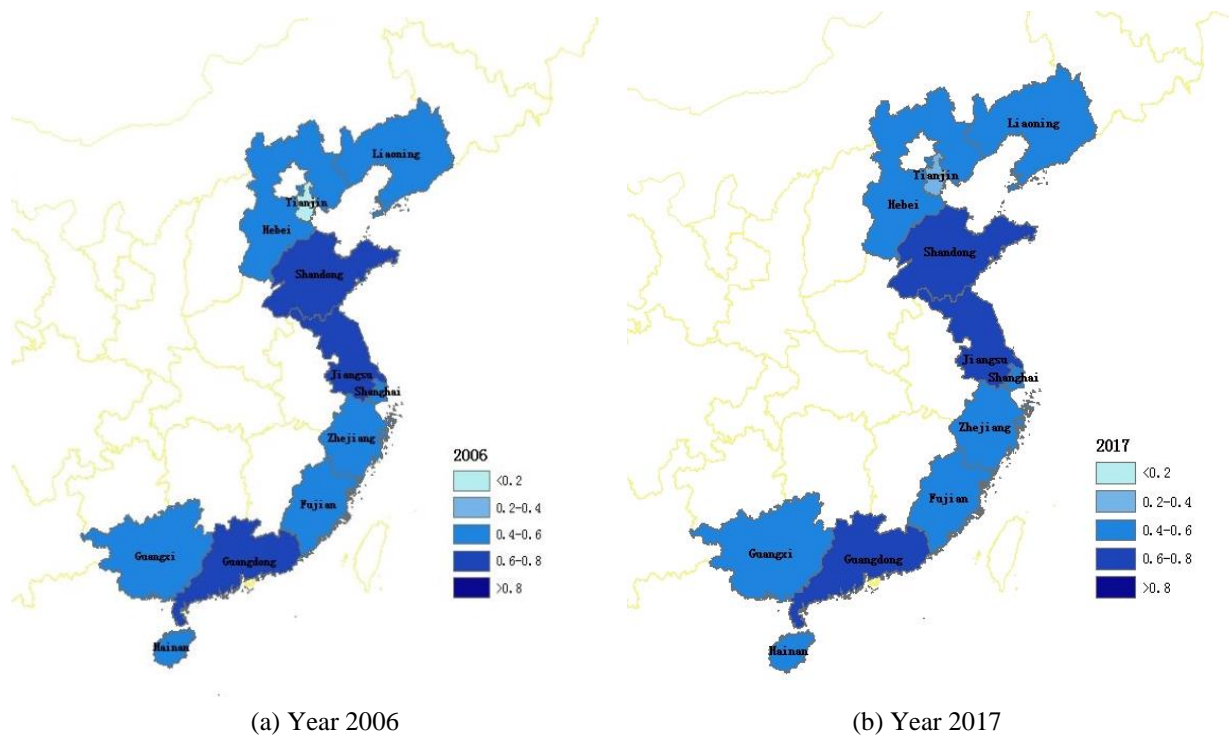
Figure 1. Collaborative spatial distribution of the marine and land subsystems in 11 coastal areas (2006-2017)

According to **Figure 1**, due to the differences in the natural environment, social economy, and industrial development among the coastal areas in China, the space for the coordinated development of marine and land resources in coastal areas is uneven. In view of the legacy and expansion of industries in spatial development, the coordinated development of marine and land resources in various provinces shares certain similarities. In 2006, the coordinated development value of Tianjin was less than 0.2, depicting a

serious imbalance; those of Shandong, Jiangsu, and Guangdong were between 0.6 and 0.8, in which the development was of moderate coordination; other regions were barely coordinated. In 2017, Shandong, Jiangsu, and Guangdong were in moderate coordination, while Tianjin was in moderate imbalance; other cities were barely coordinated.

Based on the evolution characteristics of the coordinated spatial distribution of marine and land subsystems in 11 coastal areas from 2006 to 2017, it shows that coastal areas should continue to improve the utilization efficiency of marine and land resources as well as appropriately promote social and economic development under national planning.

6. Conclusion

This paper uses the entropy method to calculate the evaluation value of the carrying capacity of marine and land resources in 11 coastal areas of China. Based on multiple indicators and time series combined with the coordinated development evaluation model, the degree of coordination and coordinated development between the two subsystems of marine and land resources supply capacity as well as the economic and social development demand capacity in coastal areas from 2006 to 2017 were measured. The following conclusions are presented in the following order:

(1) Through the index analysis of the supply-demand subsystem, the average demand level of economic and social development from 2006 to 2017 is higher than the supply capacity of marine and land resources, but the overall levels for both are not high. The imbalance between the supply and demand among regions is significant. However, the supply index of marine and land resources of each region is relatively balanced with the economic and social development demand index.

(2) According to the evaluation value of the 11 regions determined by the marine and land resources carrying capacity evaluation model, there are many regions in the state of overload. Therefore, it is crucial to improve the utilization rate of marine and land resources as well as promote the sustainable development of the economy and society in consideration of the actual development of the region and the experience of high carrying capacity regions.

(3) Based on the calculation from the coordinated development degree evaluation model, the average value of the coordinated development degree of the carrying capacity system of marine and land resources in the whole coastal area during the study period is 0.571, which reflects a barely coordinated development. The average value of the carrying capacity of marine and land resources is 0.8, which is in a state of slight overload. Although the corresponding coordinated development mechanism has been forming between the two subsystems, it has played a specific role in improving the carrying capacity of marine and land resources. However, most regions have advanced economic and social demand, indicating that rather than driving economic expansion blindly, the focus should be on the sustainable recycling of marine and land resources while promoting rapid and healthy economic and social development.

In conclusion, carrying capacity helps balance the issues of coordinated development resources, population, and environment. The purpose of marine and land resource carrying capacity is to coordinate the relationship among marine, land, economics, and society. This paper has shown that sustainable development should be taken into account while promoting the healthy and rapid development of the economy and society, rather than solely driving economic development.

References

[1] Dickens C, McCartney M, Tickner D, et al., 2020, Evaluating the Global State of Ecosystems and Natural Resources: Within and Beyond the SDGs. Sustainability, 12(18): 7381. https://doi.org/10.3390/su12187381

[2] Tang HX, Zhang XZ, Wang LX, 2020, Research on Temporal-Spatial Evolution Mechanism of Integration of Marine and Terrestrial Economy in China. China Soft Science, 12(0130): 1005-1016.

[3] Zhao L, 2018, Analysis on Coordination Degree of Land and Sea Industry in Coastal Provinces of China. CO-Operative Economy & Science, 02(04): 59-62.

[4] Hein AM, Martin BT, 2020, Information Limitation and the Dynamics of Coupled Ecological Systems. Nat Ecol Evol, 4: 82-90.

[5] Lu Y, Zhang Y, Bailey MJ, et al., 2019, Forty Years of Reform and Opening Up: China's Progress Toward a Sustainable Path. Science Advances, 5(8): eaau9413.

[6] Zhang H, Zhang Y, Zhang Y, et al., 2017, Evaluation of Comprehensive Land Carrying Capacity of Island Cities Based on Analytic Hierarchy Process Model: The Case of Zhoushan. China Soft Science, 01(10): 150-160.

[7] Zhong LD, Gai M, Ke LN, 2018, Spatio-Temporal Law and Coordinated Development of the Carrying Capacity of Marine Environmental Resource and Economic System in China. Acta Ecologica Sinica, 38(22): 7921-7932.

[8] Li A, Yang ZQ, 2018, Assessment of Marine Resource and Environment Carrying Capacity Based on Marginal Effect Analysis. Marine Development and Management, 04(07): 44-57.

[9] Tian RQ, Shao QL, Wu EL, 2020, Four-Dimensional Evaluation and Forecasting of Marine Carrying Capacity in China: Empirical Analysis Based on the Entropy Method and Grey Verhulst Model. Marine Pollution Bulletin, 160: 111675.

[10] Li RM, Yin ZQ, Wang Y, 2018, Geological Resources and Environmental Carrying Capacity Evaluation Review, Theory and Practice in China. China Geology, 1(4): 556-565.

[11] Gai M, Song QM, 2018, Development of Liaoning Coastal Economic Zone Marine resources and Environment Carrying Capacity and Economic Coordination. Resource Development & Market, 34(6): 89-102.

[12] Lai M, Jiang JL, Xie M, et al., 2021, Research Progress on Evaluating Marine Resources and Environment Carrying Capacity. Ecological Economy, 37(07): 75-87.

[13] Zhe Y, Di QB, 2020, The Coordination between Maritime Economies and Marine Carrying Capacity and Their Spatiotemporal Evolution in the Cities of the Bohai Rim in China. Ecological Modelling, 438: 109192.

[14] Imane A, Bentounsi M, Achtaich N, 2018, Carrying Capacity Influence on the Incomes of Seiners Exploiting Marine Species in the Atlantic Coast of Morocco. Mathematical Biosciences, 305: 10-17.

[15] Du YW, Wang YC, 2021, Evaluation of Marine Ranching Resources and Environmental Carrying Capacity from the Pressure-and-Support Perspective: A Case Study of Yantai. Ecological Indicators, 126: 107688.

[16] Di Q, Wu T, 2018, Spatio-Temporal Evolution Characteristics and Influencing Factors of Marine Resources Carrying Capacity in China. Geography And Geo-Information Science, 34(1): 123-135.

[17] Sun Yu, 2013, Analysis of Coordinated Development Degree of Comprehensive Land Carrying Capacity in Shandong Province. Resources and Environment, 2013(11): 123-129.

[18] Liu R, Liu R, Pu L, et al., 2020, Coastal Resource-Environmental Carrying Capacity Assessment: A Comprehensive and Trade-Off Analysis of the Case Study in Jiangsu Coastal Zone, Eastern China. Ocean and Coastal Management, 186: 105092.

[19] Mu TW, Huang LH, 2020, Analysis on Time, Space and Driving Force of Coordinated Development of Marine and Terrestrial Economies in Coastal Provinces and Cities of China. Hubei Agricultural Sciences, 59(23): 189-196.

[20] Xu S, 2019, Study on the Coordination and Economic Interaction Efficiency Evaluation of Land-Marine System in China. Journal of Shandong University (Health Sciences), 6: 126-134.

[21] Wang C, Xie YC, 2018, Study on Coordinated Development of Marine and Land Economy in Coastal Provinces Based on DEA Window Model. Science & Technology and Economy, 020(3): 78-92.

[22] Su ZL, Yuan GH, 2016, Research Overview of Marine Carrying Capacity in China. Resources & Industries, 18(6): 69-78.

[23] Sun FH, Ye CL, 2021, Modeling of the Ecological Carrying Index of reclaimed Land in Coastal City: A Sustainable Marine Ecology Perspective. Environmental Research, 201: 111612.