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Construction of coastal mineral zone development suitability evaluation model based on remote sensing

In order to make full use of the resources in the coastal zone, a kind of method for the construction of the suitability evaluation model for the coastal zone development on the basis of the automatic extraction algorithm based on the remote sensing information is put forward. In this paper, the coastal zone of Zhejiang province is taken as the research area. The sampling data and social and economic development data are combined to construct the coastal zone development suitability evaluation model based on the factors in three dimensions, that is, the social factors, the economic factors and the natural factors. The remote information automatic extraction algorithm is used to carry out the evaluation on the geological environment suitability for the region. It is shown in the studies that the model has good user interface and operability, which can better serve the evaluation on the suitability of the geological environment in the development of the coastal zones, and provide a kind of new idea for the evaluation on the suitability of the coastal zone development.

Keywords: Component merchant, formatting analysis, style arch, insert styling, remote sensing information, development suitability, coastal zone, automatic extraction algorithm.

1. Introduction

The coastal zone is an area where the land, the sea and the atmosphere interact with each other. It is a special area where the ocean system interacts with the land system, which is the most active region with the most abundant natural phenomena and processes on the surface of the earth, and also an area with the most advantageous categories of resources, the environmental conditions and the geographical locations (Lee and Lim, 2013; Meksumpun and Meksumpun, 2011). With the acceleration in the development of the modern industry and the acceleration of urbanization, the ecological environment of the coastal zone is facing many problems: the expansion of the population scale and urbanization; the rise of sea level and the coastal erosion; the shortage of fresh water resources and the deterioration of the water environment; the degradation of the fishery resources (Magarotto and Pontes, 2014; Bickle 2015). In 1972, the concept of sustainable development was first put forward at the UN Human Environment Symposium held in Stockholm. And the theory and related research of the regional sustainable development began to attract the attention of many scholars. The sustainable development of coastal areas has also become an important issue (Makowski and Rusenko, 2013; Rizal and Kadir, 2012). In recent years, there have been more and more disputes among the countries in the world on the oceans, and the importance of oceans, including the coastal resources, has begun to gain more attention. The coastal zone development suitability refers to the capacity of the coastal zone to withstand the population and industrial scale within a certain period of time and characteristics and under a certain level of technology, the sustainable development of the coastal zone resources and environment as the principle, with the goal of sustainable economic development of the coastal zone (Arndt and Lancelot, 2011). It can provide early warning of the specific environmental or resource factors from a sustainable perspective, so that the ecosystems can maintain at a healthy balance. Therefore, the evaluation of the suitability of the coastal zone development can be used as an index of the sustainable development of the coastal areas (Weschenfelder and Santos, 2014; Torresan, 2012).

With the changes in the concept of the development suitability of the coastal zones through the development of the physical coastal zone suitability - the development of the ecological coastal zone suitability - the development suitability, the scope covered by the concept becomes more complicated. At present, its evaluation methods mainly include four categories as the following: Logistic method for the number of population, the resource supply and demand balance method, the ecological footprint method, the energy analysis method, the natural vegetation net primary productivity estimation method, the resource and demand difference method, the index system method and the system model method. These studies and methods are scientific, which also have certain limitations. For example: in view of the method that the complexity of factors cannot be reflected. Suitable method cannot be identified due to the changing environmental characteristics. In addition, the suitability of the coastal zone in particular is rarely explored. On the basis of the studies on the related suitability of the relevant coastal zone development, the concept of the suitability of coastal zone development, the evaluation index system, and

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the quantification method are put forward. With the aid of the state-space method, the quantitative measurement of the suitability of the coastal zone in the sea and the prediction of the trend of the sea-borne bearing status are carried out. Combined with the actual conditions of the coastal marine ecological environment in China, the principle for the selection of indexes is determined. And through the analysis of the local social, economic, resource, and ecological and environmental factors, an index system suitable for the evaluation of the suitability of the coastal eco-environmental development in China is constructed. In accordance with the conceptual model of the “driving forces” (pressure)-state-response (P-S-R) index system, preliminary exploration is carried out on the construction of the suitability evaluation index system for the coastal zone coastal development. A kind of methodology for the evaluation of the growth limit of the number of people in tourism destinations is used. And a kind of mathematical formula to establish the limits of growth is adopted, which is suitable for the study of the open coastal zone carrying capacity. These studies have added a lot of theoretical and practical experiences for the study of the suitability of the coastal zone development, but the studies of the coastal zone are still far from enough. This has prompted the researchers to look for new methods to study the suitability of the coastal zone development. In this paper, the automatic extraction algorithm of the remote sensing information in geography science is used to study the suitability of the coastal zone development and the automatic extraction algorithm of the remote sensing information. On the basis of the improvement, it will be more in line with the actual conditions of the coastal zone.

2. Overview of the study area

The coastal zone in Zhejiang is the intersection point of the coastal north-south route and the Yangtze river waterway in China. It is also one of the main passageways for the north-south shipping in our country and the international routes in the Far East. The sea area of Zhejiang province is 2.08×104 km^2, and the total coastline length is 2,444 km. In 1972, the U.S. Government promulgated the “Coastal Zone Management Act”. In 2001, the United Nations also defined the specific scope of the coastal zone in the "Millennium Ecosystem Assessment". The definition of the coastal zone in our country was clearly put forward at the 147th Xiangshan Science Conference, that is, the range of extending 10 km from 0m fathom line to the land, and 15 m fathom line underwater to the sea. On the basis of this concept, the boundary of the coastal zone studied in this paper is as the following: the range extending from the 0 m fathom line to the land to the coastal prefecture-level

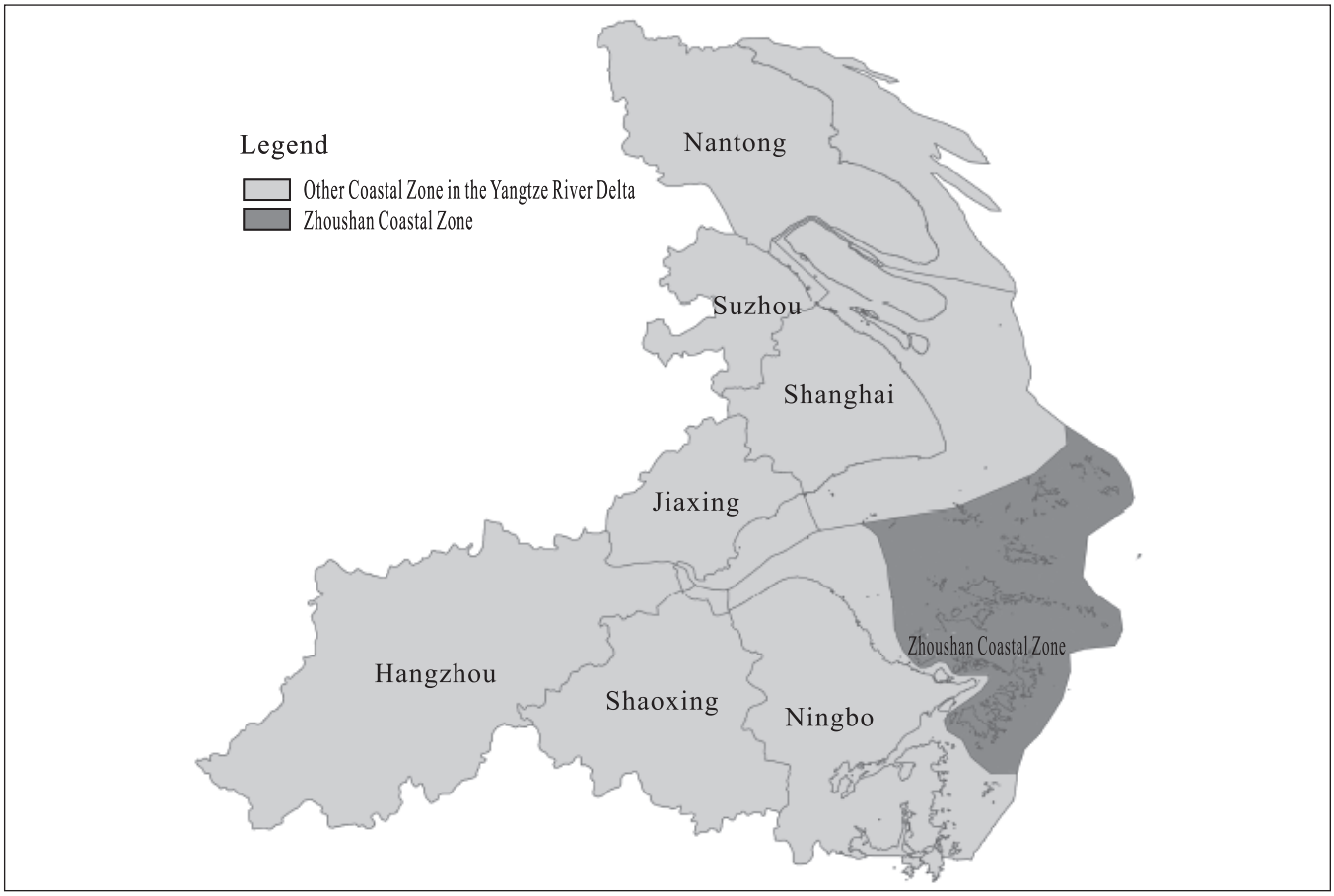

Fig. 1: Zhejiang coastal zone study area map

city (county), and 10 m fathom line underwater to the sea; that is to say, for the coastal zone of Zhejiang province, it is extending from 0 m fathom line to the land of Zhejiang province and its counties, and 10 m fathom line underwater to the sea (Fig. 1).

3. Construction of the coastal zone development suitability evaluation model

With the advancement in networking and multimedia technologies it enables the distribution and sharing of multimedia content widely. In the meantime, piracy becomes increasingly rampant as the customers can easily duplicate and redistribute the received multimedia content to a large audience.

In the studies of the suitability of the coastal zone development, the suitability of the coastal zone development is the relationship between the supply volume in the entire system and the human consumption (human demand). There is the synthetic aggregate supply-synthetic aggregate demand model in the geographical science, that is, the synthetic aggregate demand and the synthetic aggregate supply are placed on a coordinate graph to explain the decision for the national income and the price level, investigate the reasons for the price changes, as well as how to achieve the balance between the synthetic aggregate demand and the synthetic aggregate supply in the social economy (Fig. 2). In view of this model, the relationship of the system supply and the human consumption demand is combined to calculate the suitability of the coastal zone development.

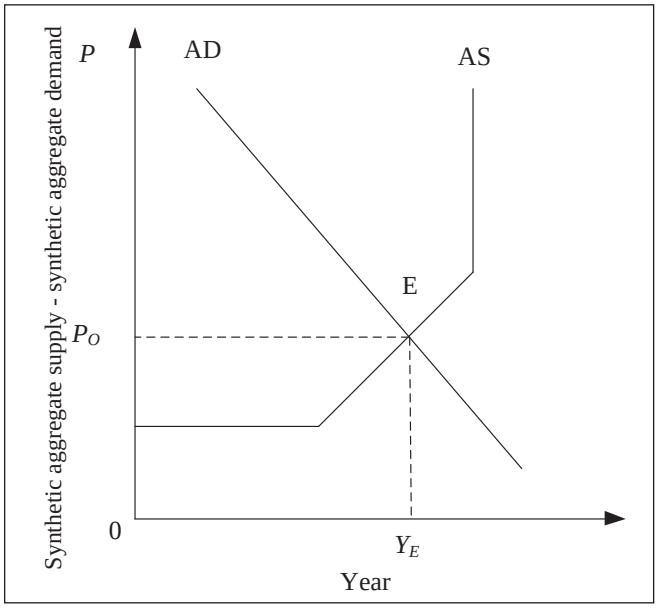

Fig. 2: Synthetic aggregate demand - synthetic aggregate supply model (automatic remote sensing information extraction algorithm)

AD: Synthetic aggregate supply; AS: Synthetic aggregate demand; Y: Year; P: AD or AS value; P0: P value at certain moment; YE: certain year; E: P value (When AD=AS)

3.1. Coastal zone development suitability evaluation model

The remote sensing information automatic extraction algorithm combines Keynesianism, classicism, rational expectation and monetarism on the basis of the synthetic aggregate supply function and the synthetic aggregate demand function. It is a tool that the Keynesian mainstream school – the neoclassical synthesis school used to analyze the national income decisions. On the basis of the Keynes's income-expenditure model and the Hicks' "Hicks-Hansen Model", the synthetic aggregate demand and the synthetic aggregate supply are further combined to explain the national income decisions and the related economic phenomena, which are the supplementation and the amendment to the first two models: The synthetic aggregate demand-synthetic aggregate supply model is expressed with the formula as the following:

$$AD = f(p); AS = f(y); AD = AS \quad (1)$$

In the equation, *AD* stands for the synthetic aggregate demand index; stands for each demand factor; *AS* stands for the synthetic aggregate supply index; *p* stands for each supply factor, *AD=AS* stands for a state in which the synthetic aggregate supply and synthetic aggregate demand reach a balance.

The remote sensing information automatic extraction algorithm is generally applied in the geographical science. When it is applied to the ecology, it needs to be further improved. The concept of system synthesis added is a kind of application of the remote sensing information automatic extraction algorithm in the studies of the development suitability.

In the evaluation model of the coastal zone development suitability, it is assumed that the system is at a certain point in time, generally a certain year. Among them, the horizontal coordinates stand for the demand in the regional ecosystem, including the demand and the consumption of the resources and environment, as well as the various pressure factors, the consumption factors and the negative communication factors which have the pressure on the entire system. The vertical coordinates stand for the sum of the own productivity in the system, the social and economic boost as well as its support force and the positive communication factor. The model stands for the proportion status of the synthetic aggregate supply and the synthetic aggregate demand of the time points. And this status is located in the region that is composed of the two coordinates. With the change in the horizontal and vertical coordinates, the location is shifted, which is the ratio of the synthetic aggregate supply SAS to the synthetic aggregate demand SAD, with the formula as the following:

$$T = \frac{SAS}{SAD} \quad (2)$$

In the equation, *T* stands for the state value of the

development suitability at a certain time point; *SAS* stands for the system synthetic aggregate supply; *SAD* stands for the system synthetic aggregate demand.

The coastal zone development suitability evaluation model performance system is expressed in the time dimension, which is generally a certain state for several years. Among them, the horizontal coordinates stand for the time dimension, the vertical coordinates stand for *T* value. The long-term model is the deepening of the short-term model. It is of practical significance to explore the development suitability in the time axis, which is conducive to mastering the dynamic trends and the dynamic changes in the suitability of the coastal zone development.

The mathematic expression of the model for the evaluation of the coastal zone development suitability is as the following:

$$S = P + J + K + Z + I \tag{3}$$

In the equation, *S* stands for the synthetic aggregate supply index; *P* stands for the supply index of the coastal zone resources; *J* stands for the index of the coastal zone economic development level; *K* stands for the support index of the coastal zone science and technology; *Z* stands for the social support index of the coastal zone; *I* stands for the positive exchange factor index of the coastal zone. In the equation 3, each of the affecting factors (also referred to as the bearing factor) is a dimensionless number, which is a comprehensive synthetic aggregate supply model of the system. For the aforementioned sub index models, the affecting factors are not single, in reference to the formula for the total amount of the ecological assets that is applied in a certain region in the measure of the global ecological assets, the calculation of each sub model is as the following:

$$P = \sum_{i=1}^{n} P_i \times C_i \tag{4}$$

$$J = \sum_{i=1}^{n} J_i \times C_i \tag{5}$$

$$K = \sum_{i=1}^{n} K_i \times C_i \tag{6}$$

$$Z = \sum_{i=1}^{n} Z_i \times C_i \tag{7}$$

$$I = \sum_{i=1}^{n} I_i \times C_i \tag{8}$$

In the equation, *i* stands for the factor ranking number of each index, X_i stands for the index factor, and C_i stands for the weight of each index.

The synthetic aggregate demand model includes the human consumption of the resources and the environment, as well as various stress factors and negative exchange factors that have pressure on the entire system. And the model for the synthetic aggregate demand is as the following:

$$D = Y + Q + H + I \tag{9}$$

In the equation, *D* stands for the synthetic aggregate demand; *Y* stands for the coastal zone community pressure index; *H* stands for the coastal zone environmental pressure index; *Q* stands for the coastal zone development intensity index; and *I* stands for the system negative communication factor. In reference to the establishment of each sub index model in the aforementioned synthetic aggregate supply, the automatic calculation formula for the remote sensing information extraction of each sub model in the synthetic aggregate model is as the following:

$$Y = \sum_{i=1}^{n} Y_i \times C_i \tag{10}$$

$$H = \sum_{i=1}^{n} P_i \times C_i \sum_{i=1}^{n} H_i \times C_i \tag{11}$$

$$Q = \sum_{i=1}^{n} Q_i \times C_i \tag{12}$$

$$I' = \sum_{i=1}^{n} I_i \times C_i \sum_{i=1}^{n} I'_i \times C_i \tag{13}$$

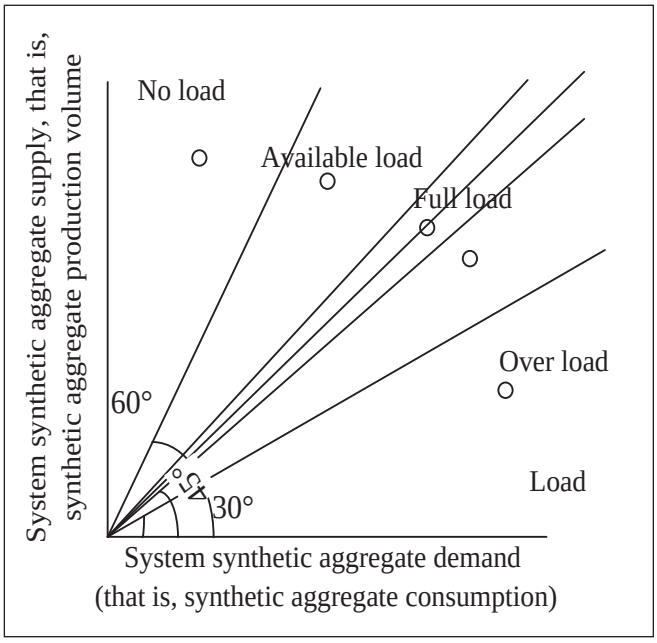

Fig. 3. Diagram of the basis for the evaluation of the development suitability of the coastal zone

For the final results of the suitability of the coastal zone development, the final results of the coastal zone development suitability can be divided into three cases on the basis of the difference relation between the demand of the population or human activities for the resources and the environment and the actual supply capacity of the resource and environment: When RCC > 1, it can be loaded; when RCC = 1, it is fully loaded; when RCC < 1, it is overloaded.

Taking the specificity of the coastal zone and the micro scale of change in the development suitability year by year into consideration, the development suitability results can be

divided into 5 categories in accordance with the ratio of the synthetic aggregate supply to the synthetic aggregate demand on the basis of 3 classes: no load, available load, full load, over load and load. The ratio of the synthetic aggregate supply to the synthetic aggregate demand is denoted by the angle θ, T stands for the size of $tan\theta$, and 30°, 45° and 60° of θ are used as the dividing line of each result. In accordance with the classification of the $tan\theta$ in Fig. 3, the results of the development suitability of the coastal zone can be divided into 5 cases: $R>\sqrt{3}$ (when $\theta>60^{\circ}$) no load; $\sqrt{3}>R>1$ (when $60°>\theta>45°$) available load; $R=1$ (when $\theta=45^{\circ}$) full load; $\sqrt{3}/3<R<1$ (when $45^{\circ}>\theta>30^{\circ}$) over load; $R<\sqrt{3}/3$(when $\theta<30^{\circ}$) load. Among them, $\sqrt{3}=1.732$, in order to facilitate the calculation, it is set to 1.8. That is, the classification results are as the following: when $R>1.8$, no load; $1.8>R>1$; available load =1 full load; $0.6<R<1$ over load; $R<0.6$ load. For a certain point in the full load region in the system model, in combination to the actual situation, the full load standard is set to the tolerance, and its value is 0.2. As shown in Fig. 4, the classification result obtained at last is as the following: When $R\geq1.8$, it indicates full load; when $1.8>R>1.1$, it indicates available load; when $0.9\leq R\leq1.1$, it indicates full load; when $0.6<R<0.9$, it indicates over load; when $R\leq0.6$, it indicates load.

3.2. Establishment of the Development Suitability Evaluation Model Index System

The development of the coastal zones is special, complex and open. It has the characteristics of both terrestrial ecosystem and marine ecosystem. It is a coupled system that integrates the society, economy, resources and the environment. It is selected in accordance with the following principle when selecting the coastal zone suitability evaluation model as the following: the principles of the scientificness, the comprehensiveness, the representativeness, the operability, the stability and the time sequence. In the factor selection, three main factors are mainly considered: social factors, natural factors and economic factors. With reference to the studies of a thousand people and in combination with the actual conditions, the evaluation index system for the coastal zone development suitability is shown in Table 1. Taking into consideration that the indexes used in this research do not always have clear national regulatory documents to stipulate, there are no clearly defined indexes. The average value of the area higher than the study area or the value of the more predecessor area at the same level is selected as the standard value. In accordance with different evaluation purpose and the data conditions, the ideal value is selected flexibly so that the suitability value of the coastal zone development can better reflect the issues in the actual coastal zone.

The overall consideration of the comprehensiveness and the balance has been given to the selection of indexes. Therefore, the method of directly using the average weight is also using the equal weight method to calculate each index: Each index has the weight of 1, if there are n factors in the index, then the weight of each factor is $\frac{1}{n}$. In the end, the suitability evaluation system for the coastal zone development is shown in Table 1.

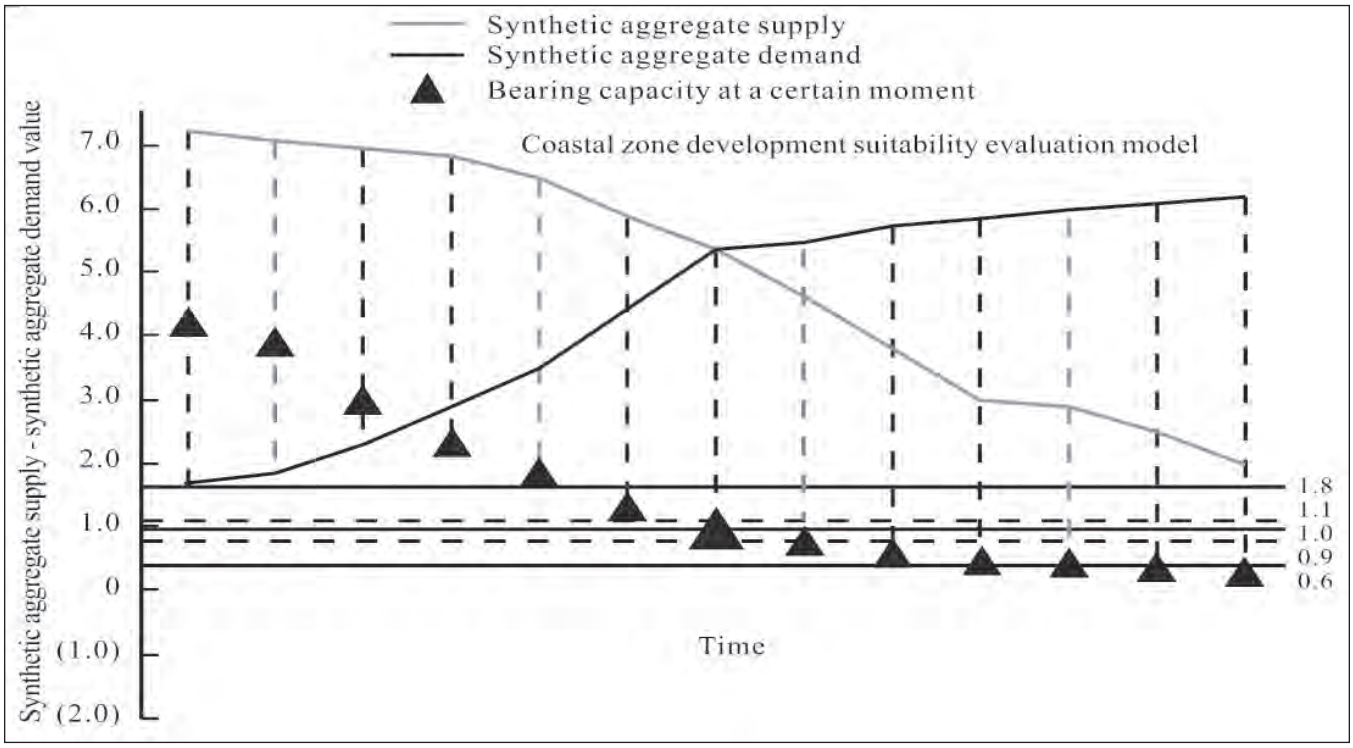

Fig. 4: Coastal zone development suitability analysis diagram

Table 1. Coastal zone suitability evaluation model construction index system

	First imdex system	Second index system	Unit	Standard	References	Weight
Synthetic aggregate supply	Coastal zone resources supply index	Per capita water resources	m^3/person	2350	4	0.2
		Per capita green area	m^3/person	11	1	0.2
		Per capita net primary productivity of the vegetation	g.c/person	240	4	0.2
		Vegetation coverage	%	23	4	0.2
		Fishery resources (including fishing output and aquaculture output)	104t	16.85	4	0.2
Synthetic aggregate demand	Coastal zone economic development level index	Per capita GDP	¥/person	25000	1	0.25
		Marine economic output	10¥/person	2.19	4	0.25
		Tertiary industry as a percentage of GDP	%	45	1	0.25
		Per capita sea salt output	t/person	0.07	4	0.25
	Science and technology support condition index	Students enrollment of regular institutions of higher education per 10,000 people	P	479	4	0.5
		Scientific research and development as a percentage of GDP	%	2.5	2	0.5
	Social support condition index	Number of hospital beds per one hundred people	PCS	0.65	4	0.33
		Environmental protection expenditure	%	3.5	1	0.33
		Per capita road area	m^2	28	3	0.33
	Forward exchange index	Port throughput	104t	59205	4	0.5
		Foreign investment as a percentage of GDP	%	0.05	4	0.5
	Coastal zone social pressure index	Unqualified industrial wastewater discharge rate	%	20	1	0.25
		Unqualified solid waste discharge rate	%	10	1	0.25
		Unit industrial added fresh water consumption	m^3/104¥	20	1	0.25
		Energy consumption per 10,000 yuan of GDP	t/104¥	0.9	1	0.25
	Coastal zone development intensity index	Annual GDP growth rate	%	8.2	4	0.25
		Natural population growth rate	‰	-1.02	4	0.25
		Beach reclamation area	km^2	3197	4	0.25
		Permanent population density	person/ km^2	532	2	0.25
	Environmental stress index	SO_2	kgt/104¥	5	1	0.5
		Water quality in coastal waters	* *	Achieve the functional area standard and no inferior V class water body in the city	1	0.5
	System negative exchange index	Engel coefficient	%	40	1	0.5
		Per capita export amount	$/person	1692	4	0.5

* 1 indicates in reference to the evaluation index for the construction of the ecological city; 2 indicates the confirmation in reference to the modern urban standard s; 3 indicates the confirmation or reckoning in reference to the urban construction standard in the international developed countries; 4 indicates the confirmation in reference to the optimal value or relatively good value of the domestic urban construction

There are significant differences in the indexes of the suitability of the coastal zone in terms of magnitude and unit dimension, and it is not convenient to directly compare and calculate. Therefore, it is necessary to eliminate the effect of the dimensionality of the original data, that is, to standardize the data. There are ideal values in the index system. Hence, in this paper, through the comparison of the actual index value and the ideal index value, various index values are standardized. The formula is as the following:

$$X_i = \frac{K_i}{K'_i} \tag{14}$$

In the equation, X_i stands for the value of each index after the normalization, K_i stands for the raw data, K'_i stands for the value of the ideal reference ratio for each index.

4. Results and analysis

With reference to the Zhejiang Statistical Yearbook 2006-2010, in combination with the synthetic aggregate supply and synthetic aggregate demand model constructed by the coastal zone suitability evaluation model, the coastal zone development suitability value is obtained through the data processing and the calculation of the coastal zone development suitability evaluation model. In addition, in accordance with the classification standard, the coastal zone development suitability level (Table 2) is obtained, and the coastal zone development suitability evaluation is shown in Fig. 5.

Table 2. Suitability indexes of zhejiang coastal zone development from 2005 to 2009

Year	2005	2006	2007	2008	2009
System synthetic aggregate supply	5.623	5.376	5.641	5.679	5.763
System synthetic aggregate demand	3.606	3.297	3.416	3.026	3.166
Coastal zone development suitability	1.559	1.630	1.651	1.877	1.820
Coastal zone development suitability level	Available load	Available load	Available load	No load	No load

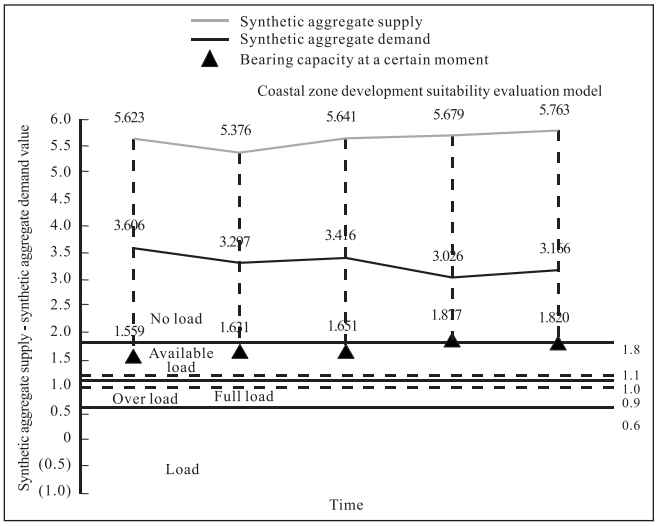

Fig. 5: Evaluation of coastal development suitability from 2005 to 2009

Judging from the synthetic aggregate supply of the system, from 2005 to 2009, the synthetic aggregate supply of the coastal zone development does not have substantial change, which is in the range of 5.3 to 5.8. Only in 2006, the synthetic aggregate supply value was slightly reduced, which started to fall back since 2007. In the subsequent years, it has always been in the state of slight increase. It reached 5.763 in 2009. From the perspective of the synthetic aggregate demand of the system, from 2005 to 2009, the synthetic aggregate demand index value of the coastal zone system in Zhejiang declined in a zigzag trend. The increase and decrease between the adjoining years were in the opposite direction. However, there was not much difference in the value. Basically, it was between 3.0 and 3.7. Although there were ups and downs between the years, the value of appreciation was always less than the value of declination, which made the synthetic aggregate demand show a decreasing trend in general. From the results of the long-term and short-term SAD-ASA model, the suitability values for the coastal zone development in 2008 and 2009 are all on the upper side of the line, indicating that the suitability of the coastal zone development is in a no-load level. However, the suitability of the coastal zone development during 2005-2007 is within the area that can be loaded, which suggests that the suitability of the coastal zone development in each year is dynamically changing. In the long-term model, we can see for the change in the synthetic aggregate supply and the synthetic aggregate demand, the synthetic aggregate supply is always greater than the synthetic aggregate demand. It suggests that the development of the coastal zone in Zhejiang is always within the range that the ecological environment can withstand. Hence the entire ecosystem is in a relatively healthy state.

5. Conclusions

In this paper, the coastal zone of Zhejiang province is taken as the study area, and the evaluation model of the coastal zone development suitability is constructed by using

the automatic extraction algorithm of the remote sensing information in geography, and an index system is built to evaluate the suitability of development. For the construction of the suitability model for the coastal zone development, it is necessary to continue to explore and improve. First of all, on the issue of indexes, the suitability index system for the coastal zone coast development needs to be further improved, and efforts should be made to solve the problem of obtaining the marine indexes. Secondly, the impact of the human activity on the ecological environment of the coastal zone cannot be ignored. However, it is also very difficult to estimate, or it is difficult or impossible to quantify, which makes it more difficult to calculate the suitability of the coastal development. In the future, the estimation of the suitability evaluation of the coastal development can make use of a series of methods to quantify the human activities to bring the calculation for the suitability of the coastal zone development closer to the actual situation. In this research, studies on the ecology, geography, statistics and other common cross-disciplinary studies are carried out. In addition, cross-disciplinary studies with the geographical science are also carried out. The demands for the supply of social systems and those for the supply of ecosystems in the geography science have certain similarities. The synthetic aggregate supply and the synthetic aggregate demand in the geographic science are similar to the synthetic aggregate supply of synthetic aggregate demand in the system, which makes it possible for similar applications. The application of the remote sensing information automatic extraction algorithm is a kind of new idea and new method for the development suitability theory. It is also a powerful instance to learn from other disciplines and the superiority of learning. The cross-disciplinary studies of the ecology and other disciplines will bring new prospect to the development.

Acknowledgements

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