DEVELOPMENT OF EVALUATION SYSTEM OF COASTLINE RESOURCE IN DAFENG

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ABSTRACT

Coastline is one type of valuable non-renewable resources. From the perspective of economic theory, it can gather population, promote traffic construction, and then improve the level of international trade. The research object of this paper is the coastline resource in Dafeng area. Firstly, we have a brief summary of the existing coastline evaluation literature, then introduce the location and natural attributes of the coastline resources in Dafeng. Following that, the Analytic Hierarchy Process (AHP) model is used to build the economic evaluation index system based on the characteristics of coastline in Dafeng. Specially, this index system consists of 6 factors, and a total of 41 detailed indicators were chosen including water depth, GDP, etc. On this basis, we use the assignment method to quantify the weight of each index, and calculate the comprehensive score of coastline resource by using the YAAHP software. The final conclusion is as follows: The total score of economic evaluation of coastline resource in Dafeng is 0.87. Therefore, the coastline resource in Dafeng will eventually be constructed a unique coastal economic zone, where the implemented port industrial projects will include shipbuilding, logistics, mechanical processing etc.

INTRODUCTION

As coastline resource is an important natural resource, scientific evaluation is a prerequisite for the efficient use of this valuable resource. Therefore, research on coastline especially the evaluation of it has been a hot topic in academic circles for a long time. However, in the existing research on coastline resource evaluation, researchers mainly use GIS or engineering index system methods to study it based on geography theory. And there are few studies focus on the comprehensive utilization of coastline resource from the perspective of economics. Though, some scholars have done the research on coastline using some special economic methods in recent years, they still ignore the economic characteristics of coastline resource. Besides, the main objects of these studies are port coastline resource, few of them are aimed at silt coastline[1,2,3,4,5]. To solve the above drawbacks, this paper constructs the economic evaluation index system which meets the characteristics of coastline resource. Then, using the AHP method to get the weight of various indicators, and evaluate the utilization of coastline finally.

The research object of this paper is the coastline resource in Dafeng area. Obviously, this coastline is located in Dafeng City. In this place, the depth of the water is about 15m and it is stable. Meanwhile, the length of the coastline is about 55km, and the width of -15m isobath is a bout 3-4km. 100000 ton-ships can enter this area. The east side of Dafeng coastline is the small sand, it is a natural barrier and can prevent the

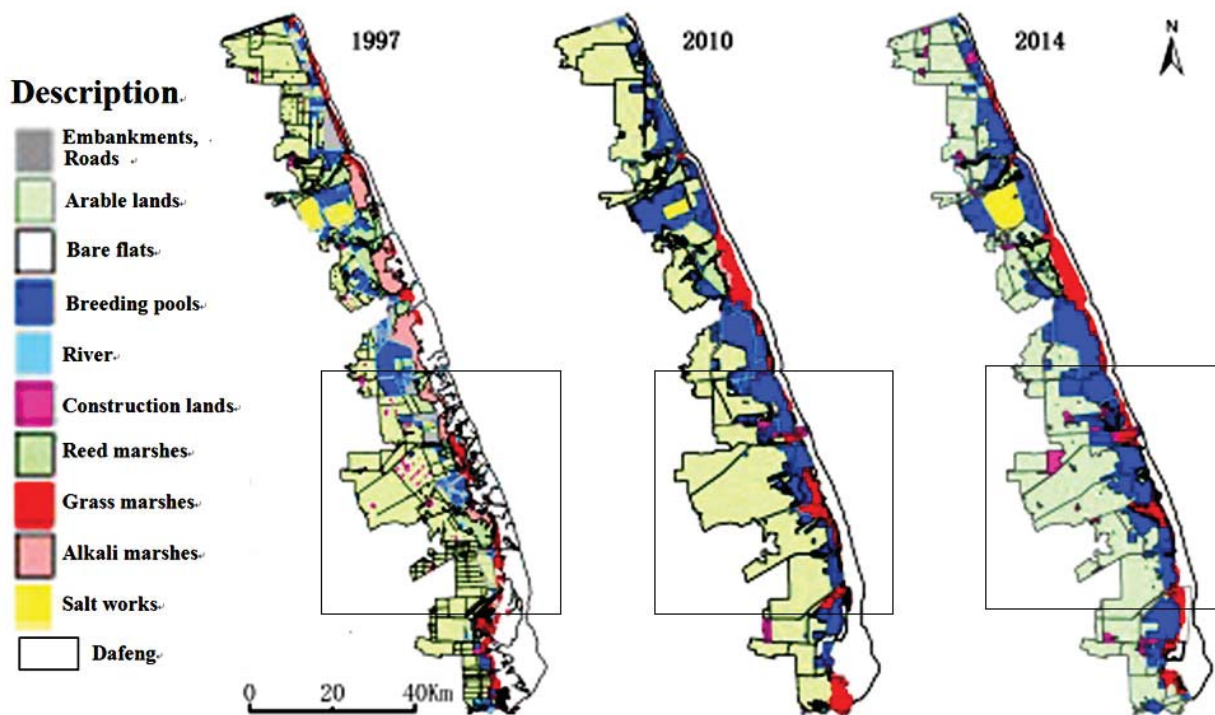Fig.1. The location of coastline resource in Dafeng

Fig.2. The TM Remote sensing image of coastline resource in Dafeng

coastline from the erosion of wind and waves. The average velocity of small tide is 0.56-1.2 m/s and the average velocity of large tide is 0.83-1.26 m/s. The coastline in Dafeng area is not frozen all year round and can be used for more than 300 days per year. The location and the TM Remote sensing image of coastline resource in Dafeng are shown in Fig.1 and Fig.2 respectively.

METHODS

THE PRINCIPLE OF THE MODEL

In this paper, the Analytic Hierarchy Process (AHP) method is used to evaluate the development of coastal resource. The model of AHP method covers the following 5 steps:

1. The establishment of hierarchical model

    The problem is divided into three specific levels according AHP method: the first level is the Target Hierarchy, it
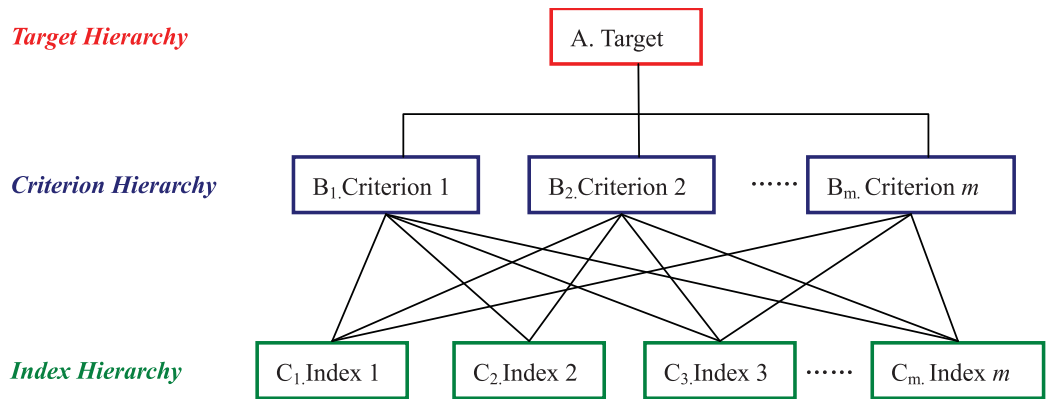
Fig.3. The schematic diagram of the AHP model

represents the goal to be resolved; the second level is the Criterion Hierarchy, it will refine the target to the relevant secondary indicators; the third level is the Index Hierarchy, it will further refine the detailed indicators. The schematic diagram of the AHP model is shown in Fig.3.

2.   The construction of judgment matrix

The judgment matrix is used to determine the relative importance of each element in the hierarchy (for an element of the previous hierarchy), the number 1-9 and its reciprocal usually used to present the value of it. The meaning of the value of the judgment matrix is shown in Tab.1:

Tab.1. The meaning of the value of the judgment matrix

The value	The meaning of the value
1	The factor i is as important as the factor j
3	The factor i is **slightly** more important than the factor j
5	The factor i is **significantly** more important than the factor j
7	The factor i is **very** more important than the factor j
9	The factor i is **extramly** more important than the factor j
2,4,6,8	Half of the value of the above situation
reciprocal	The reciprocal representation of the above situation

3.   The single sequence of the hierarchy

The single sequence of the hierarchy is the process of determining the weight of the sequence of importance of the elements associated with it (for an element in the previous hierarchy). Its specific method of operation is to calculate the eigenvalues and eigenvectors of the judgment matrix. For the judgment matrix A, the eigenvalues and eigenvectors satisfying $AW = \lambda maxW$ are calculated. Where λmax is the largest eigenvalue of A, W is the normalized eigenvector corresponding to λ max, the component Wi of W is the weight value of the corresponding element single sequence[6,7].

For the judgment matrix A, if $a_{ij}=a_{ij}/a_{jk}$ $(i,j,k=1,2,3,\dots,n)$ is satisfied, it is said to be fully consistent. But this situation is generally impossible to achieve, so it is necessary to conduct a consistency check on the basis of the single sequence of the hierarchy. Then the consistency index CI of the measurement matrix A have to be calculated ($n> 1$ order square matrix), where $CI= (\lambda_{max}-n) / (n-1)$. When $CI = 0$, A is called fully consistent. And there is the greater the CI, the worse the consistency of A. The consistency ratio CR and the average random consistency index RI are introduced to test whether the judgment matrix A has a satisfactory consistency. The values of RI are shown in Tab.2.

Tab.2. The values of RI

Order (n)	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

When $CR <0.1$, the judgment matrix A has a satisfactory consistency; otherwise, when $CR \geq 0.1$, the consistency of the judgment matrix A can not be accepted, and it needs to be adjusted until it is satisfied.

4.   The total sequence of the hierarchy

Calculate the same level of all factors for the highest level (the total target) relative importance of the sorting weights, called the total ranking of the hierarchy. If the previous hierarchy A contains the m elements A_1, A_2, ..., A_m, the value of the total sequence of the hierarchy A are $a_1, a_2, \dots, a_m$. The weights value of the n elements B_1, B_2, ..., B_n of the next hierarchy B are b_{1j}, b_{2j}, ..., b_{nj} respectively (where $b_{ij} = 0$, if B_i is not associated with A_j), then the value of the total sequence of the hierarchy B are shown in Tab.3.

Tab.3. The schematic diagram of the toal sequence of the hierarchy

| Sequence | A_1 | A_2 | ... | A_m | The toal sequence of the hierarchy |
	a_1	a_2	...	a_m	
B_1	b_{11}	b_{12}	...	b_{1m}	$\sum_{j=1}^{m} a_j b_{1j}$
B_2	b_{21}	b_{22}	...	b_{2m}	$\sum_{j=1}^{m} a_j b_{2j}$
...	...	...	...	...	...
B_n	b_{n1}	b_{n2}	...	b_{1m}	$\sum_{j=1}^{m} a_j b_{nj}$

If $\sum_{i=1}^{n} \sum_{j=1}^{m} a_j b_{ij} = 1$, then its total sequence of the hierarchy is the normalized normal vector.

5. Consistency test

The calculation steps for consistency test of the total sequence of the hierarchy are as follows:

$$CI = \sum_{j=1}^{m} a_j CI_j \qquad (1)$$

$$RI = \sum_{j=1}^{m} a_j RI_j \qquad (2)$$

$$CR = \frac{CI}{RI} \qquad (3)$$

When $CR < 0.1$, the judgment matrix A has a satisfactory consistency; otherwise, when $CR \geq 0.1$, the consistency of the judgment matrix A can not be accepted, and it needs to be adjusted until it is satisfied[8,9,10].

FORMULA OF THE MODEL

In this paper, the quantification of indicators of coastline resource utilization model is complicated. Some of the indicators can be quantified directly, such as the natural conditions in the model of climate conditions. It can be expressed by Equation (4). A satisfactory value (upper limit) and an unsatisfactory value (lower limit) can be determined according to the actual situation.

$$W_{ki} = (P_{ki} - P_{i\,min}) / (P_{i\,max} - P_{i\,min}) \qquad (4)$$

In Equation (4), W_{ki} -- the quantitative score of the index i of the coastline k, $0 < W_{ki} < 1$;
P_{ki} -- the direct value of the index i of the coastline k;

$P_{i\,max}$ -- the upper limit of the satisfaction value of the index i of the coastline;
$P_{i\,min}$ -- the lower limit of the satisfaction value of the index i of the coastline.

The value of most qualitative indicators can not be quantified directly. In this paper, the expert scoring method is used to quantify these indicators by setting the most satisfactory value (upper limit) to 1, the most dissatisfied value (lower limit) is 0.Specifically, the satisfaction value is 0.9 - 1, the satisfaction value is 0.6 - 0.8, the general satisfaction value is 0.4 - 0.5, the dissatisfaction value is 0 - 0.3.On this basis, the multi-factor comprehensive evaluation model is established according to the Equation (4)[11,12,13]. This model is used to evaluate the utilization of the coastline resource, and the specific formula is given in Equation (5).

$$S_k = \sum_{i=1}^{m} Z_i W_{ki} \qquad (5)$$

In Equation (5), S_i -- the total score of the coastline k, $0 < S_i < 1$;
Z_i -- the total weight value of the index i of the coastline, $0 < Z_i < 1$;
W_{ki} -- the quantitative score of the index i of the coastline k, $0 < W_{ki} < 1$.

RESULTS

The economic evaluation index system of coastline resource includes 6 factors (ie. Natural Factors, Policy & Regulatory Factors, Economic Development Factors, Social Service Factors, Environmental Resource Factors, Traffic Regional Factors), which contain 41 detailed indicators. The indicator system is shown in Fig.4.

In this paper, AHP method is used to assign value to 41 refinement indexes and operate by YAAHP software[14,15]. And the final score of the economic evaluation of Dafeng coastline resource is caculated according the Equations (4) and (5). The results are shown in Tab.4.

| 1. Natural Factors (B₁) |
| 2. Policy & Regulatory Factors (B₂) |
| 3. Economic Development Factors (B₃) |
| 4. Social Service Factors (B₄) |
| 5. Environmental Resource Factors (B₅) |
| 6. Traffic Regional Factors (B₆) |

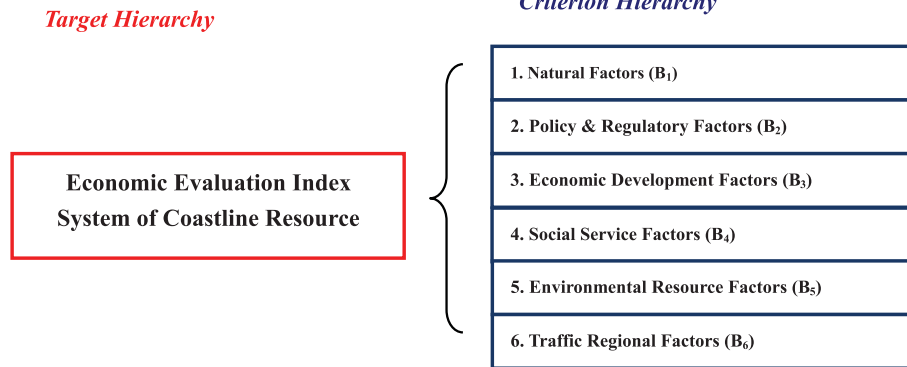Economic Evaluation Index System of Coastline Resource

Fig.4. The schematic diagram of the indicator system

The coastline resource is classified as four different grades according to the final score and the port coastline level classification criteria[11-14]. They are shown in Table 4: (1) the best economic effect of coastline resource A ($0.7 \leq A \leq 1$); (2) the excellent economic effect of coastline resource B ($0.6 \leq B < 0.7$); (3) the general economic effect of coastline resource C ($0.5 \leq C < 0.6$); (4) the poor economic effect of coastline resource D ($0 \leq D < 0.5$).

The economic evaluation of coastline resource in Dafeng is shown in Fig.5.

Tab.4. The classification criteria for shoreline resources

The results of the evaluation	Score
1. The best economic effect of coastline resource -- A	$0.7 \leq A \leq 1$
2. The excellent economic effect of coastline resource -- B	$0.6 \leq B < 0.7$
3. The general economic effect of coastline resource -- C	$0.5 \leq C < 0.6$
4. The poor economic effect of coastline resource -- D	$0 \leq D < 0.5$

Criterion Hierarchy — **Index Hierarchy**

1. Natural Factors (B₁)
C_1: Water depth	0.05970
C_2: Length	0.00910
C_3: The degree of sedimentation	0.09018
C_4: Geological conditions and stability	0.08700
C_5: Water length	0.01566
C_6: Land width	0.01566
C_7: Climatic conditions	0.03858
C_8: Flow velocity and wave height	0.02177

2. Policy & Regulatory Factors (B₂)
C_9: The reform and opening policies	0.0189
C_{10}: The sustainable development plan	0.0184
C_{11}: The national security strategy	0.0344
C_{12}: The regional development plan	0.0888
C_{13}: The regional industry support policy	0.0611

3. Economic Development Factors (B₃)
C_{14}: Direct income	0.00408
C_{15}: Transformation investment	0.00459
C_{16}: GDP	0.03878
C_{17}: The hinterland city type	0.01590
C_{18}: Industrial park scale and enterprises number	0.01869
C_{19}: Gross agricultural output	0.00702
C_{20}: Gross Industrial Product	0.01224
C_{21}: The gross domestic product of the service industry and total Trade volume	0.01232

4. Social Service Factors (B₄)
C_{22}: Total population	0.00378
C_{23}: The extent of the infrastructure	0.03933
C_{24}: Financial Services Convenience	0.01380
C_{25}: Pass Customs speed	0.00910
C_{26}: Intermediary Service Maturity	0.01029
C_{27}: Land availability	0.00585

5. Environmental Resource Factors (B₅)
C_{28}: Fishery Resource	0.00999
C_{29}: Basic farmland	0.00279
C_{30}: Wetland area	0.00130
C_{31}: Freshwater Resource	0.00684
C_{32}: Mineral Resources	0.00371
C_{33}: New energy Resource	0.00963
C_{34}: Number of Nature Reserves	0.00074

6. Traffic Regional Factors (B₆)
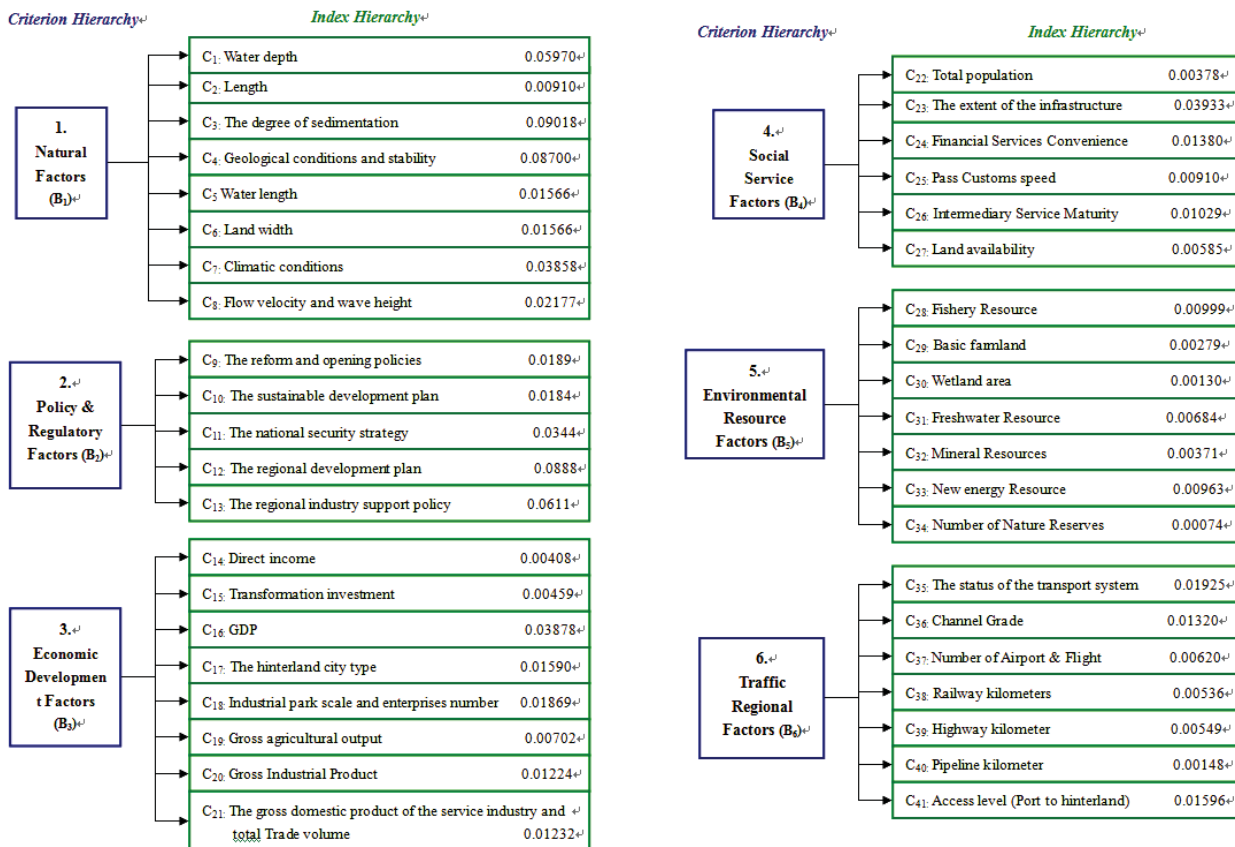| C_{35}: The status of the transport system | 0.01925 |
C_{36}: Channel Grade	0.01320
C_{37}: Number of Airport & Flight	0.00620
C_{38}: Railway kilometers	0.00536
C_{39}: Highway kilometer	0.00549
C_{40}: Pipeline kilometer	0.00148
C_{41}: Access level (Port to hinterland)	0.01596

Fig.5. The economic evaluation of coastline resource in Dafeng

CONCLUSIONS

In this paper, the Natural Factors are the most important prerequisites for the use of the coastline resource according to the above results. The total score of coastline sedimentation weight is 0.09018, which is the most important detailed factor in all. The Policy & Regulatory Factors play a significant role in the development of the coastline. Among them, the score of whether the development and utilization of coastline conforms to the regional development plan is 0.0888 and the score of the national regional industrial support policy is 0.0611. These two detailed factors are the key factors that affect the implementation of coastline development.

The comprehensive score of the coastline resource in Dafeng is 0.87. According to the classification standard, it belongs to Class A (the best economic effect of coastline resource A $(0.7 \leq A \leq 1)$) and it can be used to construct the port. And the implemented port industrial projects includes shipbuilding, logistics, mechanical processing. The coastline resource in Dafeng will eventually be constructed a unique coastal economic zone.

ACKNOWLEDGMENTS

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