

Comprehensive Evaluation of Coastline Development and Utilization Intensity——A case study of Dafeng China

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Abstract. The coastline plays an important role in the development and utilization of resources in the coastal waters and ecosystem protection. With the continued active development of coastal development and utilization activities, the development and protection of the coastline has become a major issue of the coastal zone. In order to scientifically and effectively assess the degree of coastline development and utilization, based on the characteristics of coastal wetland ecological stability, shoreline utilization disturbance characteristics and artificial dam dynamic change, a comprehensive evaluation model for coastline development and utilization intensity was established, and China Dafeng was taken as an example to conduct analytical evaluation. The results show that the total length of the Dafeng coastline is about 79.3km, and the coastal salt marsh vegetation and tidal flat landforms are widely distributed. The average depth of the coastal wetlands can reach 3.4km; the port, industry and other strong interference shores account for 16.2% of the total length of the shoreline. The moderately disturbed shores accounted for 61.8% of the total length of the shoreline, and the coastal natural attributes were better than the total length of the shoreline of 22.1%. Since 1973, the artificial levees of the Dafeng Coast continued to advance to the sea, with an average approach distance of 9.2km, which can up to 14.7 km; Dafeng coastline has significant spatial differences in development and utilization intensity. The lengths of the five types of high-strength, medium-high-strength, medium-strength, medium-low-intensity and low-intensity coastlines are 12.1km, 13.4km, 17.5km, and 21.6km, 14.7km, respectively. The high-strength and medium-high-strength development and utilization shore sections are mainly concentrated in the port shore and industrial shore sections centered on Dafeng port.

1. Introduction

Due to its advantages of special location and resource, the coastal zone has become the most concentrated area of human social and economic activities [1, 2]. With the rapid development of the economic and social development in coastal areas, coastal development activities such as towns, tourism, ports, industry, and aquaculture continue to be active. The widely distributed artificial coastal landforms have profoundly affected the coastal resources and environment [3-5], and the development and utilization of high-intensity coastlines, which make the effective protection and sustainable development of coastal waters face enormous challenges. Located on the west side of the South Yellow Sea, China Dafeng is a typical plain coast in China's coastal areas. There are many types of coastal landscapes such as ports, industries, aquaculture and protected areas along the coast. This study takes Dafeng coastline as an example, based on the typical coastal geomorphic feature line proposed by remote sensing [6-9], analyzes the ecological stability of coastal wetlands in coastal areas [10,11], and the characteristics of shoreline utilization interference [12,13], the artificial dam dynamic



change [14-16] and other characteristics, and then the comprehensive evaluation model of coastline development and utilization intensity is constructed to analyze and evaluate the development and utilization intensity of Dafeng coastline and its spatial differentiation characteristics.

2. Profile of the study area

The study area is located on the west coast of the South Yellow Sea, China, with geographic coordinates ranging from 120.62° to 120.92°E and 32.95° to 33.58°N. The study area has a large scale coastal tidal flat, and the beach is wide and gentle, which is a typical silty muddy coast. From the north to the south, the mouth of Doulonggang River, the mouth of the Four Maoyou Rivers, the mouth of the Wanggang River, the mouth of the Zhuang River, and the mouth of the Chuandong Port are distributed. The area is located in the transition zone between subtropical zone and warm temperate zone. The monsoon climate is remarkable, the rainfall is abundant, and the salt marsh vegetation is developed. It is an important coastal wetland in the world. It has the red-crowned crane nature reserve and the elk nature reserve. The coastal development and utilization of the area is active. The large-scale tidal flats in the area have been used for large-scale coastal aquaculture. Dafeng port is built using the deep tidal channel of the Western Ocean. It is a supporting port for the north wing of Shanghai port and can pass 100,000-ton sea-going vessels.

3. Experimental materials and methods

3.1. Data Sources

The Landsat series of remote sensing images in 1973, 1995 and 2017 were used as data sources. In 1973, it was MSS image. The image consisted of 4 wave bands with spatial resolution of 78m×78m. In 1995, it was TM image. The image included 7 bands, and the spatial resolution of wave bands 1-5 and wave band 7 was 30m×30m. Wave band 6's spatial resolution is 120 meters; 2017 is OLI image, the image includes 9 bands, the wave bands 1-7 and wave band 9 have a spatial resolution of 30 meters, and the wave band 8 has a spatial resolution of 15 meters. The image width is 185×185km, and the image data quality is good, which can meet the discriminative extraction of the ground object information in the study area. Remote sensing image geometry correction and remote sensing classification and extraction were carried out using ENVI 5.3 software platform, and spatial statistical analysis was performed by ArcGIS software platform.

3.2. Method

3.2.1 Classification and extraction of coastal landforms. According to the remote sensing interpretation standard of coastal geomorphology, combined with remote sensing data and on-site investigation, the coastal geomorphological characteristics of artificial coastal dyke, coastal wetland outside the dike, low tide exposed tidal flat, intertidal salt marsh vegetation and different shoreline utilization types are discriminated and analyzed. Among them, 1973, 1995 and 2017 remote sensing images were used as data sources to identify the linear geomorphology of artificial coastal dams in three periods. The remote low tide image of 2017 was used as the data source to discriminate and extract the current marginal line of salt marsh vegetation. And low tide water and land boundaries. The coastal wetland outside the dike is between the artificial dam and the low-water land-border line. The low-tidal tidal flat is the area between the seaside outer line of the salt marsh vegetation and the low-lying land-water boundary. The intertidal salt marsh vegetation is the area between artificial dam and the outer edge lines of the salt marsh vegetation. According to the characteristics of coastal development and utilization, the types of shoreline utilization can be divided into 6 types: Ecological Landscape shoreline, Culture shoreline, port shoreline, Urban shoreline, Industrial shoreline, and Unused shoreline. Because the characteristics of coastal geomorphology are affected by multiple factors of artificial and natural, the types of remote sensing spectral information are rich and varied. In the actual extraction process, according to the color, texture and morphological characteristics of

remote sensing images of different types of coastal landforms, combined with on-site survey data, comprehensive classification and image are adopted. The method of combining enhancement and manual visual discrimination is interpreted.

3.2.2 Statistical analysis of coastal geomorphology. On the basis of the typical coastal geomorphic characteristic line, the spatial distribution information such as coastal wetland, low tide exposed tidal flat, intertidal salt marsh vegetation development, artificial coastal levee dynamics and so on are statistically analyzed. Using the DSAS module under the ArcGIS platform, which are commonly used in the world, to carry out coastal geomorphological spatial analysis. The measurement reference line is set according to the overall shape of the coast, and the measurement of fracture surface section is set along the baseline from the north to the south vertical coast. The fracture surface section spacing is 1000m, and there are 68 fracture surfaces for the measurement. The statistical analysis of the spatial distance is based on the intersection of each coastal geomorphic feature line and the measured section.

3.2.3 A comprehensive evaluation model for shoreline utilization intensity. The shoreline utilization intensity is a comprehensive manifestation of many characteristics such as the natural endowment characteristics of coastal geomorphology and the interference stress of artificial coastal geomorphology. In order to scientifically and effectively assess the strength characteristics of coastline development and utilization, based on the characteristics of coastal wetland ecological stability, shoreline utilization disturbance characteristics and artificial dam dynamic change, a comprehensive evaluation model for coastline development and utilization intensity is established. The calculation formula is as follows:

$$CI_i = \frac{CU_i \times SW_i}{CW_i} \quad (1)$$

$$CW_i = \frac{TD_i \times 2 + VD_i}{WD_i} \quad (2)$$

$$SW_i = \frac{SWP_i + SWS_i \times 1.5}{\overline{SW}_i} \quad (3)$$

In these formulas, CI_i is the shore i utilization intensity index, CW_i is the shore i coastal wetland ecological stability index, CU_i is the shore i utilization type ecological interference index, and SW_i is the shore i artificial coast levee dynamic index. CW_i is calculated according to the coastal wetland width WD_i , the tidal flat width TD_i , and the intertidal vegetation development width VD_i of the shore section i . SW_i measures the sea propulsion distances SWP_i and SWS_i according to the artificial coastal levees of the 1973-1995 and 1995-2017 periods of the shore section i . Combined with the actual research, the ecological interference index of different utilization types of shore sections is determined. The shoreline utilization types are divided into ecological landscape shoreline, culture shoreline, surrounding unused shoreline, urban shoreline, industrial shoreline and port shoreline. The values of CU_i are 0.15, 0.5, 0.6, 0.75, 0.85, and 1.0, respectively. The greater the value of the shoreline utilization intensity CI_i index, the greater the development and utilization intensity. Considering the ecological stability of coastal wetlands, the interference of shoreline utilization types and the dynamic index of artificial coast dams, the coastline utilization intensity is divided into low (≤ 0.5), medium-low ($0.5 \sim 1$), medium ($1 \sim 1.5$), medium-high ($1.5 \sim 2$), high (> 2) five levels.

4. Results and analysis

4.1. Shoreline natural attribute characteristics

The Dafeng coastline starts from the middle of the Yancheng Crane Nature Reserve in China's Yancheng City and south to the south side of the Dafeng Elk Nature Reserve in China. Controlled by the natural dynamic geomorphology of the regional coast, the trend of the coastline is generally

northwest and southeast. Under the continuous influence of large-scale human reclamation activities, the coastline is continuously advanced from land to sea, and the characteristics of coastal artificialization are remarkable. The study area is located on the west coast of the radiant sandbar in the South Yellow Sea. It is a typical silty muddy coast. Under the influence of the macro-shore scouring and silting environment, the coast is generally stagnant and has developed a large number of coastal salt marsh vegetation. The total length of the Dafeng coastline is about 79.3km. The bio-coast with salt marsh vegetation has red-crowned crane protection area-Four Maoyou estuary, northern Dafeng port area, south side of Wanggang estuary, elk protection area and four shores on the north side. The cumulative length of the salt marsh bio coast is about 54.7km. The shore section of the Red-crowned Crane Protection Area and the Elk Conservation Area basically maintains the natural attribute characteristics and is a valuable native natural coastline of Dafeng. The length of the two shore sections is 7.2km and 5.7km, respectively. According to the spatial statistical analysis of the Dafeng coastal wetland based on 68 coastal survey sections, except for the 46 and 47 sections of the Dafeng Port, the coastal wetlands of the Dafeng coastal area are distributed with a wide channel, and the average depth of the coastal wetlands. Up to 3.4km. Among them, 66 coastal sections have large-scale low tide exposed tidal flats, and the low tide exposed tidal flat area is 114.5km²; 58 coastal sections have a certain width of salt marsh vegetation distribution, and the salt marsh vegetation area can reach 97.4km².

4.2. Shoreline utilization characteristics analysis

From the development and utilization of coastlines and the artificial coastline to the sea, the characteristics of shoreline utilization are analyzed. Dafeng coastal development activities mainly include sea-farming, port construction, and port-based industries. The red-crowned crane reserve and the elk reserve are two special utilization areas for the protection of typical biological species. According to the classification of shoreline utilization types, Dafeng has various types of coastlines such as ecological landscape shoreline, culture shoreline, port shoreline, industrial shoreline, and unused shoreline. According to the statistical analysis of the coastal survey section, the Dafeng coastal area has 39 cultured shore sections with fracture surface, 15 ecological landscape shore sections with fracture surface, 7 industrial shore sections with fracture surface, 4 port sections with fracture surface, and 3 enclosed unused shore sections with fracture surface. Ports, industries and other shores that strongly interfere with the natural attributes of the coast account for 16.2% of the total length of the coastline. The length of the shores with moderate degree of disturbance to the coastal natural attributes such as aquaculture, unused and unused, account for 61.8% of the total length, maintaining the natural attributes of the coast. The well-characterized shore segment only accounts for 22.1% of the total length of the coastline.

Based on the remote sensing of the artificial dam coastlines in 1973, 1995 and 2017, the statistical analysis of the spatial position of the coastline was carried out by using the statistical method of measurement section. During the period from 1973 to 1995, the artificial levee of the Dafeng coast reached an average distance of 3.8km to the sea, and the distance to the sea was up to 9.6 km, which was located on the south side of the Siyu River estuary. The shore section of the artificial dam with high intensity propelled to the sea is mainly distributed in the north side and the south side of the Siyu River estuary, and the average propulsion distance is above 9.0km. The distance between the Wanggang Estuary and the Chuandong port estuary is about 6.0km, and it has no change in the location of the artificial levee on the shore of the red-crowned crane reserve in the north and the shore of the southern elk protection zone. In this period, except for the shores where the two protected areas are located, the coastal areas between the rivers and the rivers show high-intensity seaward propulsion, while the shores near the estuary are limited by the function of the estuary into the channel, and the artificial dams vary in distance. Smaller. During the period of 1995-2017, the artificial levee of Dafeng Coast reached an average distance of 5.4km to the sea, and the maximum distance of the sea was 9.5km. It was located at the construction section of Dafeng port. During this period, the Dafeng coastal levee was fully advanced to the sea, and most of the shore extension distance was between 4.0-7.5km.

Only the northern red-crowned crane protection area has a small propulsion distance, but the average propulsion distance is also about 2.0km.

4.3. Comprehensive evaluation of shoreline utilization intensity

Considering the ecological stability of coastal wetlands in coastal areas, the characteristics of shoreline utilization disturbances and the multiple factors of dynamic changes of artificial dams, the comprehensive evaluation of shoreline development and utilization intensity is carried out. The spatial statistical analysis shows that the shoreline utilization intensity index of most of the shores of Dafeng is between 0-2, and the local shores of the port industry have high index values. The shoreline utilization intensity of the whole coast shows the overall relative average and locality. High intensity dissimilation features. The cumulative length of the high-strength development and utilization shoreline is about 12.1km, which is mainly distributed in the first-stage wharf shore section, the second-stage wharf and the south side of the surrounding shore section of the Dafeng port area. Among them, the utilization index of the second stage wharf shore is abnormally high, and the utilization intensity index is more than 15; medium and high intensity development and utilization of the shoreline cumulative length of about 13.4km, mainly distributed in the part of the shore between the Siyuhekou and Dafeng port, the bank of the Zhugang River mouth section; medium-strength development and utilization of the cumulative length of the coastline is about 17.5km, and the cumulative length of the low-intensity development and utilization shoreline is about 21.6km. The spatial distribution of the two types of shores is relatively scattered, which are mainly distributed in the transitional section between the two protected areas and Dafeng ports, and it has a cross-combination distribution in the spatial form; the cumulative length of the low-intensity development and utilization shoreline is about 14.7km, mainly distributed in the bank of the northern red-crowned crane protection zone and the southern elk protection zone.

5. Conclusion

The total length of Dafeng coastline is about 79.3km. Generally speaking, the trend of the coastline is northwest to southeast, and the coastline is continuously stagnant, and a large number of coastal salt marsh vegetation is developed. Under the continuous influence of large-scale human reclamation activities, the coastline has been continuously promoted from land to sea, and the characteristics of coastal artificialization are remarkable. The study area is a typical silty muddy coast. Under the influence of the macro-shore scouring and silting environment, the salt marsh vegetation and tidal flat landforms along the coast are widely distributed. The average depth of coastal wetlands can reach 3.4km; strong interferences such as ports and industries. The shoreline accounts for 16.2% of the total length of the shoreline, and the medium-interference zone of the aquaculture sector accounts for 61.8% of the total length of the shoreline. The coastal natural property characteristics are better than the total length of the shoreline of 22.1%. Since 1973, the artificial dam of the Dafeng Coast has continued to advance to the sea. The average approach distance is 9.2km and the maximum is 14.7 km.

Comprehensive evaluation of coastal wetland ecological stability, shoreline utilization disturbance characteristics and artificial dam dynamic change shoreline development and utilization intensity shows that Dafeng coastline development and utilization intensity has significant spatial differences, high strength, medium high strength, medium strength, medium and low intensity. The lengths of the low-strength five types of coastlines are 12.1km, 13.4km, 17.5km, 21.6km, and 14.7km, respectively. The high-strength and medium-high-strength development and utilization shores are concentrated in the industrial port section of the port centered on Dafeng port. The medium-strength and medium-low-strength developments are distributed between the two protected areas and Dafeng port. In the transitional section, the low-strength development and utilization shoreline mainly distributes the shore section of the northern red-crowned crane protection area and the southern elk protection area.

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