

Dynamic Analysis on Coastline and Sea Reclamation in the Region around Bohai Based on Remote Sensing Images

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Abstract

With 2 periods of standard false-color images as data sources, using remote sensing and GIS technology, dynamic change information extraction of the coastline and sea reclamation was completed in the region around Bohai through visual interpretation and artificial vectorization, and then this kind of information was studied deeply. The conclusions are as follows: 1) From 2000 to 2010, coastline of the region around Bohai shows an increasing trend, advancing to the sea rapidly; coastline change of the Beijing-Tianjin-Tangshan area is maximum; the advancing of coastlines of Liaoning and Shandong Province to the sea is obvious; human factors are key factors for the above change. 2) From 2000 to 2010, the sea reclamation area of the region around Bohai is rapidly increasing, the increase of Beijing-Tianjin-Tangshan region is the largest relatively and that of Shandong Province is the smallest; from the structure point of view, the area of sea reclamation for building ports is the largest and that of tideland reclamation is the smallest; different regions have different structures; social and natural factors together determine the evolution of sea reclamation. 3) To some extent, sea reclamation contributes to the increase in length of the coastline; different use types of sea reclamation have different influences on the coastline changes.

Keywords: The Bohai Rim, Coastline, Reclamation, Remote Sensing, GIS

1. Introduction

Over the past decade, the Bohai Rim has become the new focus of the Chinese economic strategy. In order to alleviate the acute contradictions between people and land, numerous reclamation projects arose around the Bohai Rim as an effective means to expand the land. However, this behavior has caused serious ecological and environmental problems while achieved great economic and social benefits (Li et al., 2010; Feng et al., 2008; Liu et al., 2008). Therefore, it is significant to grasp accurately the actual changing of coastline and reclamation and explore the interrelation between them for the coastal environmental protection and sustainable economic development of the Bohai Rim.

The researches of the coastline and reclamation at home and abroad mainly focus on two aspects. One is qualitative analysis of drivers, status, results and remediation countermeasures of both (Zhao et al., 2010; Zhang et al., 2005); The other is quantitative research using remote sensing and GIS technology (Ma et al., 2007; Yan et al., 2009). However, the former lacks real-time and accurate information (Wu et al., 2012; Yao et al., 2012) and the latter is mostly concentrated in provincial regions (Zhang et al., 2002; Wang et al., 2009). As a result, there are no quantitative surveys and studies

regarding changes of coastline and reclamation of the Bohai Rim at present. Based on this, this article combines remote sensing with GIS technology to extract dynamic information of coastline and reclamation of the Bohai Rim over the past decade, thus seizes the actual changing of coastline and reclamation accurately and do research into the interrelation between them.

2. Methodology

2.1 The Study Area

The Bohai Rim is referred to a vast economic region consisting of coastal areas that surround the entire Bohai Sea and part of Huanghai Sea, which is located at the junction of north, northeast and east China and next to Japan and South Korea, including Beijing, Tianjin, Hebei, Shandong and Liaoning Province (see Figure 1). It has vast sea areas and long and winding coastline, reaching the mouth of the Yalu River on the east and the marine administrative boundary between Shandong and Jiangsu Province on the west, possessing many famous harbors along the coast including Dalian, Qinhuangdao, Tianjin, Yantai and Qingdao Port. Since the 21th century, the Bohai Rim has become the focus of Chinese economic development strategy and an important support for economic growth (Li et al., 2010).

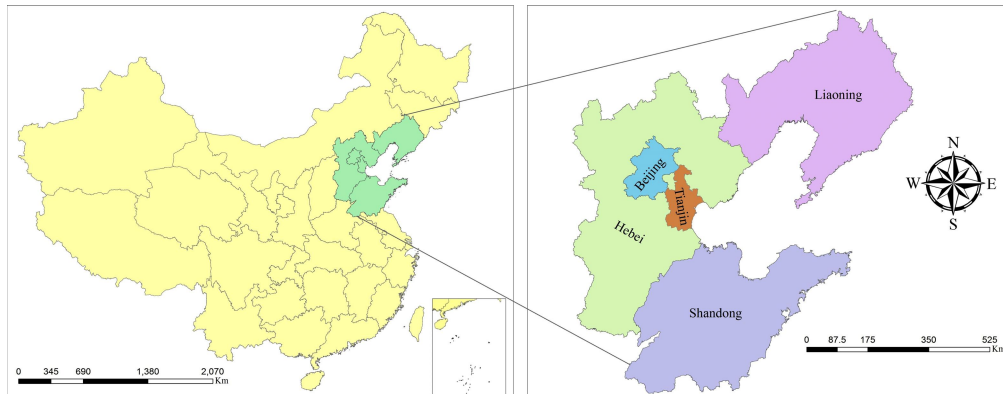


Figure 1. The location of the Bohai Rim

2.2 Data and Methods

The remote sensing data used in this article are images of the Bohai Rim from the thematic scanner (Thematic Mapper, TM) in 2000 and images of same seasons from the Enhanced Thematic Mapper (ETM+) in 2010, which are obtained without cloud and of better quality.

Achieve images' preprocessing through ENVI software and use visual interpretation and manual vectorization in ArcGIS to extract coastline changes. Then, the vector layers of coastline are overlaid with layer of administrative boundaries of the Bohai Rim to gain the length changes of the coastline of Liaoning, Shandong Province and Beijing-Tianjin-Tangshan Region.

In this paper reclamation is defined according to research purposes, namely, through sea reclamation off coastline which makes specific sea area lose its ocean attributes, human beings make more effective use of the sea area. The remote sensing images of the Bohai Rim in 2000 and 2010 are compared and the areas that the shores have changed are extracted through visual interpretation in ArcGIS. For further study, the reclamation of the Bohai Rim is divided into four categories including construction land, aquaculture ponds, beaches and harbors according to actual situation. Finally, the attribute data acquired in ArcGIS are switched into SPSS software to complete data analysis and representation.

3. Results and Discussion

3.1 Analyzing Changes of Coastline

As shown in table 1, the total length of the coastline of the Bohai Rim in 2000 is 5266.44km while the length is 5836.94km in 2010. In the past decade, the coastline of the Bohai Rim has grown by 570.5km. From 2000 to 2010, the spatial extent of coastline of the Bohai Rim has changed by 13661.47km² which moves forward by 8819.51km² and back by 4841.96km². Combined with the sea area of each region, it can be concluded that the coastline of Beijing-Tianjin-Tangshan Region has the biggest range and speed of changing, while the coastline of Liaoning and Shandong Province has a relatively gentle speed yet an obvious trend to move towards the ocean.

Table 1 Changes of the coastline of the Bohai Rim from 2000 to 2010

Province	Length Change(km)			Change Area(km ²)		
	2000	2010	Increment	Range	Forward	Backward
Liaoning	2112.47	2246.21	133.74	3047.91	5094.80	5518.76
Jing-Jin-Tang	478.33	811.05	332.22	13661.48	2640.83	2782.31
Shandong	2657.13	2779.68	104.55	3396.36	8819.51	407.08
Total	5266.44	5836.94	570.50	2312.49	2122.39	4841.96

The causes of coastline changes can be divided into two categories: natural factors and human factors. Natural factors mainly include sea level rise caused by global warming, coastal erosion at river estuaries and areas with big waves and estuarine sediment accumulation. While human factors mainly include artificial reclamation for building towns, coastal aquaculture and constructing port (Wang et al., 2011; Zhu et al., 2008; Cheng et al., 2002; Ke et al., 2012). Through function of selection by attribute in ArcGIS, extract the change largely areas to analyze the causes of coastline changes. Compare remote sensing images and combine with local survey data to analyze Daliao River, Caofeidian Region and Xianhe Town in Dongying. It can be concluded that human factors are key factors for the changes of coastline in Bohai Rim over the past 10 years. Artificial reclamation for building towns and ports makes the coastline to move forward to the ocean. Excavation of beach for aquaculture makes the coastline to move back to the inland.

3.2 Analyzing Changes of Reclamation

As shown in Figure 2, the reclamation area of the Bohai Rim has increased 8710.47km². The reclamation area of Beijing-Tianjin-Tangshan Region has a relative increasing of the biggest range while the reclamation area of Shandong Province has a relative increasing of the smallest range. In terms of using types of reclamation, the maximum amount of reclamation is used to build harbors and the minimum amount is transformed into reclaimed tidal. In Liaoning Province, the largest amount of reclamation is used to build aquaculture ponds; In Beijing-Tianjin-Tangshan Region, the largest amount of reclamation is used to build harbors; In Shandong Province, the largest amount of reclamation is transformed into construction land.

Reclamation is an artificial way to ask for survival and production space from the ocean and is affected by natural and social factors. Natural factors mainly include the length and type of coastline and the amount of beach resources. Social factors include expansion of agriculture land (arable land), industrial development, traffic demand, population growth, urbanization and policy factors (Muh Aris Marfai et al., 2008; Feng et al., 2006). Integrating acquired analytical data and local survey data, the paper explores the causes of evolution of the reclamation in Bohai Rim in different spatial scales, in terms of the composition and changes of increased area of the reclamation. It can be concluded that social factors including economic development, policy support and population growth are the driving factors for increasing of

the area of reclamation in the Bohai Rim. The composition of reclamation in each region is decided by natural factors like coast types and social factors including developing level of port, demand for land use types and policy guidance.

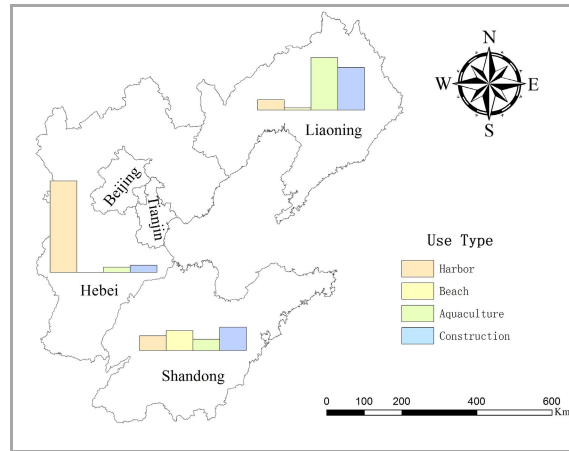


Figure 2. Reclamation change of the Bohai Rim from 2000 to 2010

3.3 Interrelation between coastline and reclamation

Reclamation generally occurs at coastline or strips of land along islands and most of it is constructed with coastline as borders and stretches to the ocean (Ke et al., 2012). According to former analysis of causes of coastline changes, developing harbors along coastline, reclamation for constructing artificial structures and reclaimed tidal make originally straight coastline complicated and bent and the length greatly increases as a result. Some of offshore aquaculture is developed on the basis of original coastline while most of it is developed back to the inland. The latter usually makes the curved coastline straight through digging sand beach and shortens the length of coastline. In conclusion, reclamation promotes the growth of coastline to a certain extent. Reclamation for construction land, ports and reclaimed tidal has a positive correlation with length of coastline while reclamation for developing aquaculture has a negative correlation with length of coastline.

4. Conclusions

This article uses remote sensing images of two periods and survey data of the Bohai Rim, integrates remote sensing with GIS technology to extract changes of coastline and reclamation in the Bohai Rim and analyze the causes of changes and the correlation between them. Here are the conclusions:

1) From 2000 to 2010 the coastline of the Bohai Rim has a trend of increasing and advances rapidly to the ocean in general. The coastline of Beijing-Tianjin-Tangshan Region has the biggest range while the coastline of Liaoning and Shandong Province has an obvious trend to move towards the ocean. Human factors are key factors for the changes of coastline in Bohai Rim over the past 10 years.

2) From 2000 to 2010 the reclamation area of the Bohai Rim has increased rapidly. The reclamation area of Beijing-Tianjin-Tangshan Region has a relative increasing of the biggest range while the reclamation area of Shandong Province has a relative increasing of the smallest range. In terms of the composition of reclamation, the maximum amount of reclamation is used to build harbors and the minimum amount is transformed into reclaimed tidal. Social factors are the driving factors for increasing of the area of reclamation in the Bohai Rim while natural factors decide the composition of reclamation in each region.

3) Reclamation promotes the growth of coastline to a certain extent. Reclamation for construction land, ports and reclaimed tidal has a positive correlation with length of coastline while reclamation for developing aquaculture has a negative correlation with length of coastline.

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