A STUDY ON SPATIAL AND TEMPORAL VARIATIONS OF COASTAL WETLAND IN PEARL RIVER ESTUARY

Yi GAO [1, 2, 3] Fenzhen SU [2] Xiaoyu SUN [2] Zhenshan XUE [2] Yawen He [1]

1. Yantai Institute of Coastal Zone Research, CAS,Yantai, 264003, China
2. Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China
3. Graduate School of Chinese Academy of Sciences, Beijing 10039, China
Email: CoastalChina@gmail.com

ABSTRACT

Great changes of coastal wetland in Pearl River Estuary have taken placed since 1970s. To investigate the spatial and temporal variations of coastal wetland in Pearl River Estuary, Landsat-MSS images in 1975 and Landsat-TM images in 1995 & 2005 were processed, and a wetland database of these three periods was established based on these satellite images. Since the changes of coastal wetland had significant relationship with coastline changes, a model for coastline changes detection was established. By means of GIS and RS, temporal and spatial changes of coastal wetland in Pear River Estuary were studied in this work. The result showed that: (1) During period of 1975~1995, coastal wetland area decreased by 3.3%, and decreased by 18.3% during 1995~2005; (2) Among 6 administrative districts of the study area, wetland dynamic degree could be sorted in a descending order as: Zhuhai, Shenzhen, Macao, Dongguan, Zhongshan and Guangzhou; (3) The centroids of wetland in Pearl River Estuary coastal zone moved 0.6km in the north direction during 1975~1995, and 6.1km in the southeast direction during 1995~2005; (4) Due to the changes of coastlines in Pearl River Estuary, the area of sea reclamation during 1975~2005 in Zhuhai, Macao, Zhongshan, Guangzhou Dongguan, Shenzhen was 12439.29, 502.60, 2946.45, 5372.21, 1815.96 and 6317.88 hectares respectively; (5) Average distance of coastline changes during 1975~2005 was 651.2m in Zhuhai, 187.1m in Macao, 1304.7m in Zhongshan, 802.8m in Guangzhou, 193.3m in Dongguan and 523.1m in Shenzhen. To conclude, this work demonstrates the importance of satellite images to monitor the temporal and spatial changes of coastal wetland.

Index Terms—Pearl River Estuary, Coastal Wetlands, Dynamic Degree, Centroid Displacement

1. INTRODUCTION

Wetlands are honored as "kidney of the globe", "species gene pool" and “the cradle of humanity” [1]. They are the most productive ecosystems in the world compared to terrestrial ecosystems and marine ecosystems. They provide important ecosystem functions such as nursery habitats for fish and crustaceans, resting and feeding area for migratory birds, they also support biodiversity, filter containments, dissipate water energy, and offer intrinsic values such as aesthetics and education [2]. Coastal wetland is an important kind of wetland and natural landscape with abundant natural resources and unique environmental effect [3], but about 30 to 50% of the area of earth's major coastal environments has been degraded during past decades [4]. Wetland is one of the most important natural resources of Pearl River delta. During the period of 1975~2005, substance changes have taken place in the coastal wetland of Pearl River Estuary as the result of natural and anthropogenic factors. Many researchers choose one part of Pearl River delta for research [5~7]. However, few studies have focused on the spatial and temporal changes of coastal wetland in Pearl River Estuary. Based on GIS and RS, the spatial and temporal changes of coastal wetland in Pearl River Estuary in the past three decade are researched.

2. STUDY SITES

The study area, Pearl River Estuary coastal zone covers an inland area of 5 km buffers from the costal lines, and extends to the -6m depth line in shallow sea, and the area is about 390,000 hectares. It is located at the middle south of Guangdong Province of China (as Figure 1 shows). The bell-shaped Pearl River Estuary receives and carries most of the outflow from the Pearl River, eventually flow into the South China Sea. The climate here is summer and winter monsoon alternating, year-round high temperatures. Since economic liberalization was adopted in the late 1970s, the area has become one of the leading economic regions and a major manufacturing center of China. Including two Special Economic Zone: Zhuhai and Shenzhen; and an Open Coastal City: Guangzhou.

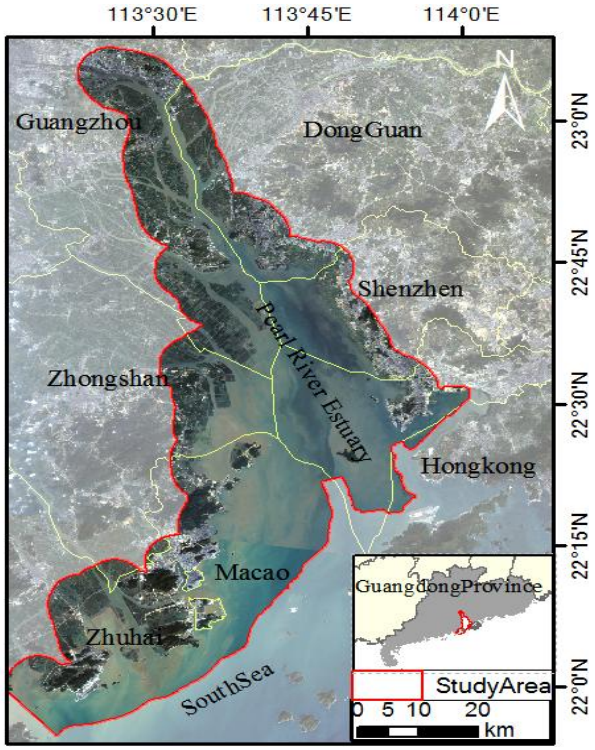

Figure1. Study area

3. DATA AND METHODOLOGY

3.1 Data

In order to analysis the spatial and temporal changes of Pearl River Estuary in the past three decades, three periods data sources were collected, including Landsat MSS images in 1975; Landsat TM in 1995 and 2005(the remote sensing images were downloaded from the USGS website: http://glovis.usgs.gov).

3.2 Data Processing

Remote sensing images processing was carried out by means of PCI Geomatica10.0. In this research all the remote sensing images were rectified to WGS-84 coordinate system, and the spatial rectify error is less than 0.5 pixels. Wetland data of the year 1975, 1995 and 2005 were extracted by visual interpretation based on these geometric rectified remote sensing images. The interpreted data were modified and edited through field investigation and sampling by GPS to reach interpreted precision of 93%, and the interpreted accuracy of wetland in 1995 and 1975 is 90% and 88% respectively. The data processing packages mainly included ArcGIS9.0, SPSS 16.0 and PCI Geomatica10.0.

According to the ecological classification principles and the classification of China and abroad [8~12], wetland in Pearl River Estuary is divided into natural wetland and constructed wetland according to the interfering degree of human activities. Natural wetland also divided into mud flat, mangrove, lake, river and shallow sea; and constructed wetland is divided into reservoir, aquaculture water, paddy field and pond.

3.3 Methodology

Land use dynamic degree model and cenctrids of wetland is applied to study the temporal and spatial changes of wetland. A model of average coastline displace model was also applied.

3.3.1 Wetland Dynamic Degree

In order to understand the rate of regional wetland changes and their characteristics differences, the wetland dynamic degree was calculated by administrative districts in Pearl River Estuary. Regional difference in wetland change characteristic can be determined by using the land use dynamic degree model that could be mathematically expressed by the following relationship [13~14]:

$$S = \sum_{ij}^{n} (\Delta S_{i-j} / S_i) \times (1/t) \times 100\% \qquad (1)$$

Where S is the wetland dynamic degree over time t; Si is the ith type wetland area at the beginning of the monitoring period, n is the number of the wetland types, and ∆ Si-j is the total area of the ith type wetland that is converted into others (other wetland types or non-wetland).

3.3.2 Spatial Changes of Wetland

Spatial changes of wetland can be described by the centroid displacement of land use resource distribution [15]. The cenctrids of wetland distributions in these three periods can be calculated as follows:

$$X_t = \sum_{i=1}^{n} (C_{ti} \times X_i) / \sum_{i=1}^{n} C_{ti} \qquad (2)$$

$$Y_t = \sum_{i=1}^{n} (C_{ti} \times Y_i) / \sum_{i=1}^{n} C_{ti} \qquad (3)$$

Where X_t and Y_t are the abscissa and ordinate centroid of wetland distribution in t period respectively. X_i and Y_i are the abscissa and ordinate of the centroid of wetland type i in the same period; C_{ti} denotes the area of each wetland patch; $\sum_{i=1}^{n} C_{ti}$ denotes the total wetland area in t period.

3.3.3 Coastline Changes of Pearl River Estuary

The changes of coastlines can be described by average displace distance, it can be calculated as follows:

As Figure 2 shows, coastline changes distance d_i can be nearly considered as:

$$d_i = s_i / l_{it0} \qquad (4)$$

Where d_i is the coastline changes distance, l_{ito} is the length of coastline in the t0 year which changed into coastline l_{it1} in the year of t1. Then the average distance $\bar{d}$ of coastline changes in an administrative district can be calculated as:

$$\bar{d} = \sum_{i=1}^{n} d_i / n \qquad (5)$$

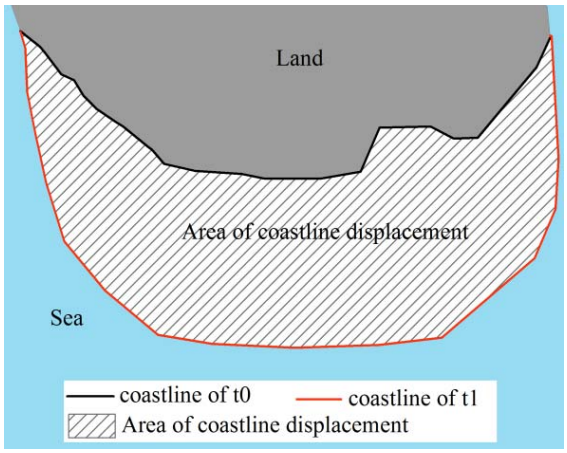

Figure2. Model of coastline changes.

4. RESULTS

4.1 Wetland Distribution

The distribution of wetland in these three periods as figure3 shows.

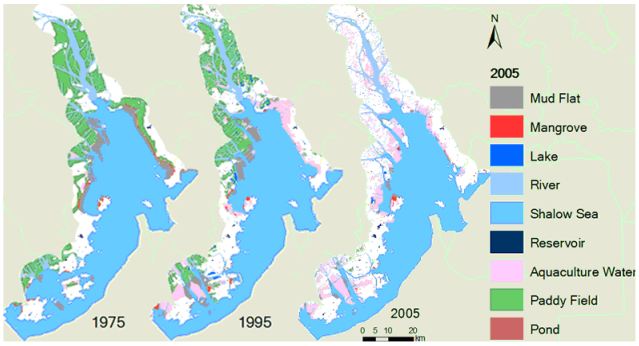

Figure3. The distribution wetland in 1975, 1995, and 2005.

The wetland area in the year of 1975, 1995, 2005 is 319512, 308946, 252392 ha separately. During period of 1975~1995, coastal wetland area decreased by 3.3%, while it decreased by 18.3% during 1995~2005. It is obviously that the wetland decrease rate during the later stage much more than that of the earlier stage.

4.2 Spatial and Temporal Changes

According to the equation (1), the wetland dynamic degree during 1975~2005 in the 6 administrative districts as figure4 shows:

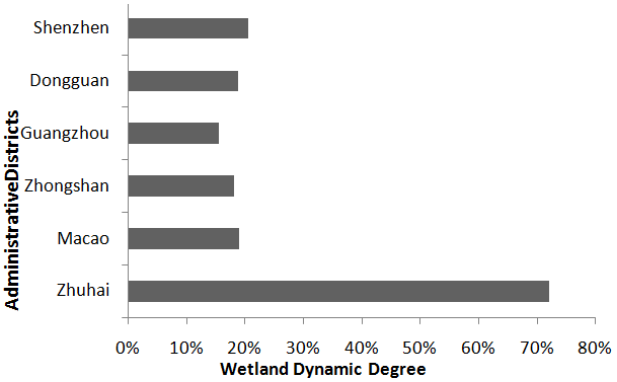

Figure 4. Dynamic degree of coastal wetland in each administrative district during 1975~2005.

The centroids of each wetland patch were extracted from wetland vector data based on ArcGIS9.0, and the centroids coordinates of each periods were calculated by equation (2) and (3). The centroids of wetland in the three different periods are shown in figure5. During 1975~1995, the cenrtoids of coastal wetland moved 0.005° to the north direction and 0.001° to the east direction, by a linear distance of 0.6km, which was related to the large-scale movement of enclosing tideland for cultivation. However, during 1995~2005, the wetland centroids moved 0.055° to the south direction and 0.01° to the east direction, by a linear distance of 6.1km, which was mainly because of inland wetland changed into non-wetland(such as construction site or factories).

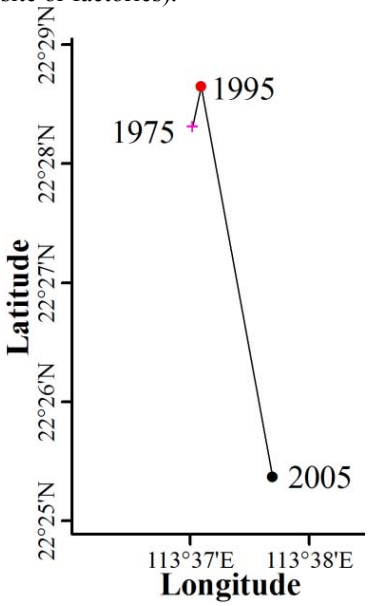

Figure5. Spatial changes of coastal wetland in Pearl River Estuary.

4.3 Changes of Coastlines

The coastline changed mainly caused by sea reclamation. By compared the coastline in 1975 and 2005, the area of coastline displacement can be acquired (as figure6 shows). And the area of coastline displacement long the inland coastline in Zhuhai, Macao, Zhongshan, Guangzhou, Dongguan and Shenzhen is 12439.29，502.60，2946.45，5372.21，1815.96，6317.88 hectares respectively.

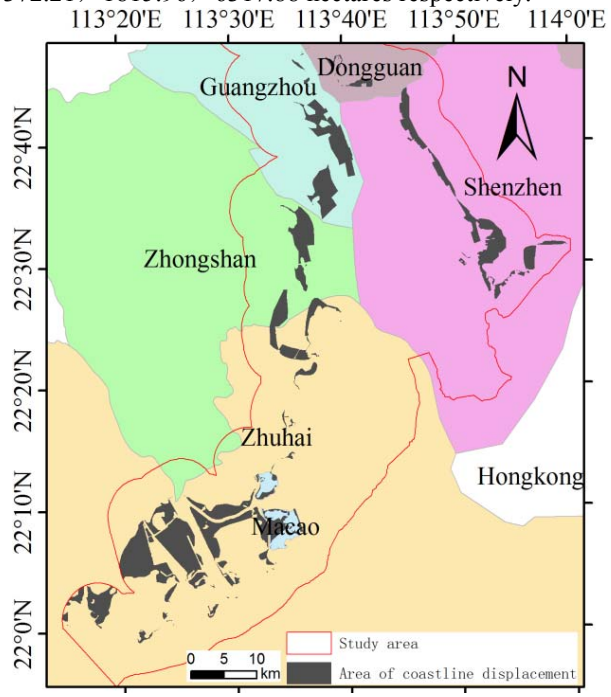

Figure6. The distribution of coastline changes from 1975 to 2005.

According to the equation (4, 5), the average distance of coastline changes is 651.2m in Zhuhai, 187.1m in Macao, 1304.7m in Zhongshan, 802.8m in Guangzhou, 193.3m in Dongguan and 523.1m in Shenzhen.

5. DISCUTION

After the analysis of coastal wetland spatial and temporal change in the nearly three decades, and the comparison between early and late stages, it can be seen that coastal wetlands in Pearl River Estuary have been significantly changed. These changes reflect an accelerating depletion of wetland. Coastal wetland depletion disturbed the ecological functions of wetland, which will cause a series of environmental problems, such as flood, coastal erosion, loss of habitat for aquatic species and so on. Wetland protection measures and long-term planning for the study area is an urgent task.

6. ACKNOWLEDGEMENT

This study was supported by the National Natural Science Foundation of China (No. 40971224) and the National High Technology Research and Development Program of China (No.2008AA121706 and No. 2009AA12Z148).

7. REFERENCES

[1] Sun, G. Development and prospect of wetlands science in China. Advance in Earth Science, 15(6): p. 666-672. 2000.
[2] Goodwin, P., A. Mehta, J. Zedler. Coastal wetland restoration: An introduction. Journal of Coastal Research, 27: p. 1-6. 2001.
[3] An, S., H. Li, B. Guan, et al. China's natural wetlands: past problems, current status, and future challenges. AMBIO: A Journal of the Human Environment, 36(4): p. 335-342. 2007.
[4] Valiela, I.,S. Fox. ECOLOGY: Managing Coastal Wetlands. Science, 319(5861): p. 290. 2008.
[5] Liu, K., X. Li, S. Wang. Monitoring of the changes of mangrove wetland around the Zhujiang Estuary in the past two decades by remote sensing. ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI, 25(2)2005.
[6] Li, X., A. Yeh, K. Liu, et al. Inventory of mangrove wetlands in the Pearl River Estuary of China using remote sensing. Journal of Geographical Sciences, 16(2): p. 155-164. 2006.
[7] Wang, S., X. Li, K. Liu, et al. Dynamic Analysis of the Wetland Resource Changes in the Estuary of the Pearl River Delta Using Remote Sensing. ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUNYATSENI, 46(2)2007.
[8] Cowardin, L., V. Carter, F. Golet, et al.Classification of wetlands and deepwater habitats of the United States: US Department of the Interior/Fish and Wildlife Service.1979.
[9] Sader, S., D. Ahl, W. Liou. Accuracy of Landsat-TM and GIS rule-based methods for forest wetland classification in Maine. Remote Sensing of Environment, 53(3): p. 133-144. 1995.
[10] Scott, D.,T. Jones. Classification and inventory of wetlands: A global overview. Plant Ecology, 118(1): p. 3-16. 1995.
[11] Yang, Y. New knowledge on the progress of international wetland science research and priority field and prospect of Chinese wetland science research. Advance in Earth Sciences, 17(4): p. 508-514. 2002.
[12] Schmidt, K.,A. Skidmore. Spectral discrimination of vegetation types in a coastal wetland. Remote Sensing of Environment, 85(1): p. 92-108. 2003.
[13] Sheng-He, L.,H. Shu-Jin. A spatial analysis model for measuring the rate of land use change [J]. Journal of Natural Resources, 5,2002.
[14] Liu, J.,A. Buhe. Study of spatial-temporal feature of modern land-use change in China: using remote sensing techniques. Quaternary Sciences, 20(2): p. 229-239. 2000.
[15] Junhong, B., O. Hua, C. Baoshan, et al. Changes in landscape pattern of alpine wetlands on the Zoige Plateau in the past four decades. Acta Ecologica Sinica, 28(5): p. 2245-2252. 2008.