

## **Dynamic Changes of Newly formed Wetlands in the Yellow River Mouth Based on GIS and Remote Sensing**

Gengxing Zhao, Yanxi Shi, Weifeng Chen, Jing Li, Seoung-won Ann\*  
Young-chil Kim\*, Jea-hoon Jung\* and Soo-cheon Chae\*

*College of Resources and Environment, Shandong Agricultural University, Taian 271018, PR China*

*\*College of Industrial Science, Kongju National University, Chungnam 340-802, Korea*

(Manuscript received 4 December, 2002 ; accepted 24 January, 2003)

The Yellow River delta is an important region where coastal and newly formed wetlands distribute in north China. Based on satellite remote sensing images and GIS techniques, this paper tends to delineate the dynamic changes of newly formed wetland in the Yellow River mouth from 1986.5 to 1996.10. Our results show that the newly formed wetland increased by 24.9 km<sup>2</sup> per year. Before 1990.1 and it decreased by 2.40 km<sup>2</sup> per year after that. The northern and southwestern parts of the Yellow River mouth are main positions of decrease and the southern and the estuary parts are main positions of increase. The advancing rate of river mouth extending into the Bo Sea is decreasing obviously. The reason for that is the decreasing of water and sediments in the Yellow River, which caused by the increasing use of water and soil conservation on upper reach.

Key words : Wetland, Yellow River, GIS, Remote sensing, Climatic change

### 1. Introduction

The Yellow River is well known for its high sediments content, which is 36 kg/m<sup>3</sup>. From 1855 Tongwaxing bust and taking Daqing watercourse, the Yellow River ran into the Bo Sea for 127 years with changing its course for more than 10 times, and formed the current Yellow River delta composed of 10 sectors<sup>2)</sup>. The current watercourse is Qingshuigou, which been taken in 1976.5; it has been running into the sea for 26 years. It is commonly believed that the Yellow River delta increases newly formed wetland by about 20 km<sup>2</sup> every year<sup>4,5)</sup>. However, the newly formed wetland is also affected by the ocean tide, which leads to the decrease in wetland. Therefore the newly formed wetland in the Yellow River delta is the result of interaction between river sediment siltation and ocean tide erosion. Using satellite remote sensing

and Geographic Information System (GIS) techniques, this paper focus on the newly formed wetland changes from 1986.5 to 1996. 10, so as to delineate its dynamic trends, and providing baseline information for wetland protection in this area.

### 2. Study area

The Yellow River, which is the second longest river in China, forms the approximately 5400 km<sup>2</sup> Yellow River delta on the edge of the northern part of Shandong Province. Because of its unique natural geographic location, the natural and socioeconomic conditions change frequently. The ecological environment is vulnerable. The mean annual temperature of this area is 12.3°C, with a =10°C accumulate temperature of 4,310.4°C. However, the rainfall, 547.2 mm, is low and not evenly distributed: 67.8% falls in summer and only 3.6% in winter. The evaporation-precipitation ratio has an annual average of 3.40, but peaks at 7.54 in the spring, often causing a serious drought. The landforms are typical for a river delta, with topography

---

Corresponding Author ; Seoung-won Ann, College of Industrial Science, Kongju National Univ., Chung-nam 340-802, Korea  
Phone : +82-41-330-1224  
E-mail : annsw@kongju.ac.kr

descending from southwest to the river mouth with gradient ratio of 1/10000 to 1/12000. The Yellow River is the main source of fresh water in this region with an annual influx of 31.7 billion m<sup>3</sup>, which varies markedly in different seasons. Statistics show that in 18 years from 1972 to 1990, the Yellow River ceased flowing more than 20 times in 13 years, generally in the spring, the longest period being 226 days in 1997. The ground water table is shallow and the water is highly concentrated with salt and other minerals hence cannot be used for drinking and irrigation. According to soil surveys the soils there can be divided into Chao soil and Solonchak soil groups, with salinized soil accounting for 72% of the total area. According to land use investigations, the main land use types in this region are wetland, unused (barren) land, cultivated land, and grassland. The protection and utilization of wetlands in this region is a crucial problem for the local government, which related to sustainable development of resources and environment.

For the purpose of area calculation and accuracy comparison, we limit our analysis to a fan-shaped area of the Yellow River mouth. Its acme is the intersection point of current and former watercourses of the Yellow River, the northern border is the dam of the river, and the southern border is from Kendong reservoir to Xiaodao River. The total area is 1,106.86 km<sup>2</sup> (1996.10).

### 2.1 Data preparation and processing

The remotely sensed data used in this study is TM and SPOT data acquired between 1986.5 and 1996.10. Five monitoring dates were chosen: (1) 1986.5; (2) 1988.12; (3) 1990.1; (4) 1995.3, and (5) 1996.10. Prior to change detection, it is imperative that all the images be geometrically rectified so that the same pixel at one date corresponds to the same pixel at the other dates. We first geometrically rectified the image at 1996.10 using 1:50000 topographic maps, with a resulting estimated *rms* error of less than one pixel. We then rectified other images using image of 1996. Ten by the method of image-to-image rectification. Based on the statistical characteristics of different bands and a visual evaluation of selected band combinations, we adopted a false color RGB composite of

bands IR, R and G. Images were enhanced for visual display with a linear stretch.

## 3. Methodology

The border between water and land can be clearly distinguished on composite satellite images. First, we visually digitized the shorelines of different dates on the images, and then we put them into GIS software of PC ARC/INFO. Overlay analysis was employed between different dates. The spatial and area changes of newly formed wetland can be discerned from the change maps and corresponding attribute databases.

## 4. Results

### 4.1 Changes in area of newly formed wetland

**Changes in total study area:** Table 1 represents the total area of the Yellow River mouth from 1986.5 to 1996.10. It shows that the total area increased as a whole, but it didn't increase every year. It can be divided into two phases by 1990.1, before which the total area increased remarkably by 91.51 km<sup>2</sup>, and after that it decreased by 21.16 km<sup>2</sup>. From 1995.3 to 1996.10, although the total area increased, however it didn't reach the area of 1990.1.

**Area changes of newly formed wetland in different periods:** By analyzing the increased and decreased areas of newly formed wetland in different periods (Table 2, Fig. 1), we can see that: (1) In the 10 years and 5 months from 1986.5 to 1996.10, the newly formed wetland had increased by 95.14 km<sup>2</sup>, and it was eroded by 26.44 km<sup>2</sup> at the same period. The net increase was 68.70 km<sup>2</sup>, 6.59 km<sup>2</sup> annually. (2) Compared with the increase in newly formed wetland of different periods, the increased area from 1988.12 to 1990.1 is the most, which is

Table 1. Changes of areas in total study area from 1986.5 to 1996.10

Date	1986.5	1988.12	1990.1	1995.3	1996.10
Total areas (km <sup>2</sup> )	1027.92	1082.02	1119.43	1098.27	1106.86

44.58 km<sup>2</sup> annually. The second are the periods from 1986.5 to 1988.12 and from 1995.3 to 1996.10; the annual increased areas are 26.46 km<sup>2</sup> and 21.56 km<sup>2</sup> respectively. The smallest increased area is from 1990.1 to 1995.3, which is 7.56 km<sup>2</sup> annually. (3) Compared with the decrease in newly formed wetland of different periods, the decreased area from 1995.3 to 1996.10 is the most, which is 17.72 km<sup>2</sup> annually. The decrease in other periods has no large difference. (4) The net increase/decrease in different periods are different obviously. Before 1990.1, the newly formed wetland net increase in area, which is 24.93 km<sup>2</sup> annually, however, it changes to net decrease after 1990.1, which is 2.40 km<sup>2</sup> annually. Therefore,

we can conclude that before 1990.1 siltation is the main process in the Yellow River delta, and the newly formed wetland had net increased. After that, erosion became the main process and the newly formed wetland changed to net decrease accordingly.

#### 4.2 Spatial changes of newly formed wetland

According to the siltation and erosion in the Yellow River mouth, it can be divided into four different places: the northern part of Yellow River mouth, the estuary part, the southern part, and the southwestern part which is from Kendong reservoir to the end of Xiaodao river (Fig. 2). From 1986.5 to 1988.12, the shape of the river mouth changed from wide and short to

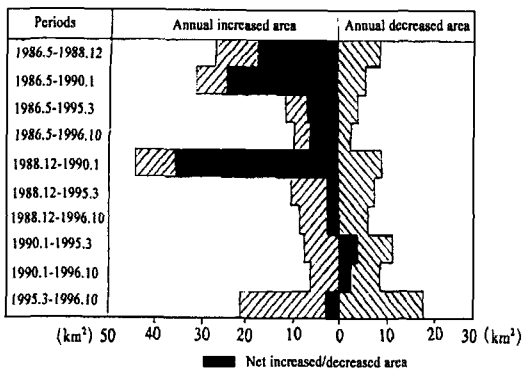


Fig. 1. The changes of newly formed wetland in different periods of the Yellow River mouth.

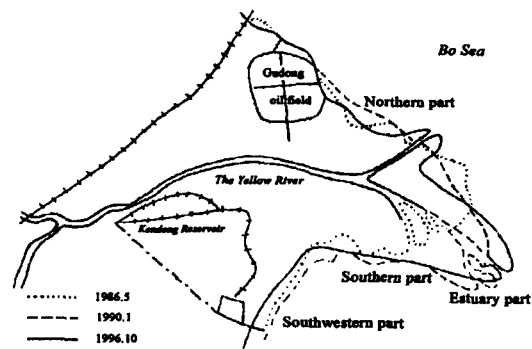


Fig. 2. The dynamic changes of newly formed wetland in the Yellow River mouth from 1986.5 to 1996.10.

Table 2. The changes of newly formed wetland in different periods of the Yellow River mouth

Periods	Time (Year)	Increased areas	Decreased areas	Net increased/decreased areas	Annual increased areas	Annual decreased areas	Annual net increased/decreased areas
86. 5~96.10	10.24	95.14	26.44	68.70	9.13	2.54	6.59
86. 5~95.3	8.83	101.05	39.72	61.33	11.45	4.50	6.95
86. 5~88.12	2.58	68.26	23.19	45.07	26.46	8.99	17.47
86. 5~90.1	3.67	112.33	20.83	91.50	30.61	5.68	24.93
88.12~90.1	1.08	48.15	10.21	37.94	44.58	9.45	35.13
88.12~95.3	6.25	63.59	48.98	14.61	10.18	7.84	2.34
88.12~96.10	7.83	64.67	44.57	20.10	8.26	5.69	2.57
90. 1~95.3	5.17	39.07	60.57	21.68	7.56	11.75	4.19
90. 1~96.10	6.75	40.52	56.70	16.18	6.00	8.40	2.40
95. 3~96.10	1.58	34.06	28.00	6.06	21.56	17.72	3.84

narrow and long. The increased wetland mainly distributed in estuary part and southwestern part that nearly vertical with the watercourse. The decreased wetland concentrated in the northern part, which made the shape of the river mouth from roughly round to sharp. From 1988.12 to 1990.1, the northern and southwestern parts was slightly eroded and didn't change very much, and wetland was formed in the southern part, which made this part thicker; From 1990.1 to 1995.3, all the wetland was strongly eroded and decreased except the estuary part, making the shape of the river mouth thinner and longer; In 1996.10, the Yellow River changed its course to a branch in the northeast, and sediments just deposited in the places where had been eroded heavily in the period of 1990.1 to 1995.3, forming a obvious bulge. At the same time, because of the changing of watercourse, the southern part was heavily eroded.

Therefore, the northern part from the river mouth to the Gudong oil field was the position where erosion always happened except the changing watercourse of 1996.10, and the southwestern part, except for the period of 1986.5 to 1988.12, was also an erosion place where newly formed wetland decreased. The estuary part and southern part were the two main silting positions where newly formed wetland increased.

Overall, the erosion of the newly formed wetland is caused mainly by the tides coming from northeast and southeast, with the former much heavier. It restrained the river from extending to the northeast and compelled it turning to the southeast. The tide coming from southeast is relatively weaker, which restrains the river from advancing to the east and make the river mouth thinner and longer.

#### 4.3 Changes in the distance of the Yellow River mouth advancing into the Bo Sea

Table 3 shows the distances of the Yellow River mouth advancing in different periods. It is obvious seen that the advancing speed was decreasing from 3.09 km annually in the period of 1986.5 to 1988.12 to 0.50 km annually in the period of 1990.1 to 1995.3, and it had been back for 0.57 km to 1996.10. The advancing of

Table 3. Speed and distance of the Yellow River mouth advancing in different periods

Periods	Advancing distance (km)	Advancing speed (km per year)
1986. 5~1988.12	7.97	3.09
1988.12~1990. 1	0.57	0.53
1990. 1~1995. 3	2.56	0.50
1995. 3~1996.10	0.57	0.36

river mouth has certain correlation with the siltation and erosion. In the period of siltation before 1990.1, the river mouth advanced 8.54 km, 2.33 km annually, and in the period of erosion after 1990.1, the river mouth only advanced 1.99 km, 0.30 km annually.

## 5. Discussion

During the 10 years, as a whole, the newly formed wetland tends to decrease, which can be divided into two periods by 1990.1, it increased by 24.9 km<sup>2</sup> annually in the former period and decreased by 2.40 km<sup>2</sup> annually in the later period. The northern and southwestern parts of the Yellow River mouth are main positions of decrease and the southern and estuary part are main positions of increase. The advancing rate of river mouth getting into the sea also can be divided into these two periods: advancing rate is fast in the first period, and it is decreasing obviously and even has been eroded back in the second period.

According to our results, the newly formed wetland in the Yellow River mouth does not continuously increase every year, and the increase is not as much as we generally considered. The results show that the increased trend of newly formed wetland is changing. Thus, attention should be paid to the decrease in wetland and the influence to local environment.

The reason of wetland decreasing is the decreasing of flux and sediments in the Yellow River. Since 1950s, especially 1980s, the flux and sediments in the Yellow River of the lower reach decrease gradually. There are three reasons for that: the first is the increasingly use of the Yellow River water, the second is the water and soil conservation in the upper reaches, and the third is the climatic change in

the upper and middle reaches of the Yellow River. According to the statistics, precipitation in the upper reach region (Hekou town to Longmen) is getting less than before, which results in decrease of the Yellow River flux, and flow cutoff.

Our study captured the dynamic changes of newly formed wetland in the Yellow River mouth from 1986.5 to 1996.10. In the next, we will update our results with new remote sensing data, and explore the influences on local ecological environment.

### References

- 1) Yi, X. L. and J. R. Chen, 1992, Characteristic of the Lower Reaches of the Yellow River. *Acta Geographica Sinica*, 47(3), 193-208.
- 2) Pang, J. Z., 1994, Watercourse Changes and Management in the Yellow River Delta, *The Yellow River*, 5, 1-4.
- 3) Li, G. X., H. L. Wei, and G. D. Cheng, 1996, Environment Development and Renovation in the Yellow River Mouth Recently, *Acta Geographica Sinica*, 51(2), 182-189.
- 4) Guo, Y. S. and X. G. Xu, 1990, Discussion on Exploitation of Land Resources in the Yellow River Delta, *Journal of Natural Resources*, 5(3), 193-205.
- 5) Jiang, W. R., 1990, Utilization of Land Resources in the Yellow River Delta, *Journal of Natural Resources*, 5(4), 326-334.