

STUDY ON WETLAND RESOURCES IN DELTAS AROUND BOHAI SEA

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ABSTRACT: Based on the data of wetlands in Huanghe delta and Liaohe delta which were got by the combination of Remote Sensing(RS), Geographical Information System(GIS) and Global Position System(GPS), the paper discusses the similarities and differences of wetlands in the two regions by comparing them in composition, distribution, spatial pattern of landscape and ecology. Problems in using and conserving wetland resources are shown in the paper, which aim to provide basis for the further study on the landscape ecology, function, and sustainable use of wetlands in the deltas. The study shows that the wetlands in the two deltas are characterized by great variety of wetland types, distribution with the shape of strip, abundant resources of wild plants and animals, intense effects of human activities on the structure of the landscapes, broad prospects for development and great environmental pressure. It is necessary to successfully solve the contradiction between development and protection. At present, the most pressing matter of the moment is to protect environment and control pollution.

KEY WORDS: Huanghe delta; Liaohe delta; wetlands resource; classification system

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1 INTRODUCTION

Wetland is one of the important resources with the highest biodiversity and productivity. Great environmental functions such as stabilizing climate, controlling floods, purifying pollution, providing habitats for creatures, etc. are performed by wetlands. Wetlands in delta areas have special ecological properties and landscape patterns. So, it is significant to study the resources of wetlands located in deltas.

Huanghe delta and Liaohe delta are two largest deltas around the Bohai Sea. They represent deltas around Bohai Sea in properties of wetlands. The two deltas have similar geographical background both in natural and economic features that are shown in Table 1. In this paper, Huanghe delta and Liaohe delta are

represented by the area of Dongying City and Panjin City respectively if no special explanations are noted.

2 METHOD

This paper aims at to make clear the basic data of wetlands in the studied site through the techniques of RS(Remote Sensing), GIS(Geographical Information System) and GPS(Global Position System) (generally refer to "3S"). After that, a comprehensive analysis is carried out under the direction of the theories of Geography, Landscape Ecology, Resource Science and Environmental Science, and the characteristics of the wetlands are presented.

How to precisely get the basic data of wetlands in the studied site is a key matter. For this reason, this

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paper sufficiently uses some successful technologies in the RS field which includes the processing and interpretation of RS images, utilization of computer and soft wares of GIS. A set of GPS is also used to examine the accuracy of the data. Comprehensive analysis and statistics of multiple information sources are made out according to the environmental situation and distribution of wetlands in the studied site. The technical process of the experiment is shown in Fig. 1.

3 CLASSIFICATION OF WETLANDS IN THE DELTAS

In delta zones, variety of wetland types and complex ecological environments are formed by the complex powers. Firstly, the delta zones, located in the transitional areas between land and sea where fresh water and salty water mixed, are affected by both land and

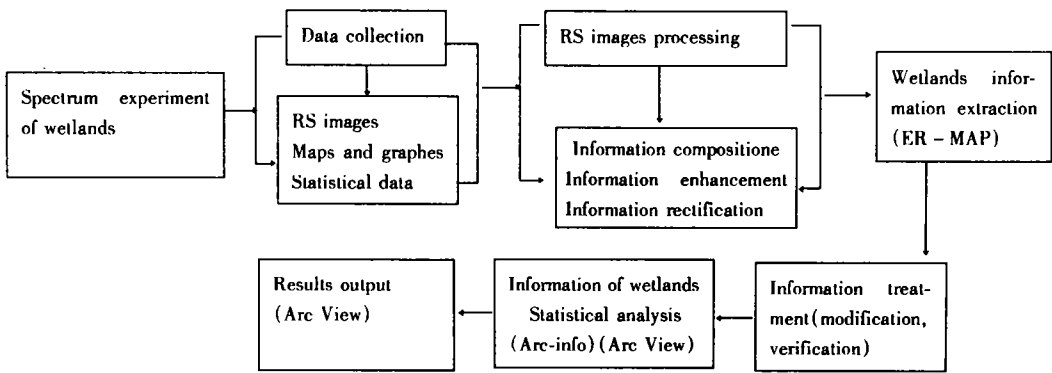


Fig. 1 Technical process of the experiment

Table 1 Geographical background of the wetlands in the studied sites

Item	Detail	Dongying City	Panjin City
Location	Area(ha)	781 200	395 900
	Latitude/Longitude	117°31' - 119°18'E/36°55' - 38°16'N	121°25' - 123°31'E/40°39' - 41°27'N
	Length of coastal line(km)	350	118
Climate	Annual average precipitation(mm)	537. 3/1900	611. 6 - 640. 0/1392 - 1705
	Annual average air temperature(℃)	12. 3	8. 3 - 8. 4
	Annual average wind speed(m/s)	4	3. 4 - 4. 8
	Main disasters	Draught, waterlogging, flood, hial, windstorm tidal, etc.	Spring draught, flood and waterlogging, etc.
Topography	Main landform	Low plain(lower than 7 m above sea level)	Alluvial plain(1 - 10 m above sea level)
	Gradient	0. 1% - 0. 2%	0. 025% - 0. 05%
Hydrology	Surface runoff(m³)	252 × 10 ⁸ (Huanghe river)	94. 50 × 10 ⁸ (total)
	Groundwater	Salt water	Salt water
Population and economy	Population	1 621 100	10 840 000
	Transportation	Highway, railway, airport, seaport, energy industry, chemical industry, agriculture, etc.	Highly developed railway, highway, seaport. agriculture, oil industry, aquaculture, reed, etc.
	Economy		

sea simultaneously or one after another. Secondly, abundant wetlands are distributed in the delta zones complicatedly or disorderly due to the reasons of lower landforms, more floods and rapid change of water-

courses. Thirdly, complicated artificial wetlands formed and covered on the natural wetlands, which intensify the complexity of wetlands' composition and distribution. To meet the end of the study, a classification system of

delta wetlands are presented in the paper. In the classification system, the powers of the wetlands' formation are taken as the key factor and the hydrological and ecological conditions and so on are also considered as important factors. The classes of the system are classified into three grades according to the principle of being scientific and practical. The criteria of classification are also figured out and presented. Among them, artificial wetlands are those new ecological systems which are generally different from the origin one

due to the disturbance of human beings.

Paddy fields and reservoirs are examples of artificial wetlands. If the wetlands remain their original ecosystems and landscapes even though some reforms and management by human being, the wetlands will be taken as natural ones such as reed fields with the management of human being. For seasonal inundated or over-wet wetlands, the term of the soils being over saturated should be not less than four months. The detail of the classification is in Table 2.

Table 2 Classification system of delta wetlands around Bohai Sea

Class- I	Class- II	Class- III	Definition of indexes
Natural wetland	Inundated or over-wet through out year	River	Freshwater area above the boundary of tidal current
		Ancient river course or lake	Freshwater area, various lakes
		Intertidal zone waters in river mouth	Freshwater and saltwater mixed, between the boundary of tidal current and gate of river mouth
	Seasonal inundated or over-wet	Heavey saline and alkaline wetland above high tide	Saline and alkaline wetland with <i>Suaeda glauca</i> , <i>Suaeda heteroptera</i> or being waste
		Reed swamp	Reed (<i>Phragmites communis</i>) field
		Other marshes	Salt marsh or cattail (<i>Tyoha orientalis</i>) marsh, etc.
		Sparse forest wetland	<i>Salix integra</i> , <i>Salix babylonica</i> , <i>Salix matsudana</i> , etc.
		Grassy marshland of bushes	<i>Tamarix chinensis</i> , <i>Robinia pseudoacacia</i>
Grassy marshland		<i>Imqerata cylindrica</i> var. <i>major</i> , <i>Aeluropus litoralis</i> , etc.	
Zone between high tide and low tide	Tidal flats in intertidal zone	Tidal flats in the coastal zone	
Artificial wetland	Inundated or over-wet throughout year	Ditch	Branch canal or main canal
		Reservoir	Reservoir
		Pond	Fish pond or pond
		Shrimp and crab aquaculture pond	Pond of Shrimp and crab
		Saltern	Saltern
	Seasonal inundated or over-wet	Paddy field	Paddy field

Table 3 Types and area of wetlands in Huanghe delta and Liaohe delta

Wetland types	Area(ha)	
	Liaohe delta (Panjin City)	Huanghe delta (Dongying City)
Saltern	754	3721
Shrimp or crab pond	8689	21228
Ditch	16697	26790
Reservoir	4133	14410
Other pond	5882	18846
Paddy field	118783	19103
Reed swamp	66383	24382
Other marshes	2985	17602
Sparse forest wetland	835	7734
Grassy marshland of bushes	722	15328
Grassy marshland	7620	16111
River	3760	10033
Ancient river course or lake	1422	4907
River mouth waters	10674	8425
Heavy saline and alkaline wetland	5118	22893
Tidal flats	60400	101914
Total	314857	333427

4 CHARACTERISTICS OF THE WETLANDS

The areas and the locations of the wetlands in Huanghe delta and Liaohe delta are obtained through the interpretation of RS images and statistics of the data . The areas are displayed in Table 3 and the distribution are shown in Fig. 2 and Fig. 3.

5 CONCLUSIONS

5.1 Similar Properties of the Wetlands Between the Two Deltas

5.1.1 Great variety of wetland types

Both in Huanghe delta and Liaohe delta, totally 16 types of wetlands displayed in Table 2 can be found and the area of the wetlands takes a great proportion in the two deltas respectively in Huanghe delta and Liaohe

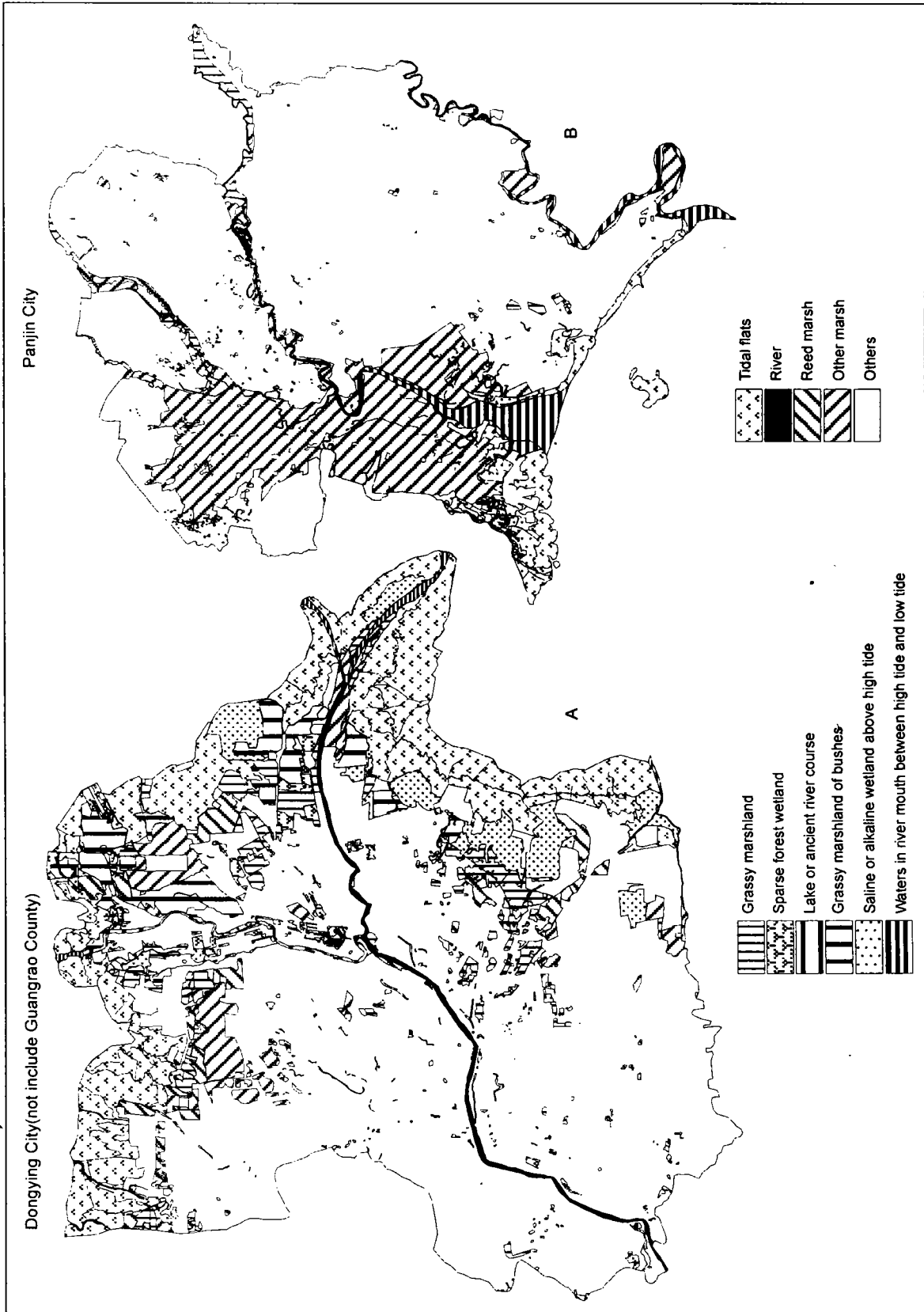


Fig.2 The distribution of natural wetlands in Liaohe Delta and Huanghe Delta

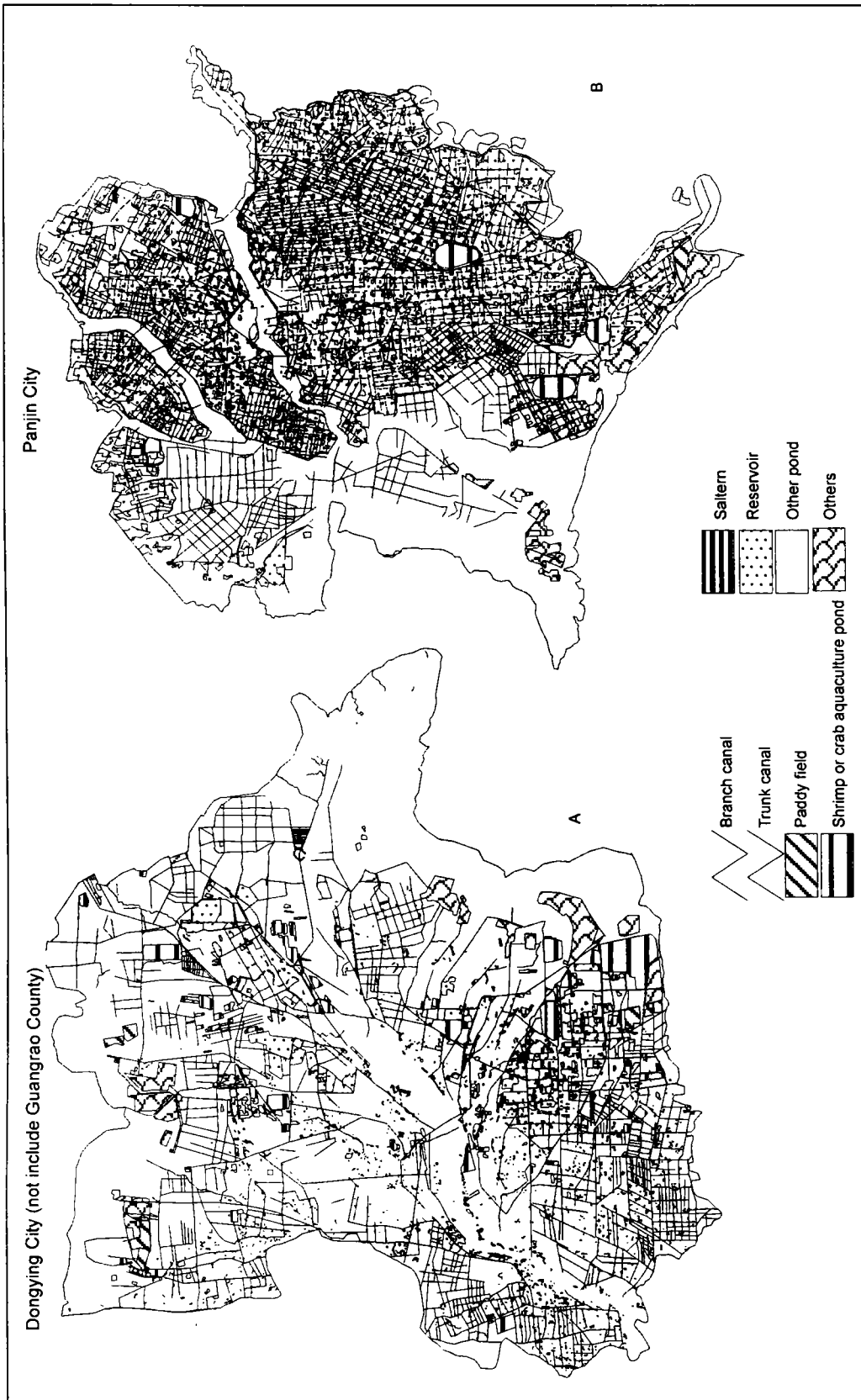


Fig.3 The distribution of artificial wetlands in Liaohe Delta and Huanghe Delta

Table 4 The composition of wetlands in Huanghe delta and Liaohe delta

Region	Total (ha)	Natural (ha)	Artificial (ha)
Dongying City	333427	229329	104098
Panjin City	314857	159919	154938

delta. Natural wetlands take 68.78% and 50.79% of the total wetlands area respectively. The proportions of every kind of wetlands to the total area are different considerably. Among all types of wetlands, tidal flats and reed fields are widely located in both Huanghe delta (30.57% & 7.31% respectively) and Liaohe delta (19.18% & 21.08% respectively) and they have the distinguishing features of the delta wetlands around the Bohai Sea (see Table 4).

Tidal flats are perfect fields for aquaculture and salt production. In addition, the tidal flats provide important habitats for the life and reproduction of fish and avifauna. The tidal flats in Huanghe delta and Liaohe delta (109 914 ha and 60 400 ha respectively) provide very fine resources and environments for economic development.

Reed is a kind of important raw material in papermaking industry. At the same time , reed has many environmental functions including wind prevention, flood control, improving soils , purifying water, terminating pollution and maintaining ecological balance. As

habitats for cranes, egrets and reed orioles, reed fields also play an important role in protecting biodiversity. The area of reed fields in Panjin City is the second largest in the world and the largest in Asia. There is also a great quantity of reed fields in Dongying City.

5. 1. 2 Distribution with the shape of strip

The situation of landforms is essential to the distribution of wetlands and the hydrological activities is the main natural power to the growth and decline of wetlands(WILLIAM *et al.*, 1986) . Huanghe delta and Liaohe delta are comparatively lower and smoother. The two deltas incline gently from the inland to the seaside. The hydrological condition changes from fresh-water river type into salt-water sea type here. The pattern of natural wetlands' distribution from inland to sea is: grassy marshland – marsh – tidal flats – shallow seawater. The pattern of artificial wetlands' distribution from inland to sea is: paddy fields – fresh-water aquaculture – salt-water aquaculture – saltern. The distribution of artificial wetlands is respondent to the natural properties of the ecology and landscape. Irrigation ditches, reservoirs and ponds are scattered in the deltas. They are closely related to the land use pattern.

5. 1. 3 Abundant resources of wild plants and animals

There are abundant resources of wild plants and animals in the two deltas. The main reason for this is • that large area of natural landscape ecology remain here with their original properties of landscape ecology. State-level reserves were also built in both regions. Details are shown in Table 5.

Table 5 The biodiversity status of Huanghe delta and Liaohe delta

Item	Huanghe delta	Liaohe delta
Flora	Vascular plant: 64 families, 185 genera, 318 species or mutations. Among them, pteridophyte: 12 species; gymnosperm: 2 species; angiosperm: 304 species.	Vascular plant: 46 families, 224 species. Among them, pteridophyte: 1 family, 2 species; angiosperm: 33 families, 174 species.
Fauna	Total: 1524 species. Terrestrial vertebrate: 300 species (beasts: 20 species; avifauna: 265 species; reptile: 9 species; amphibious animal; 6 species). Terrestrial invertebrate: 583 species.	Terrestrial vertebrate: 63 families, 273 species. Mammal: 11 families, 21 species; avifauna: 46 families, 238 species; reptile: 3 families, 10 species; amphibious animal: 3 families, 4 species.
Avifauna	National first-grade protected avifauna: 7 species; national second-grade protected avifauna: 33 species; resident (bird) 32 species; summer resident: 63 species; winter resident: 28 species; travel bird: 142 species. Notogaea and Arctogaea bird: 183 species.	National first-grade protected avifauna: 4 species; national second-grade protected avifauna: 27 species; resident (bird): 40 species; summer resident: 77 species; winter resident: 11 species; travel bird: 116 species. The most northern boundary of breeding area of saunder's gull(larus saundersi)
Fish	Freshwater fish: 58 families, 193 species; crustacean: 44 families, 148 species; mollusc: 54 families, 108 species.	Freshwater fish: 16 families, 67 species. Among them, syprinid: 36 species, taking 53.7%; sea fish: 120 species, among them, bony fish: more than 100 species, taking 90% .

5.1.4 Intense effects of human activities on the structure of the landscapes

Landscape structure is the spatial relationship between the distribution of landscape elements that are different in size and shape. It is especially important to the management of environmental resources and the conservation of biodiversity. In landscape ecology, the landscape diversity exponent, degree of landscape superiority, degree of landscape fragmentation, density of corridors, etc. are commonly used as indexes to study the situation and trends of landscape structure and then to evaluate the effects of humans' activities on the landscape patterns(LI, 1993; WANG *et al.*, 1996) . Studies indicate that in the two deltas: 1) rich landscape types provide precious habitats for wild lives; 2) degree of landscape fragmentation is not very high on an average, but it is developing rapidly; 3) there are considerable differences among the internal parts of the two deltas and the eco-environments of some parts are badly disturbed by human beings. Table 6 shows the indexes of landscape pattern of the samples in Liaohe delta which explain the effect of human beings on the landscape structure. Huanghe delta has similar characteristics in landscape pattern through the study on main indexes(CHEN *et al.*, 1996).

Table 6 The indices of the spatial pattern of the landscape in the typical sample area of Liaohe delta*

Sample plot	Landscape diversity	Landscape superiority	Artificial disturbance
River mouth	2.36	6.22	2
Paddy field	1.20	4.01	9
Dry farmland	0.68	3.49	12

* According to XIAO(1994).

5.1.5 Broad prospects for development and great environmental pressure

The two deltas are characterized by rich resources, well-developed transportation system, being easy to be developed, high benefits, etc.. With the abundant resources of plants, animals as well as large areas of tidal flats, grassy marshlands, reed fields and open waters, a broad prospects in industry and agriculture are shown. However, the deltas were located in ecotone with high level fragility in eco-environment. Natural disasters frequently occur and environmental problems are serious in the deltas.

The eco-environment of tidal flats are characterized

by low ability to resist disturbances, difficult to recover, and high level fragility because they are in the ecotone between inland and sea(XU, 1996) . Environmental problems such as sea water pollution and damages of habitats of living beings of undue developments and excessive aquaculture.

The contradiction between oil production and environment protection are even more critical in the two regions. Oil pollution, which includes air pollution, water pollution and soil pollution is the main pollution source of the two regions. Sixty-five oil fields have been found by Shengli Oil Field. Among them, 56 fields were developed and 35 fields are in Huanghe delta. 467.1×10^4 t wastewater (containing 798.8 t waste materials related to oil and 1905.2 t suspended materials) is discharged annually in the delta. High degree pollution are reached in rivers of Liupaigan, Shenxiangou, Guangpugou, etc. In three townships (Xiying, Daozhuang, Lihe) and a town (Chengguan) in Guangrao County, the total area of land irrigated by wastewater reaches 2000 ha. The highest concentration of phenol is 7.49 mg/l, being 7.4 times higher than the standard. In Liaohe delta, 1420×10^4 t raw oil and 17.7×10^8 m³ natural gas are produced annually and 537.99×10^4 t wastewater (containing 44.35 t waste materials related to oil) is discharged annually. Furthermore, the constructions of roads, electricity, water and information which are related to oil development, not only occupy large areas of wetlands but also deeply changed the landscape pattern and natural feature of the regions.

Generally, it is necessary to successfully solve the contradiction between development and protection. At present, the most pressing matter of the moment is to protect environment and control pollution in order to prevent the impact on the quality of environment. The sustainable use of wetlands in the deltas around the Bohai Sea should be further studied.

5.2 Suggestions

According to the properties of wetlands and the problems in wetland utility and conservation, the main tasks in the future are as follows:

1) Regulate the relationship between economic development and environment protection to maintain the sustainable use of wetlands, especially for the relations between the development of oil and agriculture re-

sources and environment protection.

2) Strengthen the conservation of reed resources, sufficiently realize its special value in purifying environments, providing habitats for birds, etc., eliminate the tendency of "regarding rice as superior to reed".

3) Strengthen the construction of natural reserves, pay much attention to the protection of rare and precious species and endangered species. Strengthen scientific research to understand the mechanism of ecological environment's changes and master the trends of the changes.

4) Wisely use wetland resources to give full play to their functions in purifying pollution, providing habitats, controlling floods, stabilizing climate and material production; pay great attention to their values in tourism, education, scientific research and cultural entertainment; comprehensively increase wetlands' social benefits, economic benefits and ecological benefits.

5) Successfully carry out comprehensive ecological improvement, take corresponding measures to solve local problems with the combination with production and construction, for example, combine the solution of

problems brought by the cutout of the Huanghe River with the construction of water conservancy projects.

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