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Wetland characteristics and health evaluation index system construction in the yellow river delta

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ABSTRACT

Based on on-site field tests, remote sensing image interpretation and literature, this paper gains the basic characteristics information about the Yellow River Delta wetland and selected 26 diagnostic indicators of the wetland health to construct the index system, including 3 sub-category index systems: the ecological function of the wetland, ecological characteristics of the wetland and man-social environment. It showed that the Yellow River Delta wetland ecosystem was vast in area, various in wetland types, rich in plant and animal species, and diverse in ecological functions. Besides, the index system turned out to be efficient and useful in diagnosing the wetland health, which had practical significance for future research.

KEYWORDS

Wetland characteristics; Wetland health; Principles; Index system; Yellow river delta.

INTRODUCTION

Wetland is a special kind of ecological system, different from water and terrestrial ecosystems. According to the definition of International Convention on Wetland (Ramsar Convention): wetland refers to natural or artificial, permanent or temporary marshes, peat land and waters of static or flowing fresh water, half-salt water, salt water including the sea water, the tide of which doesn't exceed six meters[1] (Han et al., 2006). Wetland not only puts land, water, biology and other natural resources as a body to provide a large amount of life and the means of production for human survival and social development, but also has significant ecological environmental functions.

The Yellow River Delta wetland located in the Yellow River estuary is the youngest and most typical delta wetland in the world. Because of its unique indigeneity, growth, vulnerability and extremely high scientific research value, the wetland draws extensive attention from both domestic and foreign wetland organizations and experts, and becomes a research focus of global wetland ecology. Experts from more than 10 countries and regions, such as China, the United States, Japan, Australia and Holland, have done a lot of investigation about wetland[2] (Cui and Yang, 2003). Ecosystem health derived from human health is a new concept belonging to a new field. At present, experts at home and abroad did not have conducted any deep research yet nor formed a set of complete systems. There are a number of concepts about wetland ecosystem health[3] (Cui and Yang, 2001), but generally they only refer to the stability and sustainability of the wetland ecosystem.

In this paper, we choose the Yellow River Delta wetland as the research area, in order to carry on with the research,first and foremost we try to get the basic characteristics information about the wetland through on-site field tests, remote sensing image interpretation and other literature, secondly based on the information above, we analyze the wetland characteristics including wetland area, type, species diversity and ecological functions, at the same time we try to construct an index system to diagnose the health of the Yellow River Delta wetland in order to advocate ecological civilization and promote harmony between man and nature through the wetland ecological research. This paper is just put forward based on this meaning and consideration.

STUDY AREA

Though it has a shorter history than other deltas, it brings billions of silt into the ocean to create new land every year, according to the history, the Yellow River Delta can be divided into ancient, modern and contemporary delta. This paper refers to the modern delta formed in 1855 when the Yellow River burst at Tongwaxiang, then occupied Daqing River and poured into Bohai Sea in Lijin County, Shandong Province. It takes Ninghai as the apex, with the southeast to the Zhimai estuary, the northwest to the Tuhai River (Taoer River) estuary. The entire fan-shaped area amounts to more than 5400 km^2. The geographic coordinate is between longitude 118°07'~119°23'E and latitude 36°55'~38°16'N. The administrative area includes Kenli County, Hekou District, Dongying District, a part of Guangrao and Lijin County, four townships of Zhanhua County and a small part of Wudi County.

WETLAND CHARACTERISTICS

Type and area

The Yellow River Delta wetland can be divided into 2 categories, natural wetland and artificial wetland. Natural wetland refers to the one which has no or little human activity interference at present, mainly including the river wetland, estuary wetland, tidal flat wetland, swamp reed wetland, meadow wetland and woodland shrub wetland. The artificial one refers to the wetland which has been obviously affected or formed directly by human activities, including reservoir wetland, ditch wetland, pit pond wetland, shrimp crab salt field wetland, rice paddy wetland and so on. The area and distribution are in TABLE 1 and Figure 1.

Species diversity

Wetland is honored as "the gene bank of species". According to the survey, there are about 42 *Familia* and 393 species of *Spermatophyte* in the Yellow River Delta wetland, of which 36 *familia* and 116 species are wild *Spermatophyte*. *Asteraceae, Asteraceae, Poaceae, Leguminosae, chenopodiaceae* are the main species. The representative plants are *Suaeda glauca Bge*, *Phragmites australis*, *Tamarix chinensis*, *Apocynum venetum*, *Glycine soja Sieb. et Zucc*, *Aeluropus sinensis*, *Imperata cylindrica*, and *Clycine soja Sieb. et Zucc* is under the second-class state protection.

The Yellow River Delta wetland is also rich in animal resources. According to the statistics, there are 1543 species of wild animals, including 641 aquatic animals and 902 terrestrial animals. Among the aquatic animals, about 9 species are under the state protection, such as *Neophocaena, phocaenoides, Phoca largha*. It is also known as "the kingdom of birds" and 283 species of birds have been discovered so far, including 200 species of migratory birds, 9 species of which are under first special state protection such as *Grus japonensis*, *Grus leucogeranus*, *Otis tard*, and about 41 species are under second special state protection such as *Cygnus atratus*, *Crus canadensis* and *Cygnus cygnus*.

Ecological functions

Different from others, the Yellow River Delta wetland has a significant function of reclaiming land. It brings large amounts of sediment (37 kg/m^3) into the ocean. The delta pushes into the Bohai Sea at the annual rate of 390 m with an average of 1.2 billion tons of silt piling up at the Yellow River estuary, which makes it possible to become the fastest-growing delta in the world.

Wetland, honored as "the kidney of the Earth", has the function of degrading pollutants. On one hand, the wetland soil can absorb part of the toxic or harmful substances; on the other hand, the strong biological activity of the wetland ecosystem can retain a large number of nutritive materials, degrade a considerable number of organic pollutants, filter and eliminate most of the harmful microorganisms and parasites.

TABLE 1 : Categories and area of the wetland unit: ha

Wetland categories		Area	Proportion (%)
Natural wetland	River wetland	14940	4.48
	Estuary wetland	8425	2.53
	Tidal flat wetland	101914	30.57
	Swamp reed wetland	41984	12.59
	Meadow wetland	39004	11.70
	Woodland shrub wetland	23062	6.92
	Reservoir wetland	14410	4.32
Artificial wetland	Ditch wetland	26790	8.03
	Pit pond wetland	18846	5.65
	Shrimp crab salt field wetland	24949	7.48
	Rice paddy wetland	19103	5.73
Total		333427	100

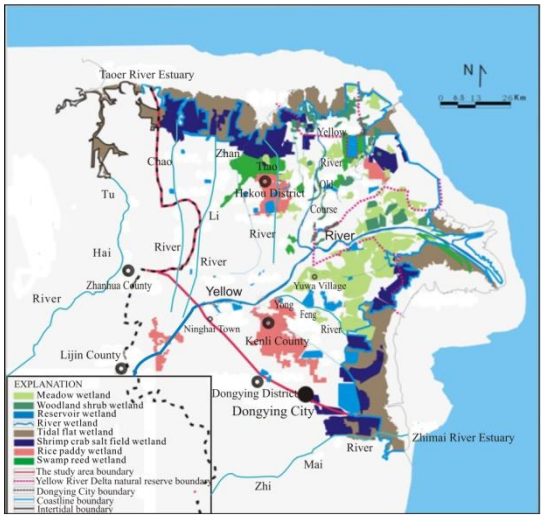

Figure 1 : Distribution of the Yellow River Delta wetland

Because of its unique geographical location and special habitats, the Yellow River Delta wetland has important habitat function, which provides not only a great amount of food and desirabel places of nesting for waterfowl, birds and other animals, but also good environmental conditions for the existence and development of biodiversity. It is the breeding habitat, migration and wintering place for birds, fishes and amphibians.

The Yellow River Delta wetland offers conditions for aquiculture, because of its rich products and large shallow waters or beaches. Production of the Yellow River such as *Eriocheir sinensis*, *Scapharca subcrenata*, *Penaeus orientalis kishinouye*, *Meretrix meretrix Linnaeus*, *Holothuria* and other fishes increase year after year. The vast wetland reed provides excellent raw material for paper industry and important material for agriculture, aquaculture and knitting industry.

In addition to the ecological functions above, the Yellow River Delta wetland also has climate regulation, flood regulation, soil protection, education and scientific research, tourism and sightseeing function.

INDEX SYSTEM CONSTRUCTION

Basic principles

Generally, 4 basic principles should be taken into account while constructing the system.

One of the principles of selecting indicators is integrity. The Yellow River Delta wetland includes many types which makes it difficult and complex when it comes to evaluating the health of different wetlands individually. The Yellow River Delta wetland ecosystem is an organic part of the nature - community - economy complex ecosystem. So, it would be better to select indicators as a whole when evaluating the wetland health.

Representativeness means that the indicators have a high degree of correlation with the wetland health, and the indicators selected can reflect certain characteristics.

Independence means that the indicators selected can reflect only one aspect of the evaluated object, and do not repeat each other.

Operability means that the indicators are qualitative and easy to be quantified, as well as for operation.

Besides, the indicators adopted are complete and reliable.

Index system

Based on the above principles, this paper selects 26 diagnostic indicators to construct the index system which covers 3 sub-category index systems: the ecological function of the wetland, ecological characteristics of the wetland and man-social environment. Each sub-category also contains a number of indicators. The ecological significance of the indicators and measurement methods are as follows.

Index system of ecological functions

(1) Water quality purification function. Artificial reed wetland is measured by the magnitude of purification rate and its stability in the treatment of urban sewage. Investigations and comparison show that reed's average rate of purification of main pollutants is about 70-80%.

(2) Material production function. Aquatic products are one of the main productive functions of the wetland system, which can be indicated by the increase rate of the harvest of wetland aquatic products. According to the survey, the Yellow River Delta wetland aquatic harvest increases 4% annually.

(3) Saline improvement function, which can be measured by the number of wetlands that exert this function in the system and its effects. Quantitative description is also used to assist the explanation.

(4) Vegetation revetment function, which is illustrated by the area proportion of the beach covered with vegetation in the intertidal zone appropriate for grass. The rate is about 70%.

(5) Hydrological regulatory function. The magnitude of the hydrological regulatory function is evaluated by the change of frequency, based on the comparison of present and past frequency of the drought and flood disaster. Besides, water conservancy facilities are also used to assist in the explanation.

(6) Sightseeing function. It is measured by landscape aesthetics value and the increase or decrease of the volume of wetland tourists. The Yellow River Delta wetland has continuously developed valuable tourism landscape in recent years, and the volume of tourists is increasing.

Index system of ecological characteristic

(7) Water assurance level. It is measured by proportion of available water to the water demand in the wetland. After calculation, the annual average guaranteed rate of the Yellow River Delta wetland is 69%.

(8) Dominant plant coverage. Coverage of the dominant plants can reflect wetland ecosystem health. Reed is a dominant plant in the Yellow River Delta wetland. So, in this paper, we use the reed growing area of the total wetland area proportion 12.59% as the dominant plant coverage.

(9) Individual changes of sensitive animals. The wetland ecosystem health is indicated by the information of the individual changes of wetland indicator species. *Scapharca subcrenata* is the typical sensitive species of the Yellow River Delta wetland. The average individual weight change of *Scapharca subcrenata* is used in this paper.

(10) Primary productivity level, which is an indicator that reflects the vigor of the wetland system, and the precise calculation of that is rather difficult. This paper used the growing conditions of reed, the wetland dominant species, as an alternative indicator. The density, height and thickness of individual are made statistics through field sampling.

(11) Water quality, reflecting the hydrological characteristic is measured by 3 parts of the wetland system water quality, including river water, drinking water and shallow seawater. According to the perennial inspection result of the Yellow River estuary, the Yellow River's overall water quality is in III category; the shallow sea water area is polluted, which makes it III category; the water quality in reservoirs and other drinking water sources is much better, in the state of II category.

(12) Soil properties. We measure the soil properties by the content of soil organic matter, nutrients and salinity, using qualitative and quantitative description.

(13) Community structure of aquatic organisms. We measure it by the complexity, self-stability and dependence of the community structure on the input from external artificial mass-energy, using qualitative description.

(14) Species diversity. We measure it by the number of species in the wetland ecosystem and the increase or decrease of species distribution.

(15) Wetlands natural disasters. We measure it by the frequency of occurrence and destructive degree of storm surges and coastal wetlands pest.

(16) Primordial of wetland. We measure the primordial of the wetland by the proportion of natural wetlands and artificial wetlands. According to the research, natural wetlands of the Yellow River Delta account for 68.79% for now.

(17) Growth rate of the wetland. With the erosion and deposition of the Yellow River Delta, area of the wetland is changing faster while the wetland ecosystem is becoming more vulnerable. Qualitative description is used.

(18) Stability of river channel. We measure the stability of river channel by the possibility of the Yellow River swinging. The longer the natural evolution of the wetland is, the steadier the river tends to be. Qualitative description is used.

Index system of man-social environment

(19) Environmental investment index. As a social resilience indicator of the wetland ecosystem, it is measured by the proportion of the investment in environmental protection in GDP. It can be found that the environmental investment index of the Yellow River Delta is 2.4% on average.

(20) Wastewater treatment Index. Wastewater treatment index, also a social resilience indicator of the wetland, is measured by the urban sewage treatment rate. It is 70% in the Yellow River Delta on average.

(21) Physical life index. It is counted by the per capita annual net income of farmers (yuan (RMB)/year). The per capita annual net income of farmers has reached 4763 yuan RMB over the past two years in the Delta.

(22) Natural population growth rate. As a population pressure indicator, it reflects the external pressure wetland systems suffered through status of the increase or decrease in population that wetland system maintained. The natural population growth rate is 6.03‰ over the past two years in the Delta.

(23) Intensity of chemical fertilizer use. It is an external pressure indicator of the wetland system health, reflecting both the extent of human pollution which wetland suffers and the external system input subsidy. It is calculated in this paper by the amount of chemical fertilizer (in purity) per hectare annually. According to statistics, the average intensity of fertilizer application is 242 kg/hm^2 in recent years in the delta.

(24) Intensity of pesticide use. Same as the fertilizer application intensity, it is also an external pressure indicator of the wetland system health, measured by the amount of pesticides used per hectare per year (kg/hm^2). The average intensity of pesticide use is 2.21 kg/hm^2 in recent years in the Delta.

(25) Wetland protection rate. It reflects human protection consciousness for the wetland and scientificness of wetland policies. In this paper, it is measured by the proportion of wetland area under protection to the total wetland area. The current protection rate of the delta wetland is 10.2%.

(26) Wetland management level. It is measured by the overall level of wetland management agencies and personnel quality. Qualitative description is mainly used.

CONCLUSIONS

This paper discusses the characteristics of the wetland, basic principles and indicators to construct the index system of wetland health.

According to the research above, the Yellow River Delta wetland is vast in area, various in wetland types, rich in plant and animal species, and diverse in ecological functions. The health of the wetland ecosystem is affected by lots of factors which directly affects the ecological function. Based on 4 basic principles, this paper selects 26 diagnostic indicators to construct the index system, which covers 3 sub-category ones: ecological function, ecological characteristics and man-social environment index systems, which turned out to be efficient and useful in diagnosing the wetland health, and had practical significance for future research.

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