Wetlands environmental degradation in the Yellow River Delta, Shandong Province of China

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Abstract

Wetlands environmental degradation is a major issue in the Yellow River Delta. The natural threats and human activities to wetlands in the delta, such as flow cut-off of the Yellow River and droughts, population growth and urbanization, cause the problem of wetland degradation during the last century, especially the recent five decades. An investigation on the wetlands environmental degradation in the Yellow River Delta and analysis of its causation were conducted. The results indicated that wetlands environmental changes were mostly tremendous in the whole delta, such as the loss of wetland area, surface water and groundwater pollution. Some new forms of management based on traditional and scientific knowledge must be introduced to solve problems of wetlands environmental degradation in the Yellow River Delta.

Keywords: Area loss and degradation of wetlands, urbanization development, human activity, the Yellow River Delta

1. Introduction

Wetlands cover 6% of the world’s land surface [1], which refer to areas covered by natural or artificial, permanent or temporal still-water or running-water, fresh-water, salt-water marshlands, peatlands, or water bodies including sea water less than 6 m in depth under low tides [2]. Wetlands contain about 12% of the global carbon pool, playing an important role in the global carbon cycle, and are very close relation with climate change [3]. In China, the loss and environmental degradation of wetlands in China is caused mainly by economic developments and human activities. Moreover, wetland protection and management are a problematic issue. Although the country is naturally endowed with relatively abundant wetland resources which had been divided into 3 broad categories with 15 sub-categories except rice fields [4], the effective and efficient management of these resources has so far remained elusive.

The Yellow River Delta, one of the largest deltas in China, is composed of large wetland areas. Wetlands in the delta are being unscrupulously degraded at a rather alarming rate due to economic developments and human activities, which naturally recharge and protect both the surface and groundwater
resources. Regrettably, no meaningful effort has so far been made to properly address the issue of wetland loss and degradation in the Yellow River Delta. Therefore, this paper aims to fill this gap. The focus of this study is on the environmental degradation of wetlands in the delta and certain wetland remediation measures are also suggested.

2. Study area

The Yellow River Delta (between 117°48′ and 119°45′E and 36°52′ and 38°12′N), one of the largest deltas in China and characterized with a temperate, semi-humid continental monsoon climate, is situated in the northeast of Shandong Province on the southern bank of the Bohai Sea [5]. Administratively, the delta mostly includes the parts of Dongying City and Binzhou City and small parts of the cities of Zibo, Dezhou, and Weifang. The delta covers an area of 7870 km² and is composed of large wetland areas, where the total area of the wetlands amounts to 4167 km² [6]. Of the total wetlands, natural wetlands cover 3131 km² (or 75.1% of the whole delta), and artificial wetlands cover 1036 km² (or 24.9% of the study area) (Table 1) [7]. Although the Yellow River Delta has experienced economic progress in recent years, the fragile ecosystems of wetlands are damaged due to economic developments and human activities in the delta.

Table 1 Major Wetland Types in the Yellow River Delta

| Types of wetlands | Main sub-types of wetlands |
|-------------------|---------------------------|
| Natural wetlands  | River wetland, Marsh wetland, Seabeach wetland, Shallow sea wetland |
|                   | Reservoir, Paddy fields, Reed fields |
| Artificial wetlands | Prawn pools, Ponds, Ditch wetland, Roadside wetland |

Environmental changes of wetlands in the Yellow River Delta

2.1 Threats to Yellow River Delta’s wetlands

Because a comprehensive and systematic study of wetlands destruction in the delta was yet to be conducted, it is therefore not feasible to statistically express the exact extent to which the Yellow River Delta’s wetlands have been decimated over the years. Nevertheless, from certain available ancillary records, it is possible to gain some useful insight into the major threats to wetland resources in the delta. The basic fact is that the delta is fast losing its natural wetlands. The natural threats to wetlands in the region include marine and coastal erosion, sea-level rise, seawater intrusion, and droughts. On the other hand, the rich wetland ecosystems of the delta are being seriously threatened by many anthropogenic factors, among which the notable human actions are increasing population pressure, rapid rate of urbanization, oil and industrial waste pollution, uncontrolled tilling for crop production, unprecedented land reclamation etc..
2.2 Area Loss and Environmental Degradation of Wetlands

Because the Yellow River Delta is not only an important base of petroleum production but also a significant food production base, the area loss of wetlands is increasingly serious (Table 2). For example, the total area of natural wetlands rapidly decreased from 2565.6 km$^2$ in 1986 to 1574.5 km$^2$ in 2008, decreasing by 811.1 km$^2$; although the total area of artificial wetlands rapidly increased during the 1986-2001 period, the decreasing trend of artificial wetlands area was obvious from 2001 to 2008, especially in recent years (Fig. 1). At addition, the area of seabeach wetland, one of types of natural wetlands, decreased from 1312.9 km$^2$ (1986) to 694.10 km$^2$ (2007), decreasing by 618.8 km$^2$ during the period from 1986 to 2007. The area of paddy fields (one of types of artificial wetlands) decreased from 188.69 km$^2$ in 2001 to 132.85 km$^2$ in 2007 (Table 2). On the other hand, because of the decreasing flow of the Yellow River (Table 3), the total area of natural wetlands sharply decreased. For example, in 1977, the area of river wetlands was 241.27 km$^2$ in the delta, but the area of river wetlands was only 90.42 km$^2$ in 2004, net decreasing by 150.85 km$^2$ [8].

| Year | Area of major wetland types (km$^2$) |
|------|-------------------------------------|
|      | Paddy fields | Reed fields | Seabeach wetlands |
| 2001 | 188.69        | 234.59      | 1019.12           |
| 2007 | 132.85        | 136.09      | 694.10            |
| Decrease | 55.84     | 98.50      | 325.02            |

Data from [9].

Table 3 Days of flow cut-off of the Yellow River

| Time series | Days of flow cut-off (d) |
|-------------|--------------------------|
| 1972-1979   | 86                       |
| 1980-1989   | 105                      |
| 1990-1999   | 902                      |

Data from [10].

Because China’s second largest oil field is located in the Yellow River Delta and the delta has become an important base of manufacturing and agricultural production in the country, wetlands pollution through
groundwater is increasingly serious, particularly with regard to the petrochemical and paper manufacturing industries [5]. With the intense performance of oil exploitation and the rapid development of local industry and agriculture, a great area of wetlands became open to reclamation. According to the statistical data in 2001, there was 199.86 km² of shrimp farms in the delta [11]. Because of intertidal wetlands plays a crucial role in biogeochemical cycle and nearshore sedimentation, the intense reclamation activities resulted in the loss of coastal wetlands and their functions as sediment traps and ecologic shelters. As a result, coastal zones were exposed to storm surges and the delta became more vulnerable.

The Yellow River Delta’s wetlands ecosystem has been subjected to over 40 years of devastation as a result of intense oil exploration and exploitation activities. Incessant oil spill coupled with indiscriminate gas flaring equally constitute a significant threat to the coastal wetlands of the delta. Oil spills contaminate the delta environment, causing substantial destruction of plants and animals as well as soil and water bodies. For example, the polluted water of the Zihe River in the delta is one of the main pollution sources, with an amount of annual pollution discharge of $1.8 \times 10^7$ m³ [12].

The ecosystem of wetlands in the Yellow River Delta is becoming more fragile and susceptible to natural hazards. Tidal flats around the rim of the delta play an important role in hydrological, geomorphological, and ecological processes in the coastal zone which are also an ideal environment for wildlife, fishing, and recreation. However, with the intense operation of oil exploitation, especially the shrimp farms, most tidal flats have been enclosed and reclaimed, so that the buffering and ecological effects of wetlands and salt marshes have greatly degenerated over the recent 20 years. The wetlands have become more and more vulnerable to natural hazards (i.e. storm erosion and ecological disaster).

Urbanization and population growth are another major cause of impairment of wetlands in the delta that has resulted in direct loss of wetland area as well as degradation of wetlands. Owing to ever increasing population coupled with intense economic activities, the demand for land in the delta is very high. But in the face of paucity of dry land and the urgent need to attend to the enormous demand for land, the local government has resorted to massive wetland reclamation, thereby resulting in the increases of artificial wetlands and the decreases of natural wetlands (Fig. 1).

Degradation is due to changes in water quality, quantity, and flow rates; increases in pollutant inputs. For example, the annual discharge amount of polluted water from the cities of Binzhou and Dongying is $4.1 \times 10^7$ m³, among which the annual discharge amount of chemical oxygen demand (COD) is $6.4 \times 10^4$ t, suspended substance $2.2 \times 10^4$ t, petroleum materials 430 t, and volatile phenol 71 t [13]. Moreover, the major pollutants associated with urbanization are sediment, nutrients, oxygen-demanding substances, road salts, heavy metals, hydrocarbons. These pollutants may enter wetlands from point sources or from nonpoint sources. Construction activities are a major source of suspended sediments that enter wetlands through urban runoff.

3. Conclusions

This study was designed to characterize and document patterns in the loss and degradation of wetlands in the Yellow River Delta. The wetlands are ecosystems which perform important ecological and socioeconomic functions for water resources management. Therefore, they should be kept preserved. The protection of wetlands, however, reflects the protection of numerous goods and services that have an economic value not only to the local population living in their periphery but also to communities outside these wetland areas.

To ensure wetland sustainability in the Yellow River Delta, an important management strategy is the prevention or reduction of additional stress that can reduce the ability of wetlands to respond to climate change. Reducing pollution, maintaining hydrology, and protecting wetland biological diversity and integrity are important activities to maintain and improve the resiliency of wetland ecosystems in the delta so that they continue to provide important services under changed climatic conditions [14-15]. Moreover,
the results of this study can be weighed against other land and water uses, including the reclamation of wetlands or the diversion of water from wetlands for the purpose of agriculture.

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