ECOSYSTEM-BASED ADAPTATION
THROUGH SOUTH-SOUTH COOPERATION

GOOD PRACTICE CASE STUDY

Water supplement for wetlands in the Yellow River Delta, China

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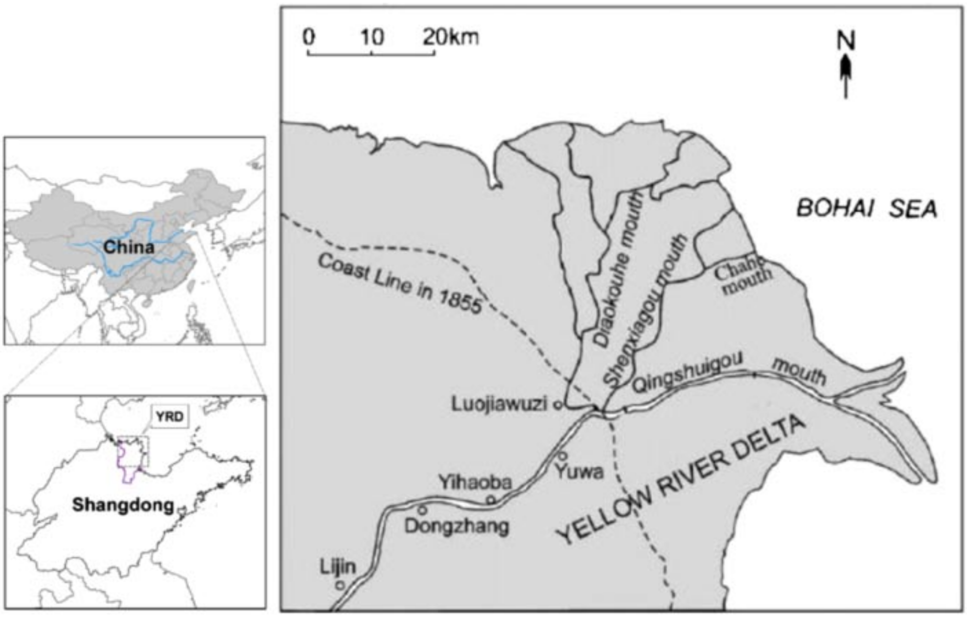

In the project "Water supplement for wetlands in the Yellow River Delta", the Yellow River Delta National Nature Reserves Administration, in collaboration with project partners, is implementing climate change adaptation interventions in the Yellow River Delta, China. These interventions promote the restoration of degraded wetlands and enhance ecosystem functioning, specifically the recharge rate of water resources. The results of the project include *inter alia*: i) restored estuarine wetlands; ii) enhanced provisioning of wetland ecosystem goods and services; and iii) income generated through the ecotourism value chain.

Key lessons

- Crises present opportunities to motivate for the reform of water management policies.
- The trade-offs between in-stream versus consumptive water use can be understood through economic analyses of the benefits provided by ecosystem services versus water extraction.
- Water management plans should account for the inherent variability of water inflows (environmental and climatic variability) and outflows (variability in water user behavior).
- Centralized and nested water governance structures within catchment-wide management institutions can contribute to revisions of water allocations in response to variations in environmental conditions, scientific knowledge and societal values.

Although some positive results have been achieved with regards to water replenishment in estuarine wetland areas targeted by the project, further challenges remain, including *inter alia*:

- The limited integration of ecological water replenishment measures into water diversion and management policies and mechanisms.
- The extensive sedimentation in diversion channels continues to impede water replenishment.
- Limitations in the water replenishment infrastructure in estuarine wetland areas.
- The absence of a long-term institutional mechanism to promote ecological water replenishment in the estuarine areas.

GOOD PRACTICE DESCRIPTION

LOCATION: estuary of the Yellow River in China

IMPLEMENTATION PERIOD: Since 2008

OPERATIONAL BUDGET: US$2.26 million

KEY STAKEHOLDERS:

The project is an initiative of the Yellow River Delta National Nature Reserves Administration

Donors:

Yellow River Conservancy Commission of the Ministry of Water Resources; Municipal Government of Dongying, Shandong

Partners:

Shandong Yellow River Management Bureau; Shengli Petroleum Management Bureau; Yellow River Survey Design Research Institute; Water Conservancy Design Institute of Shandong Province; Forestry monitoring and Planning Institute of Shandong Province; Yellow River Estuary Management Bureau; Municipal Water Conservancy Bureau of Dongying; Yellow River Estuarine Research Institute

Background information and climate change vulnerabilities

The area of perennial waterlogged wetlands in Yellow River Delta including rivers, lakes, estuary waters, pits and ponds, reservoirs, channels, salt lakes, shrimp and crab pools, and tidal flats is 964.8 km^2, accounting for 63.1% of the total area of the Yellow River Delta. The area of seasonal waterlogged wetlands (i.e. heavily saline-alkalized wetlands in supra-tidal zones, *Phragmites australis* swamps, other swamps, woodlands, shrub wetlands, wet meadows, and rice fields) is 565.2 km^2 (Xu et al., 2002; Wang et al., 2004). There are more than 800 animal species, including199 species of bird. The Yellow River Delta has become an important over-wintering and breeding site for migrating birds from North-east Asia and the western Pacific Rim. Yellow River plays a very important role to maintain the Yellow River Delta ecosystem. The Yellow River Delta ecosystem is the result of the conjunct affection of unique water flow and sediment of the Yellow River and weak tidal of Bohai Sea (Wang et al. 2011c, d).

The Yellow River originates from the arid Tibet Plateau in western China and flows through the semi-arid Loess Plateau and the semi-humid North China Plain before entering the Bohai Sea. As the global and regional climate has been changing in recent decades (Fu et al., 2004; Liu et al., 2008), the source region of the Yellow River has been negatively impacted by environmental degradation: Climate changes (mainly the rising of temperature) not only intensified soil surface evaporation, but also caused the decrease of wetland area, and degradation of Alpine frigid meadow and swamp meadow. As a result, the supplies of surface runoff and groundwater level declined, which combined with overgrazing, reduced vegetation cover and led to grassland desertification. The dominant causes of ecological degeneration in the north-eastern margin of the Qinghai–Tibetan Plateau are rising air temperatures and degradation/removal of vegetation (Wang et al., 2001; Qian et al., 2006; Yang et al., 2006). The rate of discharge of the Yellow River has been reduced to zero numerous times since 1960, which has resulted in severe negative impacts on water resources and other ecosystems downstream. It has been speculated that the Yellow River source has had a negative water budget since 1990 (Zhang et al., 2004) as a result of increased temperatures and reduced runoff from highlands. Others have suggested that changes in precipitation patterns, namely decreased rainfall in summer and increased snowfall in winter, have resulted in a net decrease in runoff and river discharge (e.g. Gu et al., 2002).

The irrigated area sourced from the Yellow River has increased enormously from some 0.8 million ha before 1949 to 7.51 million hectares in 1997. Increased withdrawals can explain about 35% of the declining runoff observed at the Huayuankou station in the lower reaches over the last half-century (Fu et al., 2004; Grafton et al. 2013). This shows that, even for such a heavily managed river, climate is a dominant factor that influences runoff. Owing to the current pronounced warming, more than 80% of the glaciers in western China are currently in a state of retreat. Changes in glacier mass balance critically affect Yellow River runoff (Liu et al., 2006; Ding et al., 2006; Yao et al., 2007; Li et al., 2010).

The frequency of zero flow in sections of Yellow River has increased since 1969. These events have started earlier in the year, and their duration has increased such that during 1997 no water discharged to the sea for 330 days. Low flows of the Yellow River have led to a decrease in water supply to the wetlands. During the past 30 years, the wetlands in the Yellow River Delta decreased in extent by more than 300 km^2 (Zonget al. 2008). Water scarcity is therefore one of the biggest threats to the biodiversity and plant growth in the wetland. It has led to the ecosystem becoming imbalanced, causing reverse succession of ecological structure. In addition, the natural wetlands of mudflat and *Phragmites australis* swamps have declined in the Yellow River estuary.

The Yellow River Delta is also a famous oil production base in China. Significant road infrastructure was constructed between the river and wetlands in recent years, causing an increased disruption of water supply to the wetland. As a result, natural hydrological relationships between the river and its floodplain were destroyed. Increasing salinization of soils and groundwater has further exacerbated these negative impacts.

In recent years the Yellow River Delta, particularly the core area of mudflat in the estuary, has been widely affected by fragmentation of natural ecosystems, resulting in accelerated destruction of species habitat and loss of biodiversity. Due to incised channels and small flow in Yellow river, it has become increasingly difficult to divert water from the floodplain to the Yellow River Delta Nature Reserve. In order to raise the water level of the river within the nature reserve and divert water into the wetland area of the nature reserve, the flow of the Yellow River needs to increase to at least 2,000 $m^3{\cdot}s^{-1}$. The diversion of water to replenish the Yellow River Delta Nature Reserve needs to be timed carefully according to seasonal variation in water availability.

Therefore, to respond to the climate change related challenges described above, one of the main adaptation measures demonstrated in the Yellow River was to supplement the River's annual water budget through: i) restoration of damaged wetlands; and ii) artificial supplementation of the River by diverting additional fresh water according to seasonal demand. Artificial recharge for ecological restoration (Donovan D J et al. 2014; Zhang et al. 2008) was considered synthetically from structure and integrity of ecosystem to restore the damaged wetlands. The ecological water demand of the Yellow River Delta wetlands is complex due to highly regulated discharge of the Yellow River, the hardly known "natural state" of the wetlands, the complex developments in land use and stream regulation, and the dynamic processes in the land-sea interface. The ecological and hydraulic models and assessment system were developed to calculate and evaluate the ecological water demand of reasonable protection target and the different water demand scenarios (Cui et al. 2009a; Cui et al. 2009b; Wang et al. 2011a).

In June 2002, a wetland restoration project (the "Five Acres Wetland") covering 2,650 ha was initiated in the core zone of the Dawenliu Management Station. In 2006, another wetland restoration project (the "Ten Acres Wetland") covering 6,700 ha was initiated adjacent to the first project. The approach to wetland restoration in both projects used water management measures such as dykes, control breaks, and pumps to increase freshwater delivery during the dry season and storage, with the goal of generating large stands of *Phragmites australis* and areas of open water suitable for waterfowl (Li et al. 2011). Based on the researches and tests of wetland restoration, Dongying Municipal Government prepared and implemented the project entitled "1 million hectares of wetland ecological water conservation planning (2010-2015)" focused on the replenishment of the Yellow River Delta's water resources.

Since 2008, Yellow River Delta Nature Reserve has been diverting water and sand from the Yellow River. The ecological water diversion area is located in the southern side of the estuary of Yellow River, with an area of about 13,300 ha. In recent years, the Yellow River Estuary Management Station has restored a total of 6,600 ha of wetlands through the implementation of wetland restoration projects. Five water diversion projects have been carried out since 2008 and have replenished a total volume of 100,966,700 m^3 of water from the Yellow River. A total water volume of 118.72 million m^3 (Zheng et al. 2012) has been replenished for the Northern Yellow River Delta Nature Reserve since 2010.

Intervention technologies

By making several discharge sluices in the original dams, and building separation dams in saline alkali soils, the water replenishment is achieved in two ways; firstly, a natural floodplain is formed with the rise of water level to replenish water. Secondly, culvert pipes are installed on weirs to replenish water.

Diaokouhe River Ecological Water Diversion Program and Experiment of Restoring Water for the Old Course of Yellow River draws off water from Cuijia Water Control Project

Description of the results

Through the repeated diversion of water from the Yellow River, the volume and surface area of the estuarine wetland has increased. This has helped to improve and maintain the ecological conditions in the local wetland areas (Wang *et al*. 2011b). The ecological benefits are as follows:

(1) The water surface area of the estuarine wetland has increased as a result of artificial and natural replenishment. In 2012, the water surface area of the wetland increased by 2,470 ha, while that of the river channel was increased by 920 ha through ecological water replenishment. The additional water provided habitat for *Phragmites australis,* the indicative vegetation of the Yellow River Delta wetland, during their period of sprouting and vigorous growth. Furthermore, replenishment of the aquatic environment provides an ideal habitat for many water birds such as *Grus japonensis, Ciconia ciconia, Cygnus cygnus, Cygnus colombianus*, and *Cygnus olor*.

(2) The underground water recharge for the estuarine area has increased and the underground water table has been raised. Following ecological replenishment, the underground water table was raised between 0.02-0.65 m in the area within 4 km of the riverbank. The recharge of underground water can help prevent sea water intrusion and reduce salinization.

(3) Freshwater in the coastal areas has been replenished, which not only maintains appropriate salinity in the offshore waters, but carries large amounts of nutrients and promotes the improvement of aquatic ecological conditions in the estuarine areas. The

figures show that approximately 50.6 billion m^3 of freshwater has been replenished through water and sand diversion. Consequently, conditions are favorable for the migration and spawning of fish in the estuarine areas.

Water birds in Yellow River Delta

GOOD PRACTICE ANALYSIS*

Knowledge building

How has the project built upon or applied the findings of specific research projects? How has the project actively contributed to international understanding on Ecosystem-based Adaptation?

The water replenishment for the Yellow River Delta builds on scientific research conducted by the Yellow River Delta National Nature Reserves Administration, the Yellow River Survey Design Research Institute, and relevant institutes and universities. To calculate the ecological water demand of reasonable protection target and the different water demand scenarios to adapt to climate change, the ecological and hydraulic models and assessment system were developed synthetically from structure and integrity of ecosystem. Driven by the demands of damaged wetlands restoration came from the stakeholders (Nature Reserve Administration, scientific institutions and experts, NGOs), numerous research experiments have been conducted – including eco water replenishment tests of 50,000 acres and 100,000 acres respectively in 2002 and 2006. The eco water replenishment tests achieved good results and influenced policy planning of the Yellow River delta. Eco water replenishment has been upscaled to thousands of hectares in this area. Research has been conducted simulating, valuating, and testing different plans of water replenishment for the Yellow River Delta.

Publications in academic journals and web information made the research freely available to the public. Field trips organized with scientific institutions and universities promoted the communication of the knowledge generated through this programme. The planned establishment of wetland museum will be beneficial for sharing success of the adaptation practices.

Financial sustainability

How has the project secured financing for sustaining and/or expanding its impacts?

The returns of the project include the increased annual ecotourism income and the increased ecosystem service value. These returns could be beneficial to the sustainable development of Dongying city. The sustainable development is very important for the future investment.

Transferability

How has the project ensured that its activities can be transferred beyond the specific contexts in which they were implemented?

The good practice of the initial wetland restoration in Dawenliu Mangement Station has been successfully applied for governmental sectors such as Doingying Municipal Government in up-scaling water replenishment of the Yellow River Delta.

In addition, the lessons learned (see “key messages”) during the water replenishment of the Yellow River Delta, such as the success of trade-offs evaluations (between water consumption and uses) and ‘share’ system to conserve the watershed as well as sustain the social-economic benefits from ecosystems services, are likely to be of great benefit to other countries and regions to cope with the wetland degradation caused by climate change.

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* This analysis is based on the “principles of good practice” developed by the EU/FP7-funded project AfriCAN Climate (2011-2014). These principles represent critical cross cutting issues shared by the majority of climate change projects, regardless of focus, scope and scale. They are intended to encourage critical reflection and help project developers and decision-makers draw out relevant lessons. Source: http://africanclimate.net/en/good-practice/8-principles-good-practice

Maximising co-benefits

How have the interventions of the project promoted additional benefits?

Based on scientific research and by making several discharge sluice in the original dams, and building some dams separating in saline alkali soil, several co-benefits can be achieved during the water replenishment.

The replenishment of the aquatic environment provides an ideal habitat for many water birds such as *Grus japonensis*, *Ciconia ciconia*, *Cygnus cygnus*, *Cygnus colombianus*, and *Cygnus olor*. The underground water recharge for the estuarine area has increased and the underground water table has been raised. The recharge of underground water can help prevent seawater intrusion and reduce salinization. Freshwater in the coastal areas has been replenished, which not only maintains appropriate salinity in the offshore waters, but carries large amounts of nutrients and promotes the improvement of aquatic ecological conditions in the estuarine areas. Conditions are favorable for the migration and spawning of fish in the estuarine areas.

With the increasing of water birds, many Chinese and foreign tourists are attracted come to visit. In the past 5 years, the growth rate of the annual ecotourism income of the Yellow River Estuary increased by 23.9%.

Monitoring and Evaluation

How has the project demonstrated its impacts in terms of achieving objectives, outcomes, and outputs? Explain how M&E plans were developed, and how effectively they have been applied.

The integrated monitoring and evaluation methods could make ecological water replenishment estimation more rational. The monitoring of the project include: hydrological monitoring work, the establishment of flow measurement cableway, check site, watchtowers, research center, wetland monitoring station, simple patrol terminal. Some research has been done to evaluate the ecological value of wetlands in the Yellow River Delta for different plans of make up water with landscape model.

Monitoring and evaluation results could assist people and government officials to “see” that a) the ecological benefits after water supplementing: the ecological function of the wetlands has been effectively recovered, wetlands value obviously increased and ecological benefits of make up water are remarkable; b) the amount of make up water does not have good linear relation with wetland value, showing water demand of the wetlands of the Yellow River Delta has a relevant range, not the more water the better.

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