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Short communication

Wetland recreational agriculture: Balancing wetland conservation and agro-development

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ABSTRACT

Agricultural development at the expense of natural wetlands is an historic and global phenomenon. The wetland-agriculture shift in ecological interactions from competition to coexistence requires more sustainable modes of development to balance wetland conservation with agriculture. Considering that the recreational values of wetlands have been gaining recognition, the concepts, types, development pathways and management challenges of wetland recreational agriculture are proposed here based on an analysis of the evolution of wetland-agriculture interactions as well as lessons and experiences derived from case studies of wetland agriculture. Through learning from traditional eco-agricultural ideas and using modern agricultural technology, wetland recreational agriculture is committed to delivering multiple ecosystem services, increasing the profitability of wetland agriculture and realizing a balance between public and private interests. Six practical guidelines are proposed, and the joint action of local residents, enterprises, scientists, governments, NGOs, and volunteers is recommended to drive the implementation of specific wetland recreational agricultural practices.

1. Introduction

Wetlands provide considerable ecosystem services, including provisional, regulatory, supportive and cultural services (Russi et al., 2013). However, the owners and/or managers of a specific wetland do not benefit from all these services (*e.g.*, regulatory, supportive and cultural) because the delivered benefits are typically enjoyed by the public for free.

Among cultural ecosystem services, recreational services have been underestimated (Sanna and Eja, 2017). Globally, recreation is one of the most important economic activities, especially in wetlands (Wall, 1998). On the one hand, wetlands support a diversity of recreational uses, including waterfowl hunting, saltwater fishing, freshwater fishing, recreational shrimping, recreational crabbing, wildlife observation, nature study, photography, *etc.* (Everard et al., 2017). However, although recreational services have been economically evaluated in wetland ecosystems (Zhang et al., 2012; Russi et al., 2013), wetland owners/managers cannot profit directly unless such activities actually occur in their wetlands. Little information is known and few policies have been implemented regarding wetland recreational activities (Park et al., 2017).

On the other hand, the characteristics of agricultural recreation have been increasingly emphasised in developed European countries (Primdahl, 2010), and the recreational activity of agritourism has been a major component of the rural economy of some European and Asian regions for several decades—even centuries—and is currently flourishing (Bernardo et al., 2004; Barbieri and Valdivia, 2010; Qiu and Fan, 2016). Therefore, wetland recreational development efforts could benefit from agricultural recreation strategies. As urbanisation increases in developing countries, more capital is invested in the surrounding agricultural wetlands, where more recreational activities, including short-term tourism, are developed as the consumption capacities of residents increase.

The objectives of this study are to (1) analyse the evolution of wetland-agriculture interactions, (2) propose a potential wetland agricultural mode to balance wetland conservation and agricultural development in view of ecosystem services, and (3) provide some recommendations to promote the harmonious existence of wetlands and agriculture.

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2. The evolution of wetland-agriculture interactions

Agricultural activities can be used as key variables to investigate many ecological processes (Gall and Orians, 1992). As a dependent variable, wetland-agriculture interactions have shifted in response to both agricultural development and wetland conservation. As agriculture has developed over ten thousand years, it has steadily spread across all continents and become a dominant form of land management (Gall and Orians, 1992; Verhoeven and Setter, 2010), and wetlands have been selected as the first target for agricultural use due to their intrinsic water and soil conditions, which are suitable for agriculture. Some wetlands with fertile soils and plentiful water in temperate and tropical zones have been drained for agricultural purposes. This has occurred for hundreds of years in many countries or even much longer in Central and South America, eastern China and northwestern Europe (Ramsar Convention on Wetlands, FAO, International Water Management Institute, 2014), where more than half of the wetlands have been lost and where agricultural uses have been identified as the primary cause of ongoing losses since the 1900 s AD (Davidson, 2014; Ramsar Convention on Wetlands et al., 2014). Between 1780 and 1992, 45% of U.S. wetlands were converted to other land uses, primarily agriculture (Heimlich, 2003), and by the 1980 s, 60–70% of wetlands had been lost in Europe, with the main losses resulting from agriculture (Cosentino and Schooley, 2016). The area of lacustrine wetlands in the middle and lower reaches of the Yangtze River of China decreased from 2.58×10^4 km^2 in the 1950 s to the current area of 1.05×10^4 km^2 in the 2010 s. The reclamation percentage of Dongting Lake is greater than 50% (State Forestry Administration of China et al., 2016).

In addition to direct loss, the other major threat to wetlands from agriculture is pollution. Due to the excessive and unreasonable use of fertilizers and pesticides, livestock and poultry manure leakage, and excessive fish feeding, agricultural non-point source pollution has led to severe eutrophication in downstream wetlands (Verhoeven and Setter, 2010; Ockenden et al., 2012). In China, the eutrophic area of lakes was approximately 135 km^2 in the 1970 s, and over the next 40 years, the area increased approximately 60 fold (8700 km^2 in 2010). Furthermore, the serious decrease in biodiversity partially resulted from pollution and eutrophication. Compared to the level in the 1980 s, approximately 70% of the common wild rice has disappeared, and the number of endangered, rare aquatic wild animals and plants increased from 80 species in 1988 to more than 500 species in 2002. At the same time, alien plant species (*e.g.*, *Spartina anglica*, *Eichhornia crassipes*, and *Alternanthera philoxeroides*) as well as fishes and shellfishes have invaded wetlands with increasing severity (Science and Technology Education Division, 2010).

Currently, wetland and agriculture are more intertwined (Rijsberman and De Silva, 2006). According to the Ramsar Convention on Wetlands (2014), 20% of Ramsar sites (the wetlands of international importance) include agricultural wetland types; 78% support agricultural production; and more than 50% are threatened by agricultural activities. In China, agricultural wetlands are the major production bases of food crops (rice), livestock, poultry and a variety of important aquatic products. Statistics from the Ministry of Agriculture of China suggest that more than 60% of the food, crops and livestock products and more than 80% of freshwater fish and cocoons in the country are produced by wetland agricultural ecosystems (Liu et al., 2010). Healthy wetlands are of great value to agricultural production and environmental conservation because they not only provide land and water for agriculture but also recharge groundwater and purify agricultural drainage (Verhoeven and Setter, 2010). In arid and semiarid areas, groundwater recharge from wetlands plays an indispensable role in maintaining local agricultural production and the livelihoods of farmers (Nabahungu and Visser, 2011).

Hence, it is necessary to explore how to improve the relationship between wetlands and agriculture to ensure an appropriate balance of multiple ecosystem services for both public and private stakeholders, especially in developing countries (Wood and van Halsema 2008).

3. Wetland agriculture: lessons and experience

Once it is acknowledged that it is almost impossible to separate agricultural activities from the wetlands that have been historically involved in agriculture around the world, the question remains as to how to sustainably develop agriculture in the indigenous wetland landscape while simultaneously conserving wetlands. Is this an impossible mission or an achievable task?

3.1. Lessons from the Sanjiang Plain in northeastern China

The Sanjiang Plain is one of the most important agricultural areas in China due to its sufficient water resources, fertile soils and a suitable climate, and it used to host the largest distribution of freshwater palustrine wetlands in the country. The Heilongjiang Agricultural Reclamation Bureau, which was established and developed as being mainly dependent on the Sanjiang Plain wetlands and surrounding areas, has provided as much as approximately one-fifth of the entire total national grain output over the past 60 years (Science and Technology Education Division, 2010).

Since the 1950 s, these wetlands have suffered from high-intensity agricultural reclamation. According to our statistics and remote sensing data interpretation, the total wetland area has shrunk from 3.75×10^6 ha in 1950 to 1.11×10^6 ha in 1980 to 6.93×10^5 ha in 2010 (Fig. 1), so more than four-fifths of the natural wetlands have been lost over the last 60 years. At the same time, the area of cultivated land increased by 4.17×10^6 ha and covered 54.2% of the plain in 2010.

In addition to the net loss of wetlands, a rapid increase in the usage of surface and groundwater resources due to large-scale agricultural development has led to a decline in wetland surface water levels, which affects the succession of wetland vegetation. A 39-year comparative study showed that the vegetation changed to a drier state and that the frequency and cover of hygrophilous and oligotrophic wetland species decreased while grasses and other non-wetland species increased; this was mainly attributed to land-use changes and climate warming (Lou et al., 2015). Additionally, non-point source nitrogen (N) and phosphorus (P) pollution from agricultural development has caused a change in wetland plant species richness. When $2.0 < N/P < 9.5$, the species richness increased with increasing N/P, but when $N/P > 9.5$, the nitrogen and phosphorus balance can be destroyed, leading to a reduction in species richness (Xu et al., 2006).

Large-scale agricultural reclamation, canalization and unsustainable practices are considered the main factors driving wetland loss and degradation in the Sanjiang Plain (Zou et al., 2018). Underlying these phenomena are the enormous grain requirement and increased purchase price of rice that are the primary causes of the conflict between wetland conservation and agricultural development.

Since the Heilongjiang Provincial Government completely stopped wetland reclamation in 1999, efforts have been made to conserve and restore the surviving natural wetlands (including 6 Ramsar sties) in the Sanjiang Plain, but thorough restoration of the lost and degraded ecosystems is impossible because national food security relies heavily on the grain produced in the region. The conflict between wetlands and agriculture still exists. In recent years, some wetland reserves have developed ecotourism (Wang and Jiang, 2011), but the inconvenient traffic, lack of reputation and scarcity of talent limit its competitiveness in the tourism market. In addition to strict law enforcement for protected wetlands and ongoing tourism that is separated between wetlands and agriculture, more sustainable modes of wetland-agriculture coexistence should be developed to mitigate conflicts and increase regional ecosystem services.