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RESEARCH ARTICLE

Driving forces behind the construction of an eco-compensation mechanism for wetlands in China

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Abstract This research revealed important driving forces behind the construction of an eco-compensation mechanism for wetlands (DFEMW) in China. Using China's provincial panel data from 1978 to 2008, a fixed-effects model was used to analyze the impacts of agricultural production systems on wetlands. We identified three DFEMW as follows: the change of wetland resources and protection measures in China; declaration and implementation of the provincial *Wetland Protection Ordinance*; and wetland degradation by agricultural production systems, which necessitated the establishment of a wetland eco-compensation mechanism. In addition to the DFEMW, a significant positive correlation between wetland area and both rural population and gross agricultural production was identified, in addition to a negative correlation with chemical fertilizer usage, reservoir storage capacity, and irrigation area. The underlying reasons for the serious degradation and inadequate protection of wetlands were market failure and government failure; these were the driving forces behind the need to establish a wetland eco-compensation mechanism. From a governmental perspective, it has been difficult to rectify market failures in resource distribution and thus to prevent wetland degradation. Factors include conflicts of interest, lack of investment, effective special laws, a simple means to protect wetlands, and a multidisciplinary management system. Therefore, the key factor is the coordination of interest relationships between those who utilize wetlands and those who seek to minimize wetland degradation and effectively protect wetlands.

Keywords China, driving forces, eco-compensation, socio-economic factors, wetlands

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1 Introduction

World Wetlands Day is held annually on 2 February, marking the anniversary of the adoption of the Convention on Wetlands in 1971 in the Iranian city of Ramsar on the shores of the Caspian Sea. China signed the Ramsar Convention in 1992. On this day, each country attempts to draw attention to, and create awareness of, wetland protection issues given that wetlands have significant ecological functions. Some countries with abundant wetlands have developed special wetland regulations and wetland protection policies; these include South Korea, the United States, and Switzerland. Wetlands are known as "the kidneys of the Earth." While they cover only 6% of the Earth's surface, they provide habitat for 20% of all known species. In addition, wetlands provide a near-inexhaustible supply of material energy for human beings and animals. Analysis of substantial authoritative data from the United Nations Environment Program in 2002 revealed that one hectare of wetland could generate revenue amounting to 14,000 USD annually, seven times more than that from a hectare of tropical rain forest, and 160 times more than that from a hectare of farmland (Finlayson et al., 2005). Satellite remote sensing revealed that the gross area of natural wetlands decreased from 366,000 km^2 in 1990, to 324,000 km^2 in 2008 (Gong et al., 2010), a decrease of 11.46%. The serious damage to wetlands necessitates the formulation of practical policies for wetland protection. A wetland eco-compensation mechanism must be developed and implemented to slow down wetland degradation (Ambastha et al., 2007).

Eco-compensation has received extensive attention throughout the world, although there is not yet a unified definition of eco-compensation given the complexity of the issue and a variety of focuses. Many scholars consider eco-compensation mechanisms to be environmental economic

policies to protect the environment and promote harmony between humanity and nature (Wen et al., 2011; Wang et al., 2012). Based on theories regarding ecosystem services, ecological protection costs, and development opportunity costs, eco-compensation mechanisms integrate administrative means and market adjustments to adjust the relationships among stakeholders involved in environmental protection and construction (Cowell, 1997; Wilding and Raemaekers, 2000; Cuperus et al., 2001; Rubec and Hanson, 2009; Villarroya and Puig, 2010).

As an incentive policy, it has been used primarily in the fields of regional ecological protection and environmental protection and is similar to the "polluter pays" and "beneficiary pays and destroyer pays" principles (Herzog et al., 2005; Albrecht et al., 2010). Through combination of the connotations of eco-compensation with influential viewpoints in academic circles, a wetland eco-compensation mechanism has been defined as an economic system to coordinate interest relationships between wetland protection and usage with the sustainable usage of wetland resources as its ultimate goal. The mechanism is as follows: first, a tax is levied on those activities that damage wetlands to eliminate negative economic externalities and limit the occurrence of damage using these funds to recover wetlands; second, capital, technology, and preferential policies are provided as compensation for contributors and interested parties who sacrificed opportunities for advancement in order to protect wetlands. In order to recover wetlands, it is necessary to facilitate a reasonable wetland protection framework and to encourage both public and social groups to participate in wetland management. The Chinese government has established a series of laws and management security systems to make the eco-compensation mechanism possible and effective (Jin et al., 2009). With the implementation and expansion of the mechanism, economists have approached eco-compensation research from a variety of perspectives. From the macroscopic point of view, many scholars have discussed the definition, applicability, principles, purpose, and meaning of the wetlands ecosystem and have confirmed the main content from the viewpoint of policy design. For example, Rubec and Hanson (2009) examined the current wetland policies, regulations, and programs as well as the past implementation of wetland mitigation and compensation in Canada. Austen and Hanson (2008) solicited opinions and synthesized regional expertise in Atlantic Canada through the Delphi method establishing five guiding principles for compensation and providing an opinion on compensation mechanisms. Han et al. (2012) calculated preliminary fund allocation and eco-compensation for wetlands according to market value loss and ecological function value loss. This study will provide an important reference for future Yellow River Delta eco-compensation studies. On the basis of field surveys and experimentation, Xiong and Wang (2010) evaluated the benefit losses of resettled farmers and the increased values of ecosystem service functions caused by wetland recovery; the value of eco-compensation for relocated farmers was calculated based on the farmers' compensation appeal. Wetlands provide significant ecological services including environmental restoration, wastewater treatment, engineering, and biodiversity (Chen et al., 2011a; Chen et al., 2011b; Shao et al., 2013).

In China, the practice of eco-compensation began in the 1980s. At this early stage, the government imposed a simple fine on ecologically damaging behavior. Thirty years later, the government encouraged the coordination of proactive eco-environmental protection with construction and provided compensation in different areas, such as forestry, farmland, natural reserves, watersheds, and the exploitation of mineral resources. While eco-compensation laws have not been perfected at the national level, the existing compensation has been reflected in the policies established by some departments and in some local practices (Wang et al., 2012). Eco-compensation has been implemented in different forms, such as national ecological projects, national transfer payments from the exchequer, inter-region transfer payments from the exchequer, and eco-compensation taxes and duties. The urgent need for wetland eco-compensation laws to ease the gradual trend of degradation and protect wetland sustainability has helped to rectify the imbalance between wetland protection and usage. Wetland protection has undergone a transition from simple economic use to simultaneous protection and use (Sharma et al., 2015). Arbitrarily strict measures were ineffective in solving wetland degradation problems; the key to sustainable development is the coordination of the imbalance of interests between wetland protection and usage. As it is based on the principles of welfare and efficiency, wetland eco-compensation is the most efficient way to coordinate the interests of involved parties.

From the viewpoint of theoretical significance, most studies on wetlands have used ecological methods to examine ecological characteristics, environmental changes, and distribution characteristics. From the economic viewpoint, studies have occasionally combined ecological and economic characteristics to study related eco-compensation systems using socio-economic characteristics, cost-benefit analyses, and stakeholders to study eco-compensation agents. What are the driving forces behind the construction of an eco-compensation mechanism for wetlands (DFEMW) in China? The present study has attempted to identify the driving forces that affect wetland eco-compensation, in particular from a socio-economic perspective. Our findings have implications for the management of Chinese wetlands with a view to establishing more effective wetland protection. This research contributes some more practical findings to the field.

2 Study area

The Second National Wetland Resources Survey (State Forestry Bureau, 2014) identified 5 categories and 28 kinds of wetland resources in China. Of a total area of 5360.26 × 10^4 hm^2 (i.e., combined patch areas above 100 hm^2), 3.77% was natural wetlands, approximately 4667.47× 10^4 hm^2. The United Nations Millennium Ecosystem Assessment of Wetlands and Water reported 1280 × 10^6 hm^2 of wetlands around the world, comprising 8.6% of the world's land area (Finlayson et al., 2005). Therefore, we know that wetland resources are globally extensive yet relatively scarce in China. Chinese wetlands accounted for 3% of the global total, ranking fourth behind Russia, Canada, and the United States. However, wetlands were reported to cover only approximately 3.77% of China, significantly lower than the global average cover of 8.6%. With the rapid global socio-economic development in recent years, wetland ecosystems have been suffering damage and serious degradation and China's natural wetlands have been disappearing even faster than previously feared. Scholars found that 33% of China's wetlands were lost between 1978 and 2008; some 55% of these were natural inland marshes, many of which are biodiversity hotspots (Niu et al., 2011). The main direct causes of wetland destruction included infrastructure construction, land reclamation, water diversion, eutrophication, pollution, overfishing, overuse, and the introduction of alien species. The main indirect causes were population growth and rapid development (State Forestry Bureau, 2000). The fundamental reason for wetland destruction was the lack of protective laws and systems. There is currently growing awareness of the threat of wetland degradation and its effect on human life, and it is now imperative to start to protect and sustainably use wetland resources as the economy develops.

3 Methods

3.1 Data sources

All Chinese wetland statistics were taken from the Second National Wetland Resources Survey from 2008 to 2014. Related statistics (mainly including areas and quantities) were taken from the list of China's nature reserves (Ministry of Environmental Protection of the People's Republic of China, 2012). Other references included data (including most of the index) on the economic development of related provinces from the Chinese Statistical Yearbook (State Statistics Bureau, 1978–2008), related wetland area statistics from Niu et al. (2012), and some secondhand statistics from the State Forestry Administration including some national-level data compiled after consultation with the relevant departments. The present study researched eco-compensation and management conditions via interviews. In June 2013 and March 2015, interviews were conducted in sample areas including Jiangxi, Liaoning, Yunnan, Hubei, Hunan, Heilongjiang, Qinghai, Zhejiang, and Guangdong. The questionnaires for managers consisted of wetland resource conditions (area), existing problems in management (personnel allocation, capital investment, surrounding conditions, etc.), and suggestions on wetland eco-compensation in the future.

3.2 Data analysis

Changes in wetland area and the number of natural reserves were analyzed using Microsoft Excel. Using panel data from 1978 to 2008, a fixed-coefficient model was applied to study the relationships between wetland area and agricultural production systems in China. Fixed effects regression is a quantitative analysis method for panel data that varies with individual data point but not time. The fixed effects model has a different intercept per individual point, which can be represented by a series of two-value variables. Wetland area was the dependent variable in this study. Given difficulties associated with the quantification of wetland ecological function, wetland area was used in place of wetland ecological function. Several factors influence wetland area; this study focused on the impact of agricultural production systems. In addition, rural population, gross agricultural production, sown area, big livestock, aquatic product, reservoir storage capacity, irrigation area, and fertilizer usage were included as independent variables in the fixed effects regression given that these do not always show correlation with agricultural production systems. Fixed-effects regression was performed using the statistical software STATA v.22.0, from which the DFEMW were determined.

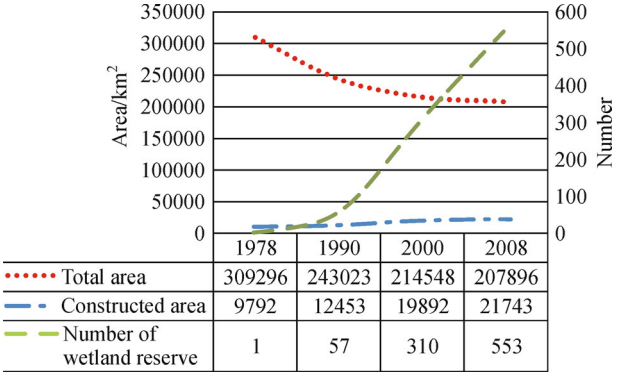
In this study, the past 30 years of statistical data on Chinese wetlands, combined with field survey data, were analyzed to reveal the socio-economic and institutional factors that result in wetland degradation. In addition, the necessity of establishing wetland eco-compensation mechanisms in China was fully explored from the perspectives of efficiency and justice. The current study calls for more attention to the imbalance between wetland protection and utilization and provides a scientific reference for the compensation of wetland ecosystems in China.

4 Results

4.1 The first DFEMW: decreases of wetland resources and increases in protection measures in China

Over the last three decades, China's wetland conservation has changed as described below (Fig. 1). Firstly, total

wetland area has decreased. In the last ten years, wetland area decreased by 3396.3×10^3 hectares including 3376.2×10^3 hectares of natural wetland area, representing an overall decrease of 9.33%. Since 2000, substantial achievements have been made in China by constantly reinforcing the protection of wetland resources, increasing financial input, and applying mechanisms of eco-compensation, e.g., the restoration of farmland lakes and wetlands, and important functional regions of wetlands. Decrease of wetland area is one of the DFEMW identified by the present study. Secondly, the number of wetland nature reserves has increased. By 2008, China established 553 wetland nature reserves. Compared with 2000, the area of protected wetland increased by 5259.4×10^3 hectares, from 30.49% to 43.51%. The amount of internationally significant wetlands increased by 25%, representing 243 wetland nature reserves and 468 wetland parks. Wetland protection has principally been achieved via wetland nature reserves, wetland parks, and natural mini-zones, and has also been supplemented by other preliminary protection forms in China. For example, China has recovered a number of natural wetlands via ecological projects and has initiated special wetland protection and recovery projects for national wetland nature reserves. China had planned to invest 9 billion CNY to restore 687,000 hm^2 of wetland from 2000 to 2005 (State Forestry Bureau, 2009). Generally, the Chinese government has relied on administrative means and financial investment to protect wetlands, but these have not met the requirements of socio-economic development. Going forward, a greater importance should be attached to institutional innovation (Maconachie, 2009). The total wetland area of China is 23.2432×10^6 hectares, of which 43.51% is currently protected. Natural wetland area makesup 21.1568×10^6 hectares of the total wetland area, 45.33% of which is protected. The establishment of wetland nature reserves has slowed the recent sharp decrease in total wetland area. Therefore, the positive environmental effect of protected wetland area is a very important DFEMW in China.



	1978	1990	2000	2008
Total area	309296	243023	214548	207896
Constructed area	9792	12453	19892	21743
Number of wetland reserve	1	57	310	553

Fig. 1 Changes in wetland areas and nature reserves in China; The data of wetland nature reserve areas is from Niu et al. (2012); The data of wetland nature reserve numbers is from the directory of 2008 National Nature Reserve (Ministry of environmental protection of the people's Republic of China, 2008).

4.2 The Second DFEMW: declaration and implementation of the Wetland Protection Ordinances of China's provinces

To strengthen wetland protection, maintain the ecological functions and biodiversity of wetlands, and to promote the sustainable use of wetland resources, *Wetland Protection Ordinances* which are based on the provision of relevant state laws and regulations and reflect the situation of individual provinces have been formulated in 19 provinces of China. The *Wetland Protection Ordinance* of Heilongjiang Province was put into force on August 1, 2003, representing the first wetland protection ordinance in China. Provincial *Wetland Protection Ordinances* have subsequently been formulated and successively disseminated and implemented in Gansu, Hunan, Shanxi, Guangdong, Inner Mongolia, Liaoning, Ningxia, Sichuan, Tibet, Jilin, Jiangxi, Xinjiang, Zhejiang, Shandong, Beijing, Qinghai, and Yunnan Provinces (autonomous regions and municipalities). The *Wetland Protection Ordinance* of Hebei Province went into effect on February 1, 2015, which was the 19th provincial-level *Wetland Protection Ordinance* in China. From 2003 to 2015, the amount of *Wetland Protection Ordinances* increased linearly from 2 to 19 (Fig. 2). Economic compensation should be given to the stakeholders around the wetlands according to *Wetland Protection Ordinances*, which, to some extent, provide a legal basis for the formulation of eco-compensation mechanisms established by the local wetland administration department.

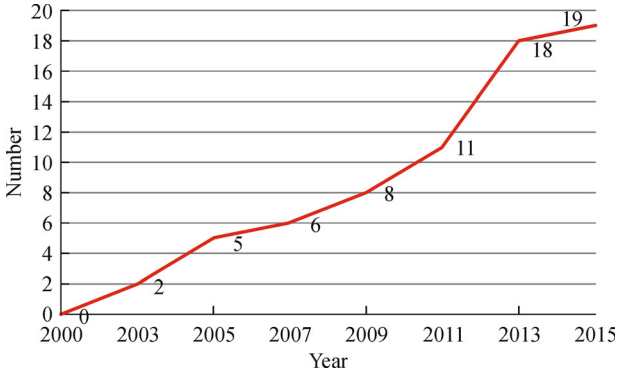


Fig. 2 The number of Wetland Protection Ordinance in China.

In recent years, all local authorities have been actively engaged in wetland protection work, and wetland eco-compensation issues have been discussed in many regions (Table 1). In short, wetland protection is an ecological public welfare issue, and the declaration and implementation of each province's *Wetland Protection Ordinance* is an important DFEMW.

Table 1 Implementation of wetland eco-compensation in various regions of China

Regions	Start time	Wetland eco-compensation measures
Guangdong Province	2010	The proposal *Strengthening wetland Protection and Establishing the key wetland Ecological Compensation Mechanism* was listed by the Chinese People's Political Consultative Conference (CPPCC) of Guangdong Province as one of the four key proposals, which was supervised by the principal provincial leaders. From 2011, 10 million CNY each year would be used for the support of provincial wetland protection, as decided by the provincial financial department
Heilongjiang Province	2009	During the period of the 12th Five-Year Plan in China, half of the natural wetlands in Heilongjiang Province were included in the compensation range of wetland ecological efficiency. In 2012, 10 million CNY was established by the provincial financial department as the specific fund for wetland protection compensation. 21 wetland nature reserves and 1 wetland park in Heilongjiang Province were put into the compensation range
Suzhou City, Jiangsu Province	2010	Drinking water sources and important ecological wetlands were listed in the eco-compensation focus of *Suggestions about Establishing the Mechanism for Ecological Compensation* that was published by Suzhou, Jiangsu Province, and included the township government, village committee, and farmers, which undertook direct responsibility for the region's ecological protection, as the compensation target. From 2010 to 2011, approximately 70 million CNY was set as the fund of total wetland ecological benefits compensation. In March 2013, Suzhou City continued to publish *Suggestions about Adjusting and Improving the policy of Ecological Compensation*. The measures of classification and tranche were applied to the village's wetland eco-compensation, improving its standard
Wuhan City, Hubei Province	2014	Wuhan City of Hubei province started to perform *The Tentative Measures of the Ecological Compensation in the Wetland Nature Reserves*. 10 million CNY was invested annually by the municipal and regional financial department in eco-compensation for the 5 wetland nature reserves of Wuhan City. Compensation would be paid to stakeholders, whose production and operation activities are restricted by the wetland protection, and operators, whose waters, intertidal zones and woodlands are economically damaged by foraging wildlife, such as birds

4.3 The third DFEMW: agricultural production systems have heavily degraded wetland function, necessitating establishment of a wetland eco-compensation mechanism

According to authoritative research (Niu et al., 2012), wetland areas have been directly impacted by agricultural production systems. A significant positive correlation between rural population and wetland area was identified by the present study ($p = 0.000$, $t = 4.27$) (Table 2). In the past 30 years, construction in rural areas has seen continuous development and the economic level of China has been constantly improving. Due to urbanization, a constant decrease has been seen in the rural population of China. The rural population accounted for 83% of the total population in 1978, decreasing to 29% in 1995, and was an estimated 50% in 2010. With the growth in China's urban population and pollution, urban dwellers' demand for wetlands has increased accordingly. Gross agricultural product showed a significant positive correlation with wetland area ($p = 0.000$, $t = 4.94$) during the present study. Gross agricultural product reflects the total scale and level of agricultural production in a country or a region. Decreases have been observed in the proportion of gross agricultural production in GDP year on year. While farmland resources have been close to the warning line, 1.8×10^9 mu (1 hm^2 = 15 mu), China's grain output has increased over ten consecutive years. This demonstrates that whilst the grain output of China has increased, water resources have been significantly consumed. The growth in the grain yield of farmland has undoubtedly increased production activities such as the use of chemical fertilizers (Zhao et al., 2012). In addition, the natural environment and biodiversity have been impacted to different extents by the economic development across regions, with implications for wetland degradation.

As of October 31 2006, the arable land area of China was 1.827×10^9 mu (1 hm^2 = 15 mu), representing a net decrease of 4.602×10^6 mu since the end of the previous

Table 2 Agricultural production impacts to wetland area

Wetland area	Rural population	Gross agricultural product	Sown area	Big livestock	Aquatic product	Reservoir storage capacity	Irrigation area	Fertilizer usage	_Cons	Number of obs	Prob > F	*R*-sq
Coef.	3.609154	5.057269	0.1205286	1.713867	−1.653901	−13.61619	−88.85849	−3.42267	24256.51	108	0	within = 0.6265; between = 0.2201; overall = 0.4234
Std. Err.	0.8461968	1.024698	0.1279138	2.054678	2.428576	3.77979	9.908921	1.687913	2383.222			
t	4.27	4.94	0.95	0.83	−0.68	−3.60	−8.97	−2.03	10.1			
$P>\|t\|$	0	0	0.347	0.407	0.498	0.001	0	0.046	0.017			

year, and the country's per capita arable land area was 1.39 mu, which was close to the warning line of 1.8×10^9 mu (1 hm^2= 15 mu). According to the statistics of the Ministry of Agriculture, the burden on farmers should have been reduced by the 2005 abolition of the agricultural tax. However, this was not the case given that the production costs of rice, wheat, and maize grew at a rate of 6%–8% per year due to the increase in cost of materials such as diesel oil, fertilizer, and pesticides. During the 33 years of reform and opening-up, the total grain output of China increased from 304.76×10^6 to 571.21×10^6 tons, i.e., by 87.43%. Over the same period, fertilizer usage increased by 581% from 8.84×10^6 to 60.27×10^6 tons. The present study therefore observed a significant negative correlation between wetland area and fertilizer usage ($p = 0.046$, $t = -2.03$). A significant negative correlation was also identified between effective irrigation area and wetland area ($p = 0.000$, $t = -8.97$). Based on the data of the statistical yearbook, continuous growth in the effective irrigation area took place in provinces that were short of water resources in north and northwest China. Viewed from the national context, the demand for water resources would inevitably increase due to the growth of paddy fields and irrigable land. Under the premise of water balance, the supply of water will decrease in wetlands, which will inevitably lead to the degradation and atrophy of wetlands; this is particularly serious in the north and the northwest regions of China that are currently suffering from shortage of water resources (Li et al., 2009).

Reservoir storage capacity is significantly negatively correlated with wetland area ($p = 0.001$, $t = -3.60$). For example, the number of dams in Heilongjiang province increased from 93 in 1990 to 414 in 2000. Over the same period, the number of reservoirs increased from 491 to 609. The construction of these water conservancy facilities will inevitably lead to the degradation of riverine wetland and marsh wetland, which rely on river water as a resource.

Over the last 30 years, the pressures on wetlands and other ecological systems have undoubtedly decreased due to reductions in the amount of Chinese big livestock. However, in some areas, livestock breeding has still impacted the degradation of the ecological systems. In the Songnen Plains of China, an important contributor to the degradation of wetlands was the large-scale reproduction of livestock, such as cattle and sheep. With the implementation of China's protection policy and its impact on rural areas the overall breeding of large livestock has decreased, resulting in a non-significant correlation between the breeding of large livestock and wetland area ($p = 0.407$) observed during the present study.

In summary, the degradation of wetland ecosystems has been seriously affected by the agricultural production system, which is also an important driving force for the construction of wetland eco-compensation mechanisms.

Therefore, with respect to the impacts of socio-economic development on wetland degradation, it is necessary to develop a wetland eco-compensation mechanism for the whole of society. In only 30 years, China's natural wetlands have been substantially degraded. While China has invested in ecosystem recovery and management, these efforts have been insufficient given the rapid development of the economy. Thus, all of society should be made aware of the need for wetland ecosystem protection, and the government must establish an effective protection system through administrative means.

5 Discussion

5.1 Government failure in wetland management

Wetland ecosystem services are considered typical quasi-public goods. There are abundant natural resources in the ecosystem, and tourism, industrial, and agricultural production activities are favored. However, wetland resource ownership has in no manner been clearly defined. In addition, economic entities have lacked exclusiveness in the usage of wetland resources, among which fishery and tourism resources have been considered as public resources. This has led to neglect of the ecological bearing threshold value and an undue degree of exploitation by agricultural reclamation, fishing, and urbanization, resulting in wetland degradation and loss of biodiversity. Wetland ecological functions are vital to guarantee ecological safety and maintain the degradation cycles of pollutants. The ecological functions have been considered as public goods, neither competitive nor exclusive to any great extent. Efforts to protect wetland ecosystems and address the pollution of lakes, rivers, swamps, and coasts could optimize the local eco-environment and other watershed areas, and may even help maintain genetic continuity. Because of their public good characteristics, it has been impossible for people and community groups to simultaneously utilize wetland services whilst ensuring the protection of endangered birds and the maintenance of clean downstream water. The typical rational economic investor has not been enthusiastic about protecting the ecosystem because they have not benefitted, while those who have paid nothing have benefited from wetland ecosystem protection.

The inseparability of eco-environmental functions and the vagueness of ownership have resulted in negative exploitation of wetland resources by external users. For example, if upstream households in a given watershed cut down large numbers of trees and destroy vegetation, this will result in upstream surface damage, water losses, and soil erosion. If upstream enterprises establish many factories and discharge large amounts of sewage, downstream water will become dangerous to drink. If people over-hunt wild animals, it will negatively influence

biodiversity. These negative externalities cause more social than private costs to be incurred during periods of increased economic activity. Thus, people have undertaken much more economic activity than is required to achieve maximum social welfare, which has resulted in the overexploitation of wetland resources and the neglect of eco-environmental values.

Wetland ecological benefits are not competitive and exclusive therefore the market cannot distribute wetland resources effectively. Thus government intervention should be regarded as a main means of distributing wetland resources. Rapid socio-economic development has led to the gradual identification of the disadvantages of the wetlands protection system. China undertook protection management very late, knowing little about wetlands and paying little attention. Protection measures todate have lacked specific laws, conditions of entity resource management, economic means, and investment in wetland protection. Effective strategies could help maintain the wetland areas and prevent ecosystem degradation. Government failure in wetland management is an important aspect in the establishment of wetland eco-compensation mechanisms.

5.1.1 Inadequate investment in wetland protection

As with forestry, wetland ecosystem maintenance relates directly to the safety of national ecology. In this paper, we regard national public finance as the main investment. Therefore, government investment is the main capital source for wetland protection. According to the available statistics, the Chinese government invested 190 million CNY in its wetlands prior to 2000 (State Forestry Bureau, 2000); this averages to 106 CNY/km^2 of wetland. Globally, developing countries invest an average of 1,256 CNY/km^2, while developed countries invest 16,464 CNY on average (State Forestry Bureau, 2003). Since the implementation of national wetland protection projects in 2005, the government has invested more in protecting, recovering, and sustainably using wetlands, as well as in capability construction projects. The government had planned to invest 9 billion CNY, out of which 4.2 billion CNY was to be from Central Finance. However, the government had only invested 1.1 billion CNY by 2009 (State Forestry Bureau, 2009), which was insufficient to meet the requirements of wetland protection and recovery. Below we discuss the main issues surrounding this inadequate investment.

First, the investment and outcomes were out of proportion. According to the results of Costanza et al. (1997), wetlands could create 1,650 billion CNY — 1,500 times the wetlands investment — that could be used for socio-economic development. In addition, in comparison with investment for the protection of forests, wetlands require more governmental attention. During the Tenth Five-Year Plan, the total investment in the protection of forests was approximately 212 billion CNY (State Forestry Bureau, 2009) — 193 times that of wetland protection. Even ecological benefits compensation received investments of 20 billion CNY. Managers from different provinces have stated that it has been difficult to promote ecological recovery effectively because of the lack of investment. Many protection projects and activities could not be carried out effectively, and established natural protection areas did not function well. Therefore, it was hard to promote basic research and to prevent degradation of wetland functions.

Second, the investment structure of the Central budget was unreasonable, lacking matching local investment. On the basis of the Implementation Plan of the National Wetlands Protection Project (2005–2010), we can conclude that the main targets of investment were international major wetlands and national nature reserves. Limited national fiscal capacity and no funding meant that local wetlands were easily impacted by socio-economic activities. Capital investments were mainly put into protection and recovery projects, not into daily protection. The government should properly fund wetland investigation, monitoring, and research, personnel training, law enforcement, and team construction.

Third, given the lack of social engagement, the government has not established a mechanism with multichannel, diversified, multilevel social participation. Government investment has been the primary source for protection, but it should not be the only one. With insufficient wetland knowledge and weak awareness of the ecological benefits, people have not been enthusiastic about participating. Hubei province established the first national wetland protection foundation, which raised 40 million CNY. In fact, our research group entered seven provinces into research activities, including Jiangxi, Hunan, Hubei, Fujian, Qinghai, Yunnan, and Liaoning. However, the foundation could not provide enough support. Some international organizations have already invested in Chinese wetlands. For example, the Global Environment Facility (GEF) invested 11.689 million CNY in Chinese wetland biodiversity conservation and sustainable utilization projects, while the International Crane Foundation invested 4 million USD to save endangered white cranes throughout the world. These foundations work to protect biodiversity, but not specifically to protect wetlands, which still suffer from a lack of investment (State Forestry Bureau, 2003).

5.1.2 Loss of special protection laws at a national level

After a general survey of eco-protection practices in China and the rest of the world, we can conclude that sound policies and laws are the main means to standardize all stakeholders' activities. Imperfect wetland laws in China

make it difficult to guarantee and support protection projects. Of three global ecosystems — wetlands, forests, and oceans — only wetlands have no special protections. Specific national laws for protection of wetlands have not been devised; they are protected and managed in the context of many other related laws. These laws have different purposes and thus the main principles and institutions of wetland protection cannot be completely supported by existing laws and regulations. This lack of specific laws has made wetland management difficult. The Water Law, Land Management Law, Environment Law, Fishery Law, and Water Pollution Prevention and Control Law all feature different definitions. Wetlands are typically defined according to functional attributes and resource factors such as water area, aquiculture area, and intertidal zone. These definitions consider the ecosystem in a piecemeal fashion and neglect its integrity. Further, most executive agencies in the related fields have chosen economic exploitation over the protection of ecosystems. Additionally, various laws came into effect at different times, creating problems and conflicts, thus making wetland management more difficult.

5.1.3 Serious conflicts between protection zones and their surrounding communities

Positive externalities are the main reason for conflict between nature reserves and their surrounding communities. The government established nature reserves by compulsory means and mandated orders to place higher demand on surrounding households without providing corresponding compensation. This reflects the principal contradiction in management, which has had a wide range and has involved a great number of people. Currently, all nature reserves, excluding national major eco-function areas, comprise 47% of Chinese wetlands. According to data released by China's Ministry of Environmental Protection, there were $1{,}790 \times 10^4$ hm^2 of wetland nature reserves. Action in these areas affects 24.7 million people's lives and development interests — this comprises 1.8% of the total population of China, averaging to 138 people per kilometer.

From the viewpoint of the initial distribution of wetland rights and legal liability, local governments and community residents have legal responsibilities and obligations to protect the ecosystem and maintain ecological balance, or, at the very least, not to destroy the ecosystem. As we emphasize their obligations, we must also realize that they have the right to utilize those natural resources and ecological factors to meet their own needs and maximize their benefits. It is fair that they have the same chance to develop as other beneficiaries. The particularity of the area has meant that providers of ecological service functions were forced to abide strictly by the law to utilize natural resources and ecological factors (for example, demands to protect biodiversity and restrictions on the use of fishery resources). This has cost the local government and community residents the development rights available to other beneficiaries. The imbalance of ecological interests has resulted in the imbalance of economic interests and, ultimately, social injustice.

Positive wetland externalities differ from those of forests, deserts, and wild animals and plants. It is much harder to manage wetlands. Throughout history, nearly all people have believed that rational utilization was the best way to obtain the maximum value of wetlands; this includes the Wetland Treaty Organization, the most authoritative wetland protection organization. To ensure wetland survival, the Chinese government has used mandatory administrative means to limit household living and production activities (Junge et al., 2011); however, these measures, which fundamentally prioritize wetland protection, have resulted in great financial losses to community residents. Furthermore, wetlands have been closely associated with residents' production and living activities because wetlands have fertile soil and superior terrain. As stated in "Rational Utilization of Wetlands", published at the Ramsar Convention: "If governments wanted to make their wetland management strategy successful, they should specially focus more on local residents' participation willingness" (Villarroya and Puig, 2010). Governments should also take executors' interests into consideration so as to ensure the protection effects of their policy.

We can conclude that community residents' interests have been seriously expropriated. The investigation teams interviewed managers and local residents in three natural wetland protection areas: Poyang Lake in Jiangxi Province, Zhalong in Heilongjiang Province, and Honghu Lake in Hubei Province. The vast majority of interviewees (90%) thought the protection areas limited the development of their community economy to some extent. Residents felt less strongly about the following issues (based on the questionnaires): 1) Fishing was prohibited in the core area, and there were fishing moratoriums in the buffer area and experimental regulations that limited the catch quantum. 2) Coercive measures influenced resident income. Grazing limitations decreased ancillary revenue. Cultivated land was reduced because of bird protection, hunting prevention, and returning farmland to lakes. The government limited aquaculture to protect water environments. 3) Wild animals in the protection area spoiled crops and threatened the safety of residents and livestock. 4) There were disputes over water areas between protection groups and rural collective economies. 5) Residents in protection areas had less agricultural acreage per capita. 6) In order to protect water quality and the environment, the government limited the development of industry and relevance estate, which made the regional economies lag behind. Thus, the residents lacked ancillary revenue.

5.2 The necessity of wetland eco-compensation mechanisms

Diversified wetland resources have made great contributions to socio-economic development. Yet, wetland ecosystems have also been under great socio-economic pressure and have been substantially degraded. The fundamental reasons for all environmental problems, including wetland problems, are the rapid growth of society, economies, and population. One of the deeper reasons is the existence of eco-effectiveness externalities (An et al., 2007), which lead to the ineffectiveness of wetland resource distribution and the overuse of wetland resources. Meanwhile, those who contributed to protecting wetlands did not receive the corresponding benefits. This was a market failure. Furthermore, existing wetland protection systems and institutions are imperfect and limit the government's ability to correct the market failure. Therefore, wetland ecosystems could not be protected effectively. That was a government failure. All of this has resulted in the gradual degradation of wetland ecosystems. If this trend continues, it will result in a larger ecological disaster and threaten sustainable socio-economic development. Thus, increasing numbers of scholars have appealed for the establishment of a wetland eco-compensation mechanism (Uchida et al., 2009; Zhu et al., 2011; Han et al., 2012). As an economic and political means that has been widely adopted in developed countries, eco-compensation can effectively coordinate the protection and usage of natural resources to rectify market loss. In addition, wetland sustainability is necessary for the sake of socio-economic sustainable development.

6 Conclusions and suggestions

The establishment of China's wetland eco-compensation mechanisms has a close relationship with the building of national systems. Although these studies are not well-developed, they can form a preliminary ecological compensation mechanism framework. The factors influencing socio-economic development are fundamental to the direction of eco-compensation mechanism improvement. This research has demonstrated the driving forces behind the construction of an eco-compensation mechanism for wetlands in China, and also revealed that market failure and government failure were the underlying reasons for ecosystem degradation and inadequate protection. We used a whole variable fixed effects model to analyze the impacts of agricultural systems on wetlands, demonstrating three DFEMW; the change of wetland resources and protection measures in China; declaration and implementation of the provincial *Wetland Protection Ordinances*; and, degradation of wetlands by agricultural production systems, necessitating the establishment of wetland eco-compensation mechanisms. In addition to the DFEMW, we found that wetland area was significantly positively correlated with rural population and gross agricultural product, and negatively correlated with chemical fertilizer usage, reservoir storage capacity, and irrigation area. The key to effective protection is the coordination of interest relationships between those who use and those who seek to protect the wetlands; such coordination could alleviate ecosystem degradation and protect wetlands more effectively. It is necessary to compensate for government failure by institutional eco-compensation innovation, allowing existing protection means and management to solve this problem effectively. Eco-compensation should include both compensation for enlisted and occupied resources that rely on market operation, and compensation for losses related to reliance on government operations that make up the market failure. In this way, eco-compensation for wetland ecosystems can be established (ECWE). The ECWE is a significant part of the eco-compensation system; the government compensates wetland constructors, protectors, and managers by financial investment and transfer payments, while non-government organizations, enterprises, and individuals set up funds to compensate them. The eco-compensation system is a comparatively weak link in China's existing laws and regulations, especially in regards to wetlands. This is still not incorporated into China's legal system, although national policy is considering such questions.

Based on the above, a wetland benefit compensation system should be implemented by combining the market with the government. First, we should establish a compensation system for practical occupancy fees to achieve the direct benefits of wetlands by adhering to market discipline. Second, government macroeconomic regulations should be given priority to provide compensation for ecological service function benefits undertaken because of market failure. By combining market discipline and the government's macro-control, we could truly realize an eco-benefit compensation mechanism and provide system guarantees for wetland protection and recovery. The "payment by polluters and users" principle can be used to establish wetland eco-compensation policies in China. On the one hand, an eco-compensation tax should be imposed on enterprises and individuals who discharge pollutants into wetlands. This eco-compensation tax should balance the cost of pollution treatment and other relevant costs. On the other hand, it should also be imposed on enterprises and individuals who utilize wetland resources. Three purposes can be achieved through an eco-compensation tax. First, destructive behaviors will be punished to reduce wetlands' negative externalities. Second, this interest-oriented rule can lead to higher protection consciousness and less harmful behavior with regard to wetlands by unifying the rights and obligations of

stakeholders. Third, it can raise funds for wetland eco-compensation and protection.

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