Chapter 14
Cost-Effectiveness of Policy Options for Sustainable Wetland Conservation: A Case Study of Qixinghe Wetland, China

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Abstract A primary cause of the loss of wetlands in China is the competition for water between wetlands and their surrounding areas. This study explores cost-effective policy options to reduce off-site water use to support the sustainable conservation of the Qixinghe Wetland in Sanjiang Plain. The cost-effectiveness of four policy options is assessed and compared using multi-criteria analysis. Option I is to reconstruct the irrigation systems in the surrounding areas of the wetland where agriculture competed with the wetland for water. This option is the government's most favored strategy, but only the third most cost-effective. Option II is to construct a dam to store and control floodwaters to relieve seasonal water scarcity. This option is the most reliable in terms of saving water. It was also farmers' most favored strategy, but it imposes a high cost on the local government and therefore did not receive strong support from the authorities. Option III is to promote the adoption of water-saving practices by providing farmers with training courses. This strategy is the most cost-effective, but is less effective in saving water. This option also did not receive strong support from farmers and the government and is therefore not likely to be selected. In Option IV, water saving is achieved by converting some paddy fields to dryland crops. This option turned out to be politically unfeasible because it was the least preferred strategy of the government and farmers. It was also the least effective in saving water. If equal weights are given to all four assessment criteria, Option I would have the best overall performance, while Option IV would be the least preferred strategy. Based on these conclusions, suggestions are offered on how the local government should tackle the wetland's water shortage problem and how the central and provincial governments could tackle the problem at the macro-level.

Keywords Wetland conservation • Multi-criteria analysis • Cost-effectiveness analysis

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Introduction

Background

Sanjiang Plain is a vast, low-lying alluvial floodplain in the northeastern segment of Heilongjiang Province. It is situated at the confluence of three rivers: the Heilong (Amur), the Wusuli (Ussuri), and the Songhua.

The plain has a high ecological significance nationally, regionally, and globally. The wetlands perform crucial ecological functions: maintaining the hydrological balance, regulating water flow, mitigating floods, and purifying the water and air. The Sanjiang Wetlands are the most important breeding grounds and migration routes of migratory waterfowls in northeastern Asia and provide habitats for numerous species of wildlife. Thirty-seven wildlife vertebrate species ranked by the World Conservation Union (IUCN) as globally threatened are found in these wetlands, 20 of which are wetland birds. For some of these wetland birds, the plain represents a significant portion of their remaining global habitat area (ADB 2004). However, these wetlands have been dramatically reduced by agricultural development during the last 50 years. In the 1950s, the wetland area was 3.7 million ha, while in 2005 it had declined to 0.92 million ha.

The Sanjiang Plain's high-quality soil and favorable climate for grain production have made it the focus of government agricultural development programs, beginning in the early 1950s. The central government has strongly encouraged settlement in and reclamation of the wetlands and the development of large-scale farming in the plain. This long-term focus on agricultural production in the plain has exacerbated the conflict between ecological conservation and agricultural development.

Water is the key factor affecting the value of wetlands. Recent statistics show that agriculture has consumed more than 75 % of the water resources in the plain, and it is predicted that the irrigated acreage under paddy will double in the next 15 years which will require – under current farming practices – increasing quantities of irrigation water, leading to a sharp drop in the water table in the wetlands (Wang et al. 2005).

The conservation of the Sanjiang wetlands raises typical conservation issues in China. Wetland ecosystems have traditionally encountered threats from the direct consumption of their precious resources by local residents, but the more important and indirect threats come from the water demands driven by the overall development strategy of the country, including agricultural development, urbanization, and industrialization.

Qixinghe Wetland

Qixinghe Wetland is a typical inland freshwater wetland, situated on the right bank of the Qixinghe River in Sanjiang Plain, Heilongjiang Province, northeast China, with a total area of 200 sq. km. It performs crucial ecological functions. For the purpose of wetland ecosystem conservation, the Qixinghe National Nature Reserve (QNNR) was founded in the year 2000. Since then, according to the China Nature Reserve Regulation (1994), activities that directly affect the Qixinghe Wetland have been prohibited, such as the expansion of farming and fishing and the harvesting of reeds and other raw materials, while activities that indirectly affect the wetland still remain, among which competing water use is the most important. The Qixinghe Wetland is already suffering from water shortage. Data collected on surrounding wells show that the water table in the Inner Qixinghe Watershed has dropped by 2.5 m from 1997 to 2005. Some wells even had a decrease of 7–12 m (Xia and Wen 2007). Water conflicts arise especially during the irrigation season.

There have not been any measures taken to deal with the water supply issue for the wetland. Although conservation efforts within the QNNR have been fully implemented, unless there are policies or plans to confront the threats from outside the wetland, the Qixinghe Wetland will not be saved.

Research Objectives

The overall objective of the study has been to explore cost-effective approaches to reducing off-site water use for sustainable wetland conservation within the policy and institutional context in China. The more specific objectives were:

- To establish a profile of water problems encountered in wetland conservation and associated water-use patterns
- To explore and propose alternative policy options to manage off-site water uses for the purpose of wetland conservation
- To analyze and assess the impacts of these options in terms of their ecological effects and economic implications on different stakeholders
- To provide recommendations on how to implement the policy options with acceptable and properly distributed costs of conservation

Methodology

Study Area

The geographic coverage of the study is the Qixinghe Wetland and its surrounding areas where users compete directly with the wetland for water use, which includes the Qixinghe National Nature Reserve, Baoqing County; the Wujiuqi (WJQ) state-owned farm on the right bank of the Qixinghe River; and the Youyi state-owned farm on the left bank.

Data Collection

Information to support the study was obtained from various sources. Data describing land areas and population were provided by the Baoqing Civil Administration and Baoqing Water Resource Authority. Similar data for WJQ farm was collected from interviews, while for the Youyi farm, data was obtained from the Youyi Agriculture Committee and Youyi farm interviews.

Detailed data relating to farmers' awareness, attitudes, and behavior were obtained from a large-scale survey conducted by the research team in July 2008, involving focus group discussions and structured interviews with farmers in Baoqing County and the WJQ state-owned farm, as well as officials of the Heilongjiang Provincial Hydraulic Design Institute, Baoqing Agriculture Technology Promotion Center, Baoqing Water Affairs Bureau, and the Qixinghe National Nature Reserve Management Bureau. Two hundred and one households were interviewed in the survey. The household survey did not include the Youyi state-owned farm due to feasibility constraints. Given that the overall conditions of the two state-owned farms were quite similar, however, the WJQ farm could be taken as representative of both. The sample of 201 households represented about 14 % of the overall number of households (margin of error of 6.5 %) and about 16 % of the total in terms of the paddy acreage.

To take into account the differences in paddy production between the villages and the state farms, a stratified sampling method was applied. The first stratum consisted of irrigation districts in the rural areas in Baoqing County, and the second stratum comprised the WJQ state farm. The samples were allocated according to the area of paddy fields: about 30 % of the samples were from the rural areas and 70 % from the state farm. In each stratum, simple random sampling was applied.

Cost-Effectiveness Analysis

Cost-effectiveness analysis was the technique applied to assess the economic efficiency of options to achieve water savings in competing uses of the resource, designed to improve the prospects for increasing the volume of water allocated to wetland areas. The cost-effectiveness (C/E) of each policy option was measured by the average cost per unit of water saved. To overcome the complication that water savings and their costs would occur at different points in time, discounting was applied to the volumes involved as well as to their costs, following the approach recommended by Warford (2003). The relevant formula is:

$$C/E = \Sigma\big(C_t/(1+r)^t/\Sigma\big(Q_t/(1+r)^t \quad t = 1, 2 \ldots T$$

where the numerator in the above expression measures the present value of the total cost of water saved and the denominator the discounted total quantity of water saved, over the assessment period from year 1 to T. In all the economic assessments, a 30-year time horizon was assumed. Residual values of capital were estimated using the straight-line method of depreciation.

Multi-criteria Analysis

To supplement the cost-effectiveness analysis, a simple multi-criteria analysis (MCA) framework was applied. Based on the consultations conducted with the local officials, four different criteria were chosen through which to compare the trade-offs between the options covered by the study. A stakeholder analysis was incorporated in this exercise.

Water Requirements for Wetland Conservation

Water Availability

For the Inner Qixinghe Watershed (wherein the QNNR is located), the long-term average annual surface water quantity is 351 million m^3 while the groundwater quantity is 246 million m^3. Neglecting the double counting between them, the total long-term average annual water quantity in the watershed is 597 million m^3. The average water resource is about 4,650 m^3 per capita and 5,550 m^3/ha, much higher than the country average (Xia and Wen 2007).

The average surface water resource quantity for the QNNR is 42.9 million m^3 while the average groundwater resources amount to 13.9 million m^3. The long-term average water quantity of the reserve is 56.8 million m^3. The surface water resources of the QNNR come from upstream of the Inner Qixinghe River and from precipitation and its runoff, while the groundwater is recharged mainly by rainfall (Xia and Wen 2007).

The interaction between groundwater and surface water is complicated and difficult to assess due to the lack of essential hydrographic and geological records. In this study, it was presumed that the impact of surface water and groundwater usage was the same. This assumption is reasonable from a long-run hydrological perspective.

Water Utilization

The overall water utilization volume for the whole Qixinghe Watershed is 540 million m^3 in which the surface water utilization volume is about 92 million m^3 with a utilization rate of 18.8 % and the groundwater utilization volume is about 448 million m3 with a utilization rate of 81.4 % (Xia and Wen 2007). Generally, water supply can meet the economic demand, but the ecological water demand has not been taken into account in these calculations.

As for the distribution of water among water-using sectors, taking Baoqing County as an example, in 2007, the total amount of water use in the county was 141 million m^3 in which agriculture used 105 million m^3 of water (74.6 % of total use), industries used 32.7million m^3 (23.1 % of total use), and households used 3.2 million m^3 (2.3 % of total use) (pers. comm. Water Affairs Bureau of Baoqing Country, 2008). Since the WJQ and Youyi state farms are dominated by agriculture, the overall water utilization level for the whole study area is expected to exceed that of Baoqing County itself.

Factors Influencing Wetland Water Shortage

According to the ADB (2007), the factors contributing to a reduced water level in the wetland are as follows:

Increasing Off-Site Water Use Surrounding areas of the QNNR compete with it for water. According to the Baoqing County's planning estimation (Water Affairs Bureau of Baoqing County 2005), from 2006 to 2010 the total water demand is expected to be almost doubled, increasing from 119 million m^3 to 206 million m^3.

Irrigation and Drainage Systems The more important but indirect effect is the development of the drainage and irrigation system driven by agricultural expansion. There is no large hydrological project in the upstream part of the Inner Qixinghe River, but the development of the drainage system along with the expansion of paddy fields has damaged the wetland's capacity to retain water. The wetland is situated in a low-lying area where water resources converge at a slow flow rate. With the expansion of agriculture along the river, however, the water drainage system has been fully developed. The system accelerates the rate at which water is drained from this region, and then irrigation systems divert the water according to various economic uses.

Reduced Water Inflow Water inflows from upstream and precipitation are the only two sources of water supply, but the natural water supply or water inflow from upstream and precipitation has reduced in recent years. As well, the flood control banks or dams that were constructed to protect economic projects prevent small- and medium-scale floodwaters from entering the wetland, and this contributes significantly to the water shortage in the wetland.

Ecological Water Demand for QNNR

In general, the water shortage in the Qixinghe Wetland has been recognized. However, authoritative quantitative estimations of the situation and the wetland water demand are as yet unavailable.

In Sanjiang Plain, some researchers have calculated the ecological water demand based on the geographical and ecological situation of the plain (Guo et al. 2004; Cui et al. 2005; SongLiao Water Resources Commission 2005). Based on their findings, the land types that should be involved in calculating the ecological water demand of the wetland are reservoirs/lakes, water swamps, marshes, and reed wet soil. By using the methodology developed by the study on the Zhalong Wetland (SongLiao Water Resources Commission 2005) and taking into account the rainfall, evaporation rate, soil infiltration capability, and other factors of the Qixinghe River Basin, Xia and Wen (2007) found that the depth of water in the core zone of the wetland should be kept at about 20–25 cm while the depth of water in the buffer zone should be 15–20 cm in order to protect the QNNR and the basin wetland habitat from degradation. According to these requirements and deducting the existing water surface area, the total ecological water demand for the QNNR was estimated to be 38.17 million m^3 (Xia and Wen 2007).

According to satellite images and the QNNR Management Bureau, the amount of water that needs to be recharged to maintain the wetland is 20 % of the total ecological water demand. Accordingly, this study set 8 million m^3 as the target amount of water to be recharged to the wetland through policy intervention.

Water Use by Agricultural Sector

As compared with industry and urban livelihoods, agriculture was the largest water user in the studied area. There were severe conflicts between agricultural water use and wetland ecological water demands. Given the large room left for water saving from the agriculture sector, agriculture has been identified to be the key sector for water saving policy interventions.

Field investigation and a survey that were carried out with farmers revealed their awareness, attitudes, and behavior in relation to water use, as reported below.

Expansion of Paddy Fields

The paddy fields in the surrounding areas of QNNR have developed rapidly in the past 10 years, which accelerated the increase of water consumption by agriculture. Since 1995, paddy field areas in Baoqing County, WJQ state farm, and Youyi state farm have increased significantly by 111 %, 105 %, and 248 %, respectively, mainly due to policies encouraging their development and the high market price of rice (Baoqing Statistics Bureau (1996, 2006); Heilongjiang State Farm Bureau (1996, 2006)). As Baoqing County's planning estimation, agricultural usage will increase from 92 million m^3 to 153 million m^3 during 2006–2010 (Water Affairs Bureau of Baoqing County 2005).

Water Efficiency

Data shows that the water efficiency in agriculture is very low. The water consumption for paddy growing is about 12,000–13,500 m3/ha in the county, whereas the standard for Heilongjiang Province is only 6,750 m3/ha, according to the Water Affairs Bureau of Baoqing County.

Our survey also reveals reasons for this low efficiency dilemma: farmers listed poor hydrological system and land features as the two key factors leading to low efficiency in water use.

Water-Use Behavior

The survey found that 28 % of the people (56/200 households) relied completely on surface water (from rivers and/or the wetland), 31.5 % (63/200 households) used only groundwater, and 40.5 % (81/200 households) used both surface water and groundwater. Generally, the farmers tended to use surface water when it was available because the higher temperature of the surface water was more favorable for rice cultivation.

Under the current irrigation infrastructure, water supply cannot be guaranteed. Farmers cannot get water in a timely manner according to crop growth requirements so they try to get as much water as they can whenever there is water available without considering water saving. Thus, in high water-use seasons, there is usually a struggle to obtain water.

Water-Saving Consciousness

The survey showed that about 54 % (107/198 households) of the people were concerned about the decrease in water resources, 24 % (48/198 households) did not think that there was really a scarcity, and 21.2 % (42/198 households) were not clear about the water situation. This indicated that there was no consensus among the farmers regarding the local water situation. One possible reason was that they live in a low area around the wetland, and it is relatively easy to get water compared with other areas.

The survey also showed that the local farmers had low water-saving skills and many did not think water-saving was necessary. Most of the interviewees (80.6 % or 112/139 households) had never done any trials on water-saving practices, while 89 % (178/200 households) had never had the opportunity to get water-saving training.

Farmers' Awareness

A majority (86.3 %) of the farmers (170/197 households) knew that the QNNR was a wetland. About 46 % (91/198 households) agreed that their livelihoods were related to the wetland, while 41.4 % (82/198 households) denied such a relationship, and 12.7 % (25/198 households) of the people did not know if there was a relationship. About 64 % (63.8 % or 125/196 households) clearly expressed that they were willing to save water for the wetland, while 17.3 % (40/196 households) said that they were not willing to do so. From these information obtained from the survey, it was concluded that some of the local people already had some environmental awareness and recognized that the quality of the environment was linked to their livelihoods. However, their awareness was still too limited to result in water-saving behavior.

Water Resource Management in Heilongjiang Province

Institutional Arrangements for Water Resource Management

The overall institutional arrangement for water resource management in Heilongjiang Province involves a multi-sectoral water administration management system in which the Provincial Department of Water Resources (PDWR) plays the core role. Generally, the PDWR and Heilongjiang State Farm Bureau (HSFB) oversee the management of water resources in Heilongjiang Province. The PDWR manages provincial water issues for the Heilongjiang government and guides the Water Affairs Bureaus in the cities and counties. The Water Affairs Bureaus under the HSFB manage water issues within the state-owned farm areas and implement water administration policies. Water conservation plans in state farms need approval from the PDWR.

At the provincial level, there is also the Provincial Agriculture Development Office (ADO) that provides guidance on water-saving practices in agriculture, but this office has no strong role at the county level. At the county level, it is the Agriculture Development Commission (ADC) of the county that provides education on how to save water.

Under such an institutional framework, water issues are clearly controlled by different agencies and jurisdictions. Agriculture plays a big role in the management of water resources. The Forestry Bureau controls the QNNR and is mandated to address the wetland's water needs; however, it is not closely involved in the institutional arrangement.

Water Policies

Policies and regulations related to water management have been developed at the national and provincial levels to form an overall policy framework which covers water intake permits, water resource plans, water resource fees, water pricing policies, water resource assessments of construction projects, discharge fees, and other issues. In 2006, China issued a regulation on water permits and water resource fees, which required all water users in the various sectors to pay for water resources via the application of a water permit. That delivered a clear signal of the move toward gradually increasing water-use efficiency by strengthening water resource management and charging the use of water resources. In general, however, these policies mainly focused on industrial water users, with an exemption or favorable discount to agricultural water users.

Water Fee Management System

Because land property rights belong to the nation, farmers have to rent land for farming. Water fees are built into the land rental agreements for state farms, and this guarantees a high collection rate. However, the water fee system and policy implementation in the rural areas are weak.

According to the interview conducted with the Baoqing County Water Affairs Bureau, in the rural areas, the present water fee levy system is as follows: the farmers or the whole village pays water fees to the town's fiscal department, which then hands the fees to the county's fiscal department. The county allocates about 60 % of the water fees collected to the city authorities and keeps about 40 %. The water fee for surface water is 300 RMB/ha in Baoqing County, but there is no charge for well water. The county or town provides grants from its budget for the maintenance of the local reservoir. The fee collection rate was very low, below 30 %, showing that the water fee management system was inefficient.

On the WJQ state farm, the Water Affairs Bureau levies water fees for each working district, and the collected fees are handed to the management bureau of the farm. The management bureau from each branch farm buys water from the reservoir (government owned and run by the Reservoir Management Bureau). In practice, the water fees are handed over together with the land taxes, i.e., the water fees are bundled together with land contract fees and collected in advance when farmers rent land. The levy collection rate is as high as 100 %. The water fee standard for surface water is 300 RMB/ha, while well water costs 75 RMB/ha.

Water fees should be linked to water quantity and charged by volume, but the implementation of this policy requires corresponding metering devices which most irrigation districts do not have at present. Charging based on acreage rather than volume cannot establish a nexus between the quantity of water used and the water fee, so the existing water pricing policy will not induce water saving. This is partly due to the poor irrigation infrastructure and lack of water measurement devices.

Prospects for Economic Instruments in the Agricultural Sector

Various studies have discussed mechanisms for water resource allocation including water pricing and water rights markets (Randall 1981; Shen et al. 2001; Jiang 2003; Dietrich and Grossmann 2005). Many researchers have also focused on agricultural water-use efficiency. Amir and Fisher (1999) analyzed the demand for water from agriculture under various price scenarios. Bazzani (2005) applied the DSIRR (decision support system for irrigated agriculture) model to analyze the impact of a water pricing policy on water consumption at the catchment level. Gómez-Limón and Riesgo (2004) developed a methodology to evaluate alternative irrigation water pricing policies, while Varela-Ortega (2003) and Mejias et al. (2004) examined the effect of different policy scenarios for wetland conservation (mainly water pricing policies) on agricultural water use, farmers' incomes, and government revenue. Fu et al. (2002) developed an agricultural production function with water as a factor input for setting up irrigation water quota targets in Sanjiang Plain. Guo and Wang (2004), Mao (2005), Wei et al. (2007), and Su (2003) discussed the effectiveness of a water pricing policy in enhancing agricultural water efficiency in China. Wang and Zhou (1987), Liu et al. (2005), and Zhao (2006) applied an agricultural water-saving decision support model for western China, where water scarcity is a major issue.

In China, the direction of agricultural water price reform has been as follows: first, improving the measurement devices; second, charging on volume instead of acreage; and third, increasing the water price to cover the water supply cost. The goal of the first two is to promote water saving while the last one is to maintain the operation and management of the irrigation services.

But in Sanjiang Plain, generally speaking, administrative mechanisms, such as water resource plans and engineering projects, are still the dominant instruments in water resource allocation (Songliao Water Resources Commission 2005). The use of market mechanisms in water resource allocation is still rare in the region. The existing system, which lacks economic incentives to control water use, is unsustainable.

There are problems that cannot be solved by a water pricing policy alone, for example, the low willingness to pay of farmers; difficulty in collecting water fees, water fee cuts, and embezzlement by the fee collectors; and the poor management and maintenance of the irrigation canals, especially the end parts, the maintenance of which is not funded by the government. These problems must be addressed by a proper reform of the irrigation district management system.

Policy Options

Policy Goal

As noted, for the purpose of this study, to meet the water conservation demands of the Qixinghe Wetland, the policy goal was assumed to be a reduction in off-site water use of about 8 million m^3 (equivalent to about 20 % of the ecological water demand of the wetland), thereby allowing an increased water supply to the wetland without diminishing socioeconomic growth of the surrounding areas. Conservation of the wetland will ultimately improve the water resources and climate in the watershed and support its sustainable development.

Prospective Policy Options

In China, most reforms in water allocation have been initiated by the upper-level government authorities rather than at the local/county levels, so in the policy design in this study, the focus was on what could be implemented at the local level without excessive political or bureaucratic complexity. Through consultation with local officials and experts, policy options to reduce off-site water use were considered that included water-saving measures involving agro-hydraulic engineering, better agricultural skills, and water management reforms.

Before designing policy options for solving the water scarcity problem in the wetland, a preliminary screening was carried out of all potential policy options, based mainly on the general feasibility of the options, including the legal and political feasibility. The results of this assessment are shown in Table 14.1.

Options for Evaluation

Based on the above preliminary screening, the most feasible options selected for detailed evaluation were the following:

Option I: Irrigation System Reconstruction (ISR) Reconstructing the irrigation network for water-saving purposes

Table 14.1 Framework for policy options selection

Problem	Factors contributing to the problem	Strategy	Options
Decreasing water table in wetland	Competitive water use in surrounding area	Reducing off-site agriculture water use	(1) Reconstructing the irrigation system for water conservation
			(2) Water-saving planting practices
			(3) Change from paddy to dry crops
			(4) Management measures like water permits and water fees
	Accelerated water drainage in whole watersheds	Increasing the amount of stored water	(5) Restricting the expansion of paddy fields
			(6) Building new facilities to retain water
	Reduced water inflow	Securing water	(7) Afforestation in upstream areas
		Inflow (by improving the water cycle in the watershed)	

Option II: Ecological Water Control Reservoir (EWC) Constructing a small dam to store and control floodwater to increase the water supply and relieve seasonal water scarcity

Option III: Water-Saving Practices (WSP) Introducing water-saving practices to reduce water usage for paddy planting

Option IV: Switching from Paddy to Dry Crops (PTD) Changing from paddy to dry crops to reduce water use in paddy planting

Each policy option was evaluated in terms of cost (10^4 RMB/year), water saved (m^3/year), farmers' income loss, and government revenue and expenditure.

Implementation Zone and Stakeholders

Based on our local investigation and experts' advice, we chose six zones directly adjacent to and competing in water use with the QNNR in which to implement the four policy options: two small towns in Baoqing County in the rural areas (Qixinghe town (QHT) and Qixingpao town (QPT)) and two branch farms of the WJQ state farm (WJQ-4 and WJQ-5) and two of the Youyi farm (Youyi-6 and Youyi-8.) The main stakeholders potentially affected by the selected policy options at the local level included the government (Water Affairs Bureau, Agriculture Development Commission, Wetland Management Bureau, etc.), enterprises (state-owned farms, water supply enterprises, etc.), and farmers.

The state-owned farms are normally categorized as enterprises, but they function as government units and are operated according to government procedures. Water supply enterprises (such as reservoir and irrigation district enterprises) are not pure enterprises but are part of the Water Affairs Bureau. They have to remain financially viable in terms of their operational costs by providing water supply services and charging water fees, similar to some public service sectors. In the analysis, state-owned farms and water supply enterprises were treated as part of the government with their own specific interests under each policy option.

For each policy option, stakeholders may have different roles and be affected in different ways or to different degrees. They may also attach different degrees of importance to the options or exert varying levels of influence on the decision-making and implementation processes.

Economic Evaluation of Water-Saving Policy Options

Option I: Irrigation System Reconstruction (ISR)

Description

In order to save water to meet the ecological water demand of the wetland, this option involves a reconstruction of the irrigation system in the surrounding areas that compete with the wetland for water by – among other things – sharing the same water sources as the wetland.

These measures would more effectively ensure the supply of water for agriculture, improve the efficiency of the water canal system, and lay the foundation for implementing field water-saving practices and water pricing policies. The option includes designing an appropriate irrigation system to save 8 million m^3 of water to meet the wetland's ecological water needs.

Cost-Effectiveness

The main costs involved in Option I comprise the capital costs of the infrastructure and running costs, with the residual value of capital as a cost offset. The cost-effectiveness results are shown in Table 14.2. They were calculated in terms of the cost of water saving per ha, the water-saving volume per hectare, and cost-effectiveness at discount rates of 2 %, 5 %, and 8 %.

Distributional Effects

In order to understand how the stakeholders would contribute to or gain from Option I, the incidence of costs and effects was assessed, as shown in Table 14.3.

Table 14.2 Cost-effectiveness analysis of Option I (at different discount rates)

r	E_{ISR}^{t} (10^6 m^3/year)	TC_{ISR} (10^6 RMB)	TE_{ISR} (10^6 m^3)	C/E **(RMB/m^3)**
2 %	8.00	22.89	179.17	0.128
5 %	8.00	20.14	122.98	0.164
8 %	8.00	18.52	90.06	0.206

Table 14.3 Distribution of the costs and effects of Option I

Stakeholder	Costs	Effects
Farmers	The operation and maintenance of the irrigation system need to be covered by the water fees paid by the farmers, i.e., 552 RMB/ha	–
Government	Irrigation reconstruction investment cost: 19.74 million RMB	Saving 8 million cubic meters of water per year

Table 14.4 Cost-effectiveness analysis of Option II

r	TC_{EWC} (10^6 RMB)	TE (10^6 m^3)	C/E (RMB/m^3)
		EWC	
2 %	100.97	155.43	0.650
5 %	87.39	106.68	0.819
8 %	79.44	78.13	1.017

Option II: Ecological Water Control Reservoir (EWC)

Description

This option involves building a small dam to store and control floodwater at a suitable location in upstream areas. Such a proposal was raised by the local government years ago. Preliminary investigations were also conducted. The same proposal was used in the present study. It involves building a reservoir midstream along Qixinghe's first branch, the Jinshahe River, located in Qixingpao town in Baoqing County, with the aim of retaining floodwaters and the excess water of the Jinshahe River for irrigation.

Cost-Effectiveness

The costs incurred for Option II are again the capital costs of infrastructure and running costs. The results of the cost-effectiveness analysis are shown in Table 14.4 assuming discount rates ranging from 2 % to 8 %.

Distributional Effects

The investment for this project would be mainly funded by the government, and the government would also have to bear the running costs (see Table 14.5). The water

Table 14.5 Distribution of costs and effects of Option II

Distribution	Costs	Effects
Farmers	–	–
Government	Investment cost, 67.55 million RMB; compensation cost, 19.38 million RMB; running cost, 1.93 million RMB/year	Water saving of 6.94 million m^3/year

saving would mainly serve the purpose of supplying water to the wetland to create ecological benefits. There would be no direct costs and effects for the farmers as there would be no direct impact on yields and water-use methods. However, an indirect benefit could be a yield increase as a consequence of improved local environmental conditions

Option III: Water-Saving Planting Practices (WSP)

Description

In this option, the government provides training in water-saving planting skills for farmers by organizing classes and promoting the implementation of the skills. The Agricultural Techniques Promotion Center (ATPC) of Baoqing County would be the appropriate implementing agency, responsible for engaging agricultural professionals to give water-saving training to farmers at the village level. The training would be held every year during the project period of 30 years. Each class is estimated to have 20 trainees. The ATPC would provide the trainers, training materials, and support services until the farmers could successfully implement the water-saving practices. The ATPC would also monitor and evaluate implementation of the program.

Cost-Effectiveness

For the government, the costs of this option consist of the training and management costs, including monitoring and evaluation. On the farmers' side, the option would involve learning costs, mainly in terms of time, but the benefits would be savings on water fees, water, and energy and increased productivity. The cost-effectiveness analysis results for this option are shown in Table 14.6 at discount rates of 2, 5, and 8 %. Although the cost-effectiveness of this option seems ideal, it could not be achieved without meeting some prerequisites such as irrigation system improvement, installation of water measurement devices, and economic incentives. A high water price would act as an economic incentive for farmers to implement water-saving practices.

Table 14.6 Cost-effectiveness analysis of Option III (at different discount rates)

R (%)	TC_{WSP} (10^6 RMB)	TE_{WSP} (10^6 m^3)	*C/E* (RMB/m^3)
2	1.50	179.17	0.008
5	1.03	122.98	0.008
8	0.75	90.06	0.008

Table 14.7 Distribution of the costs and effects of Option III

Stakeholder	Costs (10^3 RMB)	Effects (10^6 m^3)
Farmers	–	–
Government	Training cost: 51,940 RMB/year	Saving 8 million m^3 of water per year
	Management cost: 14,840 RMB/year	

Distributional Effects

This proposal assumes that the government would provide the water-saving training at no charge, which means that the government would bear the main cost (Table 14.7).

Option IV: Switching from Paddy to Dry Crops (PTD)

Description

Switching from paddy to dry (or dryland) crops is another potential choice to achieve water saving. In the targeted policy implementation areas, dry crops are completely reliant on rainfall and do not require irrigation. Thus, switching from paddy to dry crops is expected to save a large amount of water. Changing from rice to dry crops is not unusual in local areas. In the survey, it was found that farmers chose to change crops for many reasons such as crop price fluctuation and conditions of land and water resources.

The roles of the government in this option include being the provider of information, helping farmers identify appropriate farmland, and promoting the change from paddy to dry crops. Farmers are the most important actors in this option. Changing from paddy to dry crops will impact farmers' net incomes. Significant price gaps between paddy and dryland crops would decrease farmers' willingness to switch, so the net income change caused by this option should be carefully considered.

Table 14.8 Cost-effectiveness analysis of the switch from paddy to soybean (at different discount rates)

Paddy to soybean (%)	TC_{PTD} (10^6 RMB)	TE_{PTD} (10^6 m^3)	C/E (RMB/m^3)
2	15.53	179.17	0.087
5	10.90	122.98	0.089
8	8.18	90.06	0.091

Table 14.9 Cost-effectiveness analysis of the switch from paddy to corn (at different discount rates)

Paddy to corn (%)	TC_{PTD} (10^6 RMB)	TE_{PTD} (10^6 m^3)	C/E (RMB/m^3)
2	17.34	179.17	0.097
5	12.13	122.98	0.097
8	9.07	90.06	0.101

Cost-Effectiveness

The main costs of this option involve short-term costs associated with reduced productivity and the cost of leveling land. Long-term costs would comprise losses of farmers' income resulting from the switch from rice to dryland crops, for which only a lower price can be obtained. The results of the cost-effectiveness analysis are presented in Table 14.8 for a switch from paddy to soybeans and in Table 14.9 for a switch to corn.

The cost of changing from paddy to corn is a little higher than that of changing from paddy to soybean, and the higher one was chosen to compare with the cost-effectiveness of the other three options.

Distributional Effects

Table 14.10 shows how farmers absorb both the short-term and long-term costs of Option IV. However, as the representative of public welfare, the government can be considered the main beneficiary from meeting the water-saving target.

Economic Comparison of Options

The overall results of the option analysis are shown in Table 14.11. Option III is the most cost-effective. The next most cost-effective is Option IV and then Option I. The least cost-effective is Option II. Regarding the distribution of costs, Option I distributes the costs between farmers and the government. Option II imposes a high cost on the government. Option III involves a low cost to the government. Option IV has a medium-level cost, borne by farmers.

Table 14.10 Distribution of the costs and effects of Option IV

Stakeholder	Costs		Effects
	Paddy to soybean	Paddy to corn	
Farmers	Short-term cost:	Short-term cost:	
	1,518,055.8 RMB in the first year	1,559,975.8 RMB in the first year	
	Long-term cost:	Long-term cost:	
	655,569.75 RMB/year	738,035.6 RMB/year	
Government			Saving 8 million m^3 of water per year

Table 14.11 Comparison of the cost-effectiveness and distributional cost effects of options (at a discount rate of 5 %)

Options	Costs (10^6 RMB)	Effects (10^6 m^3)	C/E (RMB/m^3)	Distributional Cost Effects	
				Government revenue and expenditure	Farmers' income
I (ISR)	20.14	122.98	0.164	19.7 million RMB for irrigation reconstruction – a one-off investment cost	552 RMB/ha/year for the running cost of the irrigation system
II (EWC)	87.39	106.68	0.819	67.7 million RMB one-off investment cost	–
				19.4 million RMB compensation cost	
				1.9 million RMB running cost per year	
III (WSP)	1.03	122.98	0.008	51,940 RMB/year training cost	–
				14,840 RMB/year management cost	
IV (PTD)	10.90	122.98	0.089	–	Paddy to soybean as example: short-term cost = 1.52 million RMB in the first year; long-term cost = 0.66 million RMB/year

Regarding the sensitivity of the cost-effectiveness (C/E) ratio to different discount rates, it was determined that Option II is the most sensitive, followed by Option I and then Option IV. Option III is insensitive to the discount rate. The comparative relationship between the four options, however, does not change under discount rates ranging from 2 to 8 %. The only exception is the comparative relationship between Option I and Option IV, which changes under very low discount rates.

Trade-Off Between Policy Options

Multiple Criteria for Comparing Options

Based on consultations with the local officials, four different criteria were chosen to compare the trade-offs between the four options: cost-effectiveness, reliability in achieving the water-saving effect, government's attitude, and acceptance by farmers. Cost-effectiveness was quantified in terms of RMB per m^3 of water saved, while the other three were scored on a scale of 1–4. Reliability and government's attitude were investigated by interviewing technical experts and relevant government agencies, respectively. Farmers' attitudes were surveyed, during which farmers were required to choose only two preferred options from the four, and a higher score means the options were chosen as the best two more often. Trade-offs between the four options are summarized in Table 14.12.

Ranking of Options

The final ranking of options appears in Table 14.13. If an option ranked first, it was allocated a score of 10. If it ranked second, third, and fourth, it received a score of 8, 5, and 0, respectively.

It can be seen that each of the options has pros and cons. Option III is the most cost-effective, while Option II has the highest reliability in terms of water saving

Table 14.12 Trade-offs between the four policy options

Criteria	Option I: ISR	Option II: EWC	Option III: WSP	Option IV: PTD
Water saved	8 million m^3	6.94 million m^3	8 million m^3	8 million m^3
Cost-effectiveness	0.164 RMB/m^3	0.819 RMB/m^3	0.008 RMB/m^3	0.089 RMB/m^3
Reliability in achieving the effect	High	High	Medium	Low
	Needs good management	Needs mechanism to guarantee supply to wetland	Needs incentive	Needs incentive
	Needs mechanism to guarantee supply to wetland			Unsustainable in the long run
Government's attitude	High	Medium	High	Low
	Matches policy priority and funding mechanism	Has technical support but no financial capacity	Not independent	
Acceptance by farmers	High	High	Medium	Low
	Not sure about cost burden	No cost		

Note: For cost-effectiveness, the lower the value, the more cost-effective the option

Table 14.13 Ranking of the four policy options

Criteria	Option I: ISR	Option II: EWC	Option III: WSP	Option IV: PTD
Cost-effectiveness	5 (3)	0 (4)	10 (1)	8 (2)
Reliability in achieving the effect	8 (2)	10 (1)	5 (3)	0 (4)
Government's attitude	10 (1)	5 (3)	8 (2)	0 (4)
Acceptance by farmers	8 (2)	10 (1)	5 (3)	0 (4)
Total score (ranking)	31 (1)	25 (3)	28 (2)	8 (4)

Note: The rank of the options is given in parenthesis (1 = best option; 4 = worst option)

and is the most supported by the farmers, but the cost is extremely high for the local government. Option I, on the other hand, has the government's greatest support. Given the same weighting for all four criteria, Option I is the best overall policy, while Option III ranks second, Option II ranks third, and Option IV is the least feasible.

Conclusions and Policy Recommendations

General Conclusions

Among the four policy options designed at the local level to manage the off-site agricultural water use, taking consideration the reliability of supplying water to the wetland, cost-effectiveness, and the attitudes of the government and farmers, we concluded that Option I (irrigation system reconstruction or ISR) was the optimal option. Option III (the promotion of water-saving planting practices or WPP) was the second best and could in fact be complementary to Option I. As for the implementation, both the ISR and WPP options require reform of the water pricing policy and improvement of the irrigation district management system.

The current water pricing system (charging according to acreage and having a low charge rate) has brought about low collection of water fees, to the extent that the water fees collected are insufficient to cover the running costs of the irrigation system. Even if the irrigation project were to be put in place, without strengthening the implementation of the water pricing policy, it would still result in an ineffective irrigation system.

The same is the case for water-saving planting practices. Under the low water pricing policy, there is no incentive for farmers to take water-saving action, so even if the irrigation project were put in place, incentives would still be needed to encourage farmers to adopt these practices to create real water savings.

In order to ensure the effectiveness of the proposed measures, an effective pricing policy should be established that provides economic incentives to ensure implementation. Increasing the water price is a logical *must* step in this direction.

The irrigation district management system should also be reformed in order to create an institutional environment to support a new water pricing policy.

Other mechanisms are required to ensure that the water-saving effects are converted to ecological benefits in terms of wetland conservation. The options above presume that the water saved will not be diverted to other water users but will be allocated to the wetland. However, the analysis revealed that whether the water saved will be allocated to the wetland depends mainly on the water resource management authorities.

Policy Recommendations

Given the findings of the study, several policy recommendations can be made. In order to tackle the wetland water shortage problem, the local government could reconstruct the irrigation system in the surrounding area of the Qixinghe Wetland for water-saving purposes as soon as possible, while restricting further expansion of paddy fields in the Qixinghe River basin.

Water-saving practices should be continually promoted by providing regular training to farmers. The option of water-saving planting practices was found to be the most cost-effective, so it should be applied as fully as possible. The training is also necessary because the study found that local farmers were not very open to water saving.

Speeding up water pricing reforms and irrigation district management system reforms is important. The implementation of hard measures needs to be strengthened by using economic incentives.

Reconstructing the irrigation system and promoting water-saving planting practices should be conducted at the same time as irrigation management and water pricing reforms to accelerate the whole process. The direction of agricultural water pricing reform should be to make economic benefits play a role in water resource allocation.

The key constraint for wetlands in competing with other water users is the lack of funding. Making the wetland a competitive water user, by arranging for funding for reliable water supply under the National Wetland Protection Program, is necessary. In view of the wetland's spill-over benefits, such funds should be guaranteed by the government. The current funding mechanism for wetland conservation does not take full account of the wetland's water resource demands. It is suggested that the central government set up a special budget for dealing with the problem of water shortage in wetland conservation.

For the provincial government, it is recommended that a water resource plan for the whole Qixinghe River basin be made as soon as possible, taking account of the real ecological water demands of the wetland.

Appropriate institutional arrangements should also be made at the provincial level by involving representative wetland departments in the decision-making process for water allocation and agricultural development.

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