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Empirical assessment of water management institutions in northern China

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ABSTRACT

We examine the development of irrigation management in northern China using data from village and household panels. During the past decade, reform-oriented institutions, such as water user associations and contracting, have largely replaced the traditional institution of collective management in village-level irrigation systems. A feature unique to China is that water user associations and contractors are provided with monetary incentives to save water. Water user associations have not yet achieved the broad-based participation of farmers that some advocates consider as a primary goal for forming the associations. Many village leaders serve also as the leaders of water user associations, thus possibly reducing opportunities for receiving operational input and policy direction from farmers. However, we observe improved performance of irrigation systems managed by water user associations, relative to collective management, in terms of maintenance expenditures, the timeliness of water deliveries, and the rates of fee collection. Performance has improved also in systems managed by contractors, although not as substantially as in the case of water user associations.

1. Introduction

Since the 1980s, conservation and development organizations and international funding agencies have embraced the idea of devolving the decision-making authority and management responsibility over natural resources from central government agencies to local user groups (Shyamsundar et al., 2005). The most extensive action is in the irrigation sector. More than 57 countries have begun to reform their irrigation sectors and launched irrigation management transfer (IMT) or participatory irrigation management (PIM) programs (Garces-Restrepo et al., 2007). IMT and PIM are two conceptually different, but interrelated, programs. IMT specifically refers to the transfer of irrigation management responsibilities from government bureaus to farmer-run organizations, while PIM refers to the increasing involvement of farmers in irrigation management. In most countries, core components of reform include establishing either water user associations (WUA) or irrigation associations and transferring irrigation management to those entities.

Similar to development in most other countries, reforms in the irrigation sector in China are fueled by the recognition of the limits of local government agencies. While China's economic reforms in the late 1970s and early 1980s led to rapid economic growth, they also weakened leadership at the village and town levels. Decollectivization resulted in ambiguous property rights over many local irrigation systems (especially at the level of tertiary canals and below). The unclear rights produced weak incentives for irrigation managers to invest in and maintain the infrastructure of their systems (Lohmar et al., 2003). Fiscal reform in the 1990s further decreased the local government's ability to invest in and maintain irrigation infrastructure (Lohmar et al., 2003). As a result, the village leadership that was traditionally responsible for the management and maintenance of tertiary canals and on-farm structures became dysfunctional. Deteriorating irrigation systems, unreliable water delivery, and poor cost recovery were common (Xie, 2007). One study, for example, estimated that, due to the poor management of the nation's canal network, only 50% of the water from primary canals is actually delivered to the field (Xu, 2001).

With China's rapid growth, the increasing demand for limited water resources from rapidly growing industry and cities adds to the existing pressure on the irrigation water supply in the agricultural sector, especially in northern China (Zhang and Zhang, 2001). According to China's government, agricultural users will not be given priority for any additional future allocations of water (China, 2002). In an environment of increasing water scarcity, problems created by deteriorating irrigation systems have negatively affected agricultural production and exacerbated conflicts among farmers (Xie, 2007). After implementing several traditional approaches, such as increasing water supply and extending water saving technologies, water officials were not able to overcome the nation's

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water problems (Lohmar et al., 2003). In response, policy makers in China have turned to water management reform (Wang et al., 2005).

In China's version of water management reform, officials have mostly focused on promoting WUAs and contracting. With the assistance of international agencies, such as the World Bank (Reidinger, 2002), WUAs were created to take the place of village committees in the management of village-level irrigation systems. Since the first WUAs were established in south China in 1995 under the World Bank "Yangtze Basin Water Resources Project" (World Bank, 2003a), WUAs spread across China. The Ministry of Water Resources of China (2007) reports that by 2006 there were more than 30,000 WUAs in China. At the same time reformers were also encouraging villages to use an alternative form of irrigation management—contracting. In a contracting system, the management responsibilities of the village-level irrigation system are contracted to an individual who operates the irrigation system. Contractors, in theory, are motivated to provide irrigation services by a set of incentives embodied in the contract.

Internationally, mixed results are found in studies on IMT and PIM (Garces-Restrepo et al., 2007; Vermillion, 1997; Zekria and Easter, 2007). Most authors report that implementing IMT/PIM has improved the timeliness of water deliveries. Partly as a result of more timely deliveries, the rate of fee collection has increased (Garces-Restrepo et al., 2007). There is little consensus about other outcomes. For example, the quality of maintenance has improved in some countries, such as Sri Lanka and India, but worsened in others, including the Philippines, Indonesia, Bangladesh and several African countries (Vermillion, 1997). Surprisingly, despite the high stakes of the reforms, there have been few empirical studies to assess the effectiveness of water management reform in China through the 2000s.

Our goal is to develop a better understanding of the development of irrigation management in northern China. We begin by describing the evolution of institutions that govern local irrigation systems. Using a set of panel data collected up to 2007, we extend our previous work that have reported such trends (Huang et al., 2008a; Huang et al., 2008b; Wang et al., 2009; Wang et al., 2005, 2006), focusing specifically on irrigation management at the village level. We also examine the characteristics of governance under different forms of water management and evaluate the performance of institutional reforms and implications for the financial and physical sustainability of irrigation systems. We consider three performance indicators: maintenance expenditures, timeliness of water delivery, and the rate of fee collection.

2. Data

Comprehensive, village-level data describing China's surface water systems and the institutional arrangements that govern them are limited. Longitudinal data are even less available. We use data that we collected as part of the *China Water Institutions and Management* (CWIM) Panel Survey. The objective of the CWIM Panel Survey is to study the management institutions of water in northern China, including both groundwater and surface water.

The Yellow River Basin (YRB) and the Hai River Basin (HRB) are among the most important river basins in northern China. Sample provinces of the CWIM survey were chosen from these basins. Ningxia province is located in the upper reaches of the YRB. Henan province is located in the middle reaches of the YRB. Hebei province covers most of the HRB and surrounds Beijing. In this survey we track the same sample villages in Hebei, Ningxia and Henan provinces in 2001, 2004 and 2007 (Fig. 1).

Three features of the CWIM survey distinguish it from the data collection efforts of most previous studies on countries other than China. First, unlike most previous studies in which study sites are selected without randomization, often as case studies (Poteete and Ostrom, 2008), we used a random sampling strategy to select the sample villages. Within each province, we used a stratified random sampling strategy to select villages with varying degrees of water scarcity.

In Ningxia we chose one irrigation district (ID) in the segment of the Yellow River where the river enters the province and one in the middle of the province. We then chose five counties randomly within the two IDs. In Henan we selected counties randomly from IDs at varying distances from the Yellow River. When IDs are geographically located further away from the river, they are typically associated with increasing water scarcity. In Hebei, most of the water supply for irrigation comes from groundwater. Hence we selected three counties randomly from regions at varying distances to the source of groundwater recharge, which is the mountain range that runs north to south in the western part of the province. After the counties were selected, we randomly chose sample villages from a census of villages in the counties. Because our sample villages were randomly selected, our analysis is representative of our study regions.

The second feature of our survey is its broad scope. We collected detailed information on the nature of water resources, the characteristics of the canal system, the characteristics of water users and the social-economic characteristics of the sample villages. We also collected detailed information on the governance of the irrigation system, the characteristics of each specific institutional arrangement and its operational and maintenance (O&M) practices. With such a large set of variables, we can compare various aspects of governance under different water managerial forms and examine several variables that influence the performance of irrigation systems.

The third feature of our survey is that we collected information from different groups of stakeholders, including village leaders, canal managers, and farmers. Within each village, we randomly chose four households. We used separate sets of survey instruments and held in confidence the answers of each respondent. We believe our efforts have produced accurate information that can be used to assess the nature of management practices of WUAs, contracting, and collective management. For example, instead of relying on managers for their perspectives, we asked farmers to assess the timeliness of water deliveries.

Since our focus is on surface water management, we include in our analysis only sample villages that used surface water. In the 2001 survey, 57 of the sample villages used surface water for irrigation, including all 32 villages in Ningxia, 19 villages in Henan and 6 villages in Hebei. The 2004 CWIM only included 51 villages from the original 2001 sample, because six villages that had used surface water in 2001 no longer used surface water in 2004. In 2007 the study included 52 villages from the 2001 sample.

3. Institutional reform in northern China

In China, irrigation districts (IDs) and local water resource bureaus (WRBs) often manage the upper levels of irrigation systems (the main canals and branch canals) that transfer water out of major rivers (e.g., the Yellow River) or reservoirs and channel it to lower levels. Local irrigation systems (tertiary canals and below) are administered by county, township governments and village committees (Xie, 2007). Officials from the ID design a water allocation plan for each of the villages within their command area. In most IDs there is a metered gate along the branch canal that supplies water to each village. This design essentially allows each village to operate as an independent agent of the ID. The canal network in the village, then, is completely maintained by the village and all of the water

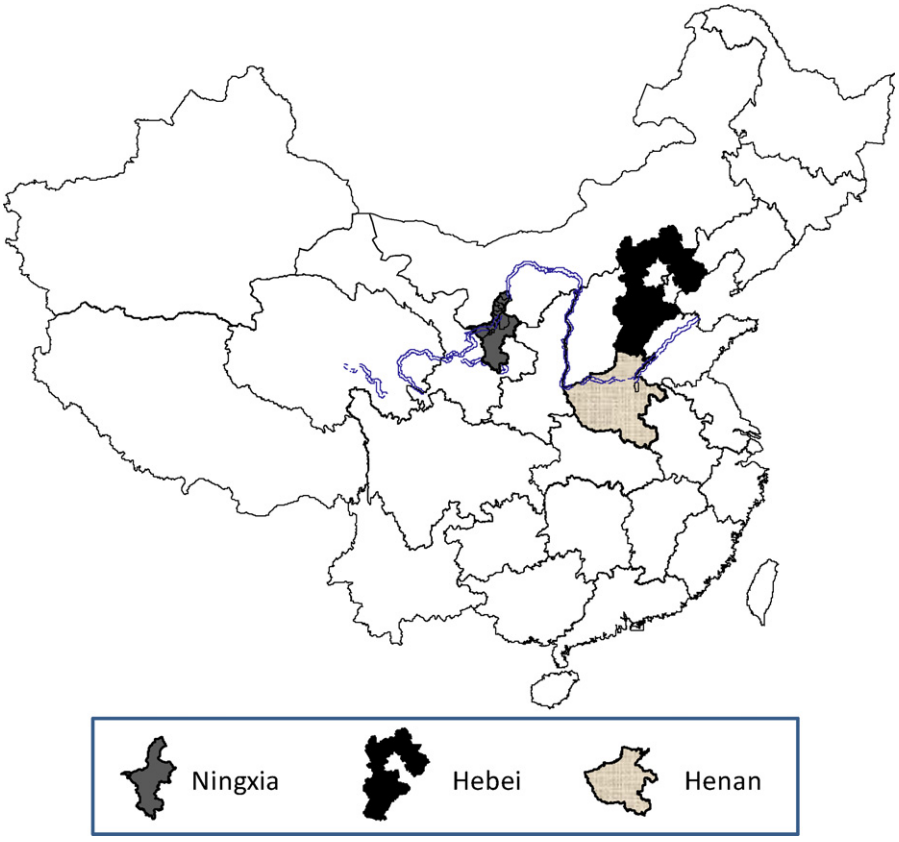

Fig. 1. Location of the study sites in China.

that flows into the village is for the exclusive use of the village's residents (and not shared with villages either up or down stream of it). Therefore the focus of this paper is irrigation management at the village level.

Based on our field surveys, local irrigation systems in northern China villages are managed in three general ways. In traditionally managed systems, the village's leadership council (called the village committee) takes direct responsibility for the allocation of irrigation water, O&M tasks and fee collection. While the village leaders make the major decisions, daily irrigation-related activities are often administered by a water officer appointed by the village committee. When the village committee is in charge, we consider the village's irrigation system to be run under *collective management,* and we refer to this as the *traditional system*.

In some of our sample areas, WUAs were established to take over irrigation management from the village committee. In principle, a WUA is a farmer-based, participatory organization that manages the village's irrigation system. Supposedly villagers elect a board, which manages the village's water and facilitates farmer participation. As villages are the basic hydrologic units within which irrigation is managed, most WUAs were established at the village level. In four of the sample villages, WUAs were established in 2007 at the level of branch canal and governed several villages.

In addition to providing more timely irrigation deliveries to farmers, WUAs are also expected to maintain the village's irrigation infrastructure and collect water fees. When the village's irrigation system was under collective management, water fees were collected and transmitted upward to IDs through several layers of bureaucratic hierarchy (from farmers to village; village to township irrigation stations; towns to counties and finally from counties to IDs). In contrast, most WUAs bypass the traditional village-township-county channels and directly purchase water from the ID on a volumetric basis. It is hoped that this more direct way of fiscally managing the ID can lead to lower fees for farmers (Lohmar et al., 2003; Xie, 2007).

In addition to collective management and WUAs, we also identified a third institutional arrangement in our data – *contracting*. This is a way of managing an irrigation system in which the village committee, contracts the village's canal system out to an individual. The contractor manages the canal in return for a payment that might or might not be related to the size of water savings he/she can achieve. Although in most areas contracting is not formally initiated by the effort of upper-level governments, contracting is a commonly observed form of management in many different contexts of China's reforms (e.g., in the management of township and village enterprises; grain enterprises; extension system agencies; etc.––Park and Rozelle, 1998). We consider WUAs and contracting as *reform-oriented management systems* (in contrast to collective management institutions which are traditional systems).

When examining villages that use surface water, the data reveal that WUAs and contracting have been replacing collective management at a rapid speed during the past decade (Table 1). Although collective management still was the dominant form of management in 2001 (column 2). By 2007, more than 75% of villages in our study area had been affected by water management reform (column 6).

The reform efforts have shown a shift of focus over the years. In the early 2000s, contracting was developing more rapidly than WUAs. Between 2001 and 2004, the share of villages that managed their canals under contracting increased by 10.7% (Table 1, row 3, column 1–4). In contrast, the share of villages that managed their water through WUAs remained at about 10%, and dropped slightly in 2004 (row 2, column 1–4). The more rapid emergence of contracting may be explained by the ease of establishing the system. Contracting had already been used frequently in other reforms in rural China (Nyberg and Rozelle, 1999; Park and Rozelle, 1998). By

Table 1
Number of sample villages under different water management institutions.

	Northern China	2001		2004		2007	
		(Number)	(%)	(Number)	(%)	(Number)	(%)
1	Collective management	32	56	25	49	12	23
2	Water user association	6	10	4	8	24	46
3	Contracting	14	25	18	35	8	15
4	Mixed institutions	5[a]	9	4[b]	8	8[c]	15
5	Sums	57	100	51	100	52	100

[a] In three villages, some canals were managed under contracting and others were under the control of collective management. In two villages, WUAs managed some canals and collective management controlled the remaining canals.
[b] WUAs managed the canals jointly with contractors in two villages. In another village, WUA managed the canals jointly with the village committee. In the third village, some canals were jointly managed by WUAs and contractors, while others were managed by contractors.
[c] In all eight villages canals were jointly managed by contractors and WUAs.

contrast, WUAs were still a relatively new concept, with which local governments and villages had little experience.

After 2004, the focus of reform began to shift from contracting to WUAs, due partly to the government's renewed and extensive reform efforts to promote WUAs. By 2007, almost half of the sample villages were managing their canals through WUAs (Table 1, row 2, column 6). Another 15% of the sample villages also reformed by combining WUAs with contracting (row 4, column 6). Among these villages, more than half were originally managed by contractors in 2004.

While the trends in northern China's villages are clearly reform-oriented, there is evidence that some villages, which had reformed by 2001, are continuing to experiment with different institutional forms and are not averse to reverting back to collective management. For example, of the six villages that had created WUAs to manage their canal systems in 2001, three had either discontinued or partially discontinued the experiment by 2004. Village leaders and canal managers in these villages explained that they only nominally adopted WUAs and the WUAs were not at all active in irrigation management. Three of the 14 villages that chose contracting in 2001 decided to return to collective management by 2004, because nobody wanted to contract the canals. These shifts into and out of WUAs and contracting may indicate that water management reform is not universally successful. This finding, if true, is of concern to national leaders worried about whether or not surface water management reform is suitable for China's villages.

Water management reform also varies significantly across the sample provinces. The reform efforts have been more substantial in Ningxia province, where efforts clearly focused on creating WUAs. The CWIM data show that by 2007, none of the sample vil-

Table 2
Characteristics of the governance of water management institutions.

		Proportions of Villages (%)		
		2001	2004	2007
	Water user associations			
	Formality of WUAs			
1	WUA has a constitution	62.5	87.5	93.8
2	WUA is registered	25	37.5	87.5
3	WUA has a written contract	25	50	78.1
	Participation (reported by farmers)			
4	Farmers involved in the decision to establish a WUA	12.5	25	31.8
5	The chair of WUA was elected by farmers	0	37.5	45
6	WUA board members were elected by farmers	25	25	41
7	WUA has regular meetings	75	87.5	96.9
8	Farmers or farmer representative invited to attend the meetings	25	19	75
9	Percentage of farmers attending meetings (median)	6	5	15.4
10	(standard deviation)	7	8	31
	Overlap between the WUA and the village leadership			
11	The head of WUA is a village leader	70	100	62.5
12	At least one or more WUA board members are village leaders	70	100	62.5
	Transparency of management			
13	WUA publicizes all three types of information[a]	37.5	75	87.5
14	WUA publicizes two of the three types of information	50	12.5	6.3
15	WUA publicizes one of the three types of information	12.5	12.5	3.1
16	***Water saving incentives provided***	25	12.5	87.5
	Contracting – *Formality*			
17	Has a written contract	84	86	75
	Contracting - *Transparency of management*			
18	Contractor publicizes all three types of information[a]	18.2	63.6	37.5
19	Contractor publicizes two of the three types of information	31.8	4.5	6.3
20	Contractor publicizes one of the three types of information	9.1	4.5	25.0
21	Contractor publicizes no information	40.9	27.3	31.3
22	**Contracting – *Water saving incentives provided***	42.1	45.5	31.3
	Collective management – *Transparency of management*			
23	Village committee publicizes all three types of information	0	6.9	0
24	Village committee publicizes two of the three types of information	0	5.2	23.1
25	Village committee publicizes one of the three types of information	0	0	69.2
26	Village committee publicizes no information	100	87.9	7.7

[a] The three types of information include the total amount of water fees collected, the volume of water actually delivered by the ID to the village, and the actual area irrigated.

lages in Ningxia province remained under collective management. Instead WUAs were managing canals in about 72% of the villages and were jointly managing canals with contractors in another 22% of the villages. By contrast, in Hebei and Henan, collective management was still the dominant institution in 2007 (around 60% in both provinces). Furthermore, most of the villages that reformed in Hebei and Henan decided to manage their canals through contracting, instead of WUAs. Clearly the reforms are far from universal, which is what we would expect in China, a nation that often allows local governments considerable freedom in making their own decisions on the exact form and timing of reform.

4. Differences in governance among water management institutions

We compare three aspects of the governance structure under WUAs, contracting, and collective management:

1. The organizational features that China's water officials believe are important for successful water management institutions: the formality of water management arrangements, the degree of participation by farm households, and the transparency of management;
2. The operations performed by the agents involved in each management institution, and how roles are shared with the local village leadership; and
3. The nature of the incentives faced by those who manage WUAs or hold the management contracts.

4.1. Organization of water management institutions

Formality of WUAs. In 2001 most WUAs were in the early stages of development. About 62% of the WUA had a constitution (Table 2, row 1, column 1). When looking beyond the relatively simple formality of having a written constitution (which can be copied from a publicly-available document), only 25% of WUAs had registered their organizations with the local Civil Affairs Bureau as an "official WUA" (row 2, column 1). Only 25% of the WUAs had written contracts between WUAs and the ID that described the terms and conditions for water transactions (row 3, column 1). Over the years more WUAs have developed a constitution, have registered, and have produced a written contract (row 1–3, column 2–3). During interviews, village leaders explained that the increasing share of formal WUAs partly reflected the efforts of the government to promote more formal WUAs.

In contrast to WUAs, collective management and contracting were mostly informal. Although more than 80% of the contractors had a written contract (Table 2, row 17), there were no written constitutions or terms of reference that governed their actions or defined their scope of work. No contractors were registered. When villages were run under collective management, the village committee managed irrigation activities along with their other duties. There were no constitutions, contracts or registration requirements (and in fact none of the village committee was registered).

Farmers' participation in decision making in irrigation management. Despite the important role that farmers play in water management in some parts of the world, according to our data, participation in decision making is not part of either collective management or contracting. Traditionally, government services in China are conducted from the top down, with little consultation or participation of local villagers (Zhang et al., 2003). Although in principle collectively managed services are supposed to be determined by the entire village (or the collective), in reality, village leaders manage their villages largely based on the authority they have derived from higher-level officials and other sources of governance legitimacy. In our sample villages, farmers participated little (and mostly not at all) in managing the irrigation activities when the local system was collectively managed.

Similarly, there was little participation by farmers in contracting villages. According to our data, contracting involved transferring control and income rights to the contractor. Village leaders usually decided whether to contract out canals or not. Farmers rarely played any role in the transition. In only a few villages were farmers asked to participate in selecting the contractor. Once the contractor was selected, there was no formal role for villagers in supervising, coordinating, or in any other governance aspects.

Although the international literature emphasizes the importance of farmer participation in the promotion of successful WUAs (World Bank, 2003b), practice often varies from principle. During the 2001 wave of the CWIM survey, there was little or no participation by farmers in China's WUAs. Only a few WUAs were created after consultations with farmers (Table 2, row 4, column 1). Farmers also had little voice in appointing the chair or the board members of WUAs (row 5–6, column 1). In most villages, these positions were appointed by either the ID or the village committee. Partly because of this, in 70% of the villages in 2001 the WUA board was comprised of the village leadership (row 11–12, column 1). Farmers were seldom encouraged to participate in other aspects of water management. Although 75% of WUAs had regular management and operations meetings, only 25% of WUA leaders invited farmers to attend. Even in those villages, only 6% of farmers actually attended (row 7–10, column 1).

During the mid- to late 2000s farmers have become more active in deciding whether to establish a WUA, and electing the chair and board members (row 5–6, 11–12, column 2–3). However, participation improved only gradually. In particular, although the share of the WUAs that invited farmers to attend their regular meetings rose sharply to 75% by 2007, the median percentage of farmers that actually attended was only 15% (row 9, column 3). In addition, the attendance rate varied significantly across villages. In some the attendance rate was below 5%, while in other villages it was above 60% (row 10, column 3). The wide variation is probably explained by the variation in the characteristics of villages and of farmers, which influence the costs and benefits of participation as perceived by farmers. In our household survey, some farmers reported "busy" as their reason for not participating. In villages where farmers are busy with wage-earning jobs or other off-farm employment, the opportunity cost of attending meetings is high. Other farmers reported "the size of the village" (in larger villages, farmers tend to think they benefit less from participation) and "level of education" (illiterate farmers are less likely to attend meetings). Moreover, the characteristics of villages and farmers vary significantly in our sample areas. For example, the share of wage earners in the village's labor force in 2007 ranged from 1% to 100%, with a mean of 33% and a standard deviation of 24%.

Transparency. The data show that management under WUAs is more transparent than under collective management or contracting. As early as 2001, WUAs shared considerable amounts of information with farmers (Table 2, row 13–15, column 1). For example, nearly 40% of WUAs shared three key types of information about irrigation management with farmers: (a) the total amount of water fees collected; (b) the volume of water actually delivered by the ID to the village; and (c) the actual area irrigated. Management under WUAs has also become more transparent over the years. By 2007 almost 90% of the WUAs shared all three types of information (row 13, column 3). By contrast, even in 2007, most villages under collective management shared only one of the three key types of information (row 25, column 3). Thirty-one percent of the contractors chose to share no information with farmers (row 21, column 3).

4.2. Operational responsibilities

The division of responsibilities varies distinctively with the type of management institution (Table 3). When a village's canal system is managed collectively, the village committee conducts most management activities, including canal maintenance, water fee collection, and conflict resolution (row 1, 4 and 5, column 1). In more than half of the villages, the village committee was also responsible for operating sluice gates and coordinating water deliveries (58%, row 2–3, column 1). However, leaders in other villages shared these tasks with the farmers, IDs or water officials from the township government (row 2–3, column 6).

When a WUA is formed, the responsibilities for operating sluice gates, coordinating water deliveries, and collecting water fees shifts to the WUA board in most villages (Table 3, row 7–9, column 2). In 42% of WUA villages, the WUA board was fully responsible for canal maintenance. However, in 16.7% of the villages, the village committee retained the responsibility and in 33% of the villages, the village committee and the WUA shared the responsibility (row 6). One reason behind the sharing of responsibilities is that in some areas of rural China, villages are divided into several village groups, and the plots of households in each village group are located together. While canal maintenance in some villages is conducted by village group members, the WUA is a village-wide organization and the village leadership, which includes the leaders of the village groups, must coordinate efforts among the village groups. WUAs also share responsibilities with village leaders for other tasks, such as coordinating water deliveries (12.5%) and resolving conflicts (16.7%, row 8 and 10, column 4).

Similar to the case of WUAs, when canal networks were contracted out to individuals, the contractors assumed responsibility for maintaining canals, operating sluice gates, coordinating water deliveries and collecting water fees (Table 3, row 11–14, column 3). Conflict resolution, however, was transferred to the contractor in only 56% of the villages (row 15, column 3). Conflict resolution might be an activity that contractors cannot accomplish in some villages. The contractors, who often are fellow villagers (and neighbors or relatives of a village's water users), do not have the same authority as village leaders, and thus would be less effective in resolving disputes.

4.3. Incentives

Although there are many similarities between the international experience and the experience of water management in China, the nation's water management reform strategy has taken on some unique characteristics. Above all, water officials have promoted the use of incentives to make water management reform more effective. The use of incentives is not new in the context of China's overall economic reform effort (Naughton, 1995). For example, the key reform introduced during the implementation of the household responsibility system (HRS) was the new profit incentives provided to farmers to induce them to exert more effort, allocate resources more efficiently and enter into new economic activities (Lin, 1992). Fiscal reforms gave local leaders strong incentives to begin township and village enterprises (Walder, 1995). Grain reforms gave grain bureau personnel incentives to commercialize commodity trading (Rozelle et al., 2000).

With the past success of using incentives in various reforms, water officials in China thought that similar mechanisms would improve water management. In many IDs, water managers are supposed to be provided with monetary incentives associated with water savings. In China's irrigation systems, a village pays the ID for the water delivered to the village (through main canals and branch canals) according to a volumetric price determined by the ID. Within the village, however, farmers pay water managers on per unit of land basis, because there are no water meters along the gates of the tertiary and lower canals that deliver water to farm fields.

Incentives often are designed as follows. Prior to the irrigation season, ID officials determine the amount of water a village should use. Often, this targeted quantity is determined on the basis of historic use (e.g., the average water use during three previous years). The fixed water fee that farmers must pay for each unit of land is calculated as the product of the targeted quantity (divided by the village's land area) and the volumetric price the ID charges water managers. Water managers must pay the ID only for the water that is actually used (actual quantity). If the actual quantity of water delivered to the village (at the request of the water manager) is less than the targeted quantity, the difference is the water savings generated by the manager. The manager would collect more water fees from farmers (based on the targeted quantity) than the amount he would need to pay the ID. The manager then could keep the part of water fee that is in excess of the amount paid to the ID as the profit he makes from saving water.

There are sharp differences in the implementation of the incentive part of the reform packages across villages. In none of the collectively managed villages were village leaders provided with incentives, perhaps because any profits from saving water would be counted as village fiscal revenue. By contrast, managers in WUA villages faced better incentives. In 2001, in 25% of the WUAs, incentives were provided to managers for saving water (Table 2, row 16, column 1). Incentives were used more frequently in contracting villages (42% of the contractors, row 22, column 1).

Using the 2001 CWIM data, Wang et al. (2005) showed that, holding other factors constant, in villages in which managers were provided with incentives to save water, water use declined by about 40%. The research also showed that water savings were achieved without negatively affecting crop yields or cropping income. Importantly, Wang et al. (2005) showed that there was little water saving in villages that did not offer incentives to managers. In those villages, contractors and WUA managers acted much like village leaders in collectively managed systems. There was little effort in any of these villages to save water.

The use of incentives in WUAs has risen sharply over time. By 2007, incentives were provided to more than 80% of the WUAs (Table 2, row 16, column 3). The use of incentives in contracting developed at a slower rate, rising to 45.5% in 2004, and then declining to 31.3% in 2007 (Table 3, row 5, column 2–3). Although the reasons are not yet clear, the fall in the use of incentives from 2004 to 2007 might be due to the declining effectiveness of incentives. As the water target is based upon past water use, if the incentives had been effective in reducing water use in the past, the water target in subsequent years would need to be set at increasingly lower levels, to achieve additional water savings. Of course, over time, the room for saving water would shrink, thus making profits harder to earn, and effective incentives more difficult to set.

5. The effectiveness of the institutional reform

Establishing WUAs or contracting is not an end in itself. The reform is only successful if WUAs or contracting improve irrigation management and ultimately help boost food production or raise farm incomes. For example, while the reforms provide financial incentives to managers to save water, it is possible that managers could deliver less water than the volume demanded by farmers.

Therefore, we assess the impact of the transfer of irrigation management to WUAs or contracting on the performance of the irrigation system. In particular, we construct three indicators to describe the financial and physical sustainability of each type of irrigation system. The first indicator, total maintenance expendi-

Table 3
Division of water management activities by water management institutions in 2007.

			Proportions of sample villages in which a water management activity is conducted by:					
			(1) Village committee	(2) WUA	(3) Contractor	(4) With village committee[a]	(5) WUA & contractor	(6) Other[b]
Collective management	1	Canal maintenance	100					
	2	Operation of sluice gates	58.3					41.6
	3	Coordination of water delivery	58.3					41.7
	4	Water fee collection	100					
	5	Conflict resolution	100					
Water user association	6	Canal maintenance	16.7	41.7		33.3		8.4
	7	Operation of sluice gates		95.8				4.2
	8	Coordination of water delivery	4.2	75		12.5		8.3
	9	Water fee collection	12.5	83.3		4.2		
	10	Conflict resolution	12.5	66.7		16.7		4.2
Contracting	11	Canal maintenance			77.8	11.1		11.1
	12	Operation of sluice gates			77.8			22.2
	13	Coordination of water delivery	11.1		77.8			11.1
	14	Water fee collection			77.8	11.1		11.1
	15	Conflict resolution	33.3		55.6	11.1		
Water user association and Contracting	16	Canal maintenance		25	50		12.5	12.5
	17	Operation of sluice gates		12.5	75			12.5
	18	Coordination of water delivery		25	50		12.5	12.5
	19	Water fee collection		25	75			
	20	Conflict resolution		50			37.5	12.5

[a] Under WUA refers to WUA manage jointly with the village committee. Under contracting means contractors manage jointly with the village committee.
[b] Other means village committee, WUA board members or contractor manage together with other agents including farmers, ID and township government.

ture per meter of the canal, measures the quality of maintenance. Cleaning canals by removing weeds and silt is the major maintenance activity undertaken by most villages to keep their irrigation systems functioning. Cleaning can be done in one of three ways: hiring seasonal labor, renting machinery (or contracting for custom cleaning services), or mobilizing corvee labor from within the village. In many villages these expenditures are financed from funds that were collected as part of water fees. When corvee labor was used in maintaining canals, although we could only collect information on the amount of corvee labor, we were able to impute its cash equivalent using the wage rate of the hired seasonal labor in the local labor market. The total maintenance expenditure is the sum of outlays for any machinery/service rental, wage compensation for hired labor, and the cash equivalent of corvee labor assessments.

The second indicator of irrigation system performance measures the quality of water delivery service. During the survey, we asked farmers to report the total number of times they were scheduled to receive irrigation water for their crops and the number of times that the scheduled irrigation was delayed or cancelled. From these two pieces of information, we calculated the proportion of times that irrigation was *not* delayed or cancelled (or proportion of time that water delivery was timely).

The third indicator measures the effectiveness of water fee collection. We calculate the ratio describing the actual water fees collected from farmers as a portion of the total fees payable by farmers. The effectiveness of water fee collection is crucial to the financial sustainability of transferred irrigation schemes. In our sample villages, as O&M costs are derived fully from water fees collected, the proportion of water fees collected directly affects the quality of maintenance and water delivery services.

We observe that WUAs improve the performance of the irrigation system relative to that under either traditional collective management or contracting (Table 4). In both 2004 and 2007, all three performance indicators are higher for WUAs. For example, in 2007, on average, villages with WUAs spent 27.5 yuan per meter on maintaining canals (1 USD = 7.5 yuan, in 2007), while villages under traditional collective management or contracting spent less than 10 yuan per meter (column 1). In both 2004 and 2007, water was delivered on time in villages with WUAs (column 2) more than 92% of the time. By contrast, in 2007, water was delivered on time less than 60% of the time in collectively managed villages, and

Table 4
Irrigation system performance by institution and year.

	(1) Total maintenance expenditures (yuan/meter)		(2) Proportion of timely water delivery (%)		(3) Proportion of water fee collected (%)	
	2004	2007	2004	2007	2004	2007
Collective management	9.5	9.3	78.8	57.2	93	71.9
Water user association	16.6	27.5	94	92.4	95.3	93.5
Contracting	9.4	6.6	87	78.8	93.1	91.9

less than 80% of the time in villages under contracting. While the performance of traditional collective management and contracting has declined over the years, that of WUAs has increased. Expenditures made for maintenance under contracting declined from 9.4 yuan/meter to 6.6 yuan/meter from 2004 to 2007. Although maintenance expenditures only decreased by a small amount under collective management, the indicators of timely water delivery and water fee collection both declined by more than 20%. By contrast, WUAs have increased maintenance expenditures by more than 10 yuan/meter. Even with a slight decline in the indicators for timely water delivery and water fee collection, both indicators remain above 90%.

6. Conclusions

Water user associations (WUAs) and contracting are rapidly replacing the traditional institution of collective management, in many villages in northern China. In particular, WUAs are gradually being recognized as the representatives of water users in dealing with external agencies (such as irrigation districts) and internally (within the village), by assuming the authority to mobilize resources (Meinzen-Dick et al., 1997).

Although governance of the reformed institutions often takes on new features, reform has been a gradual process. Even today, WUAs are not completely separated from the village leadership. In reformed villages, village committees, which manage canals under collective management, retain full or shared responsibility for certain irrigation tasks. There is still a large overlap between the leadership of WUAs and that of the villages. The dominance of the village leadership is also found in other countries that have established WUAs (Vermillion, 2006).

This type of gradual process has two sides. On the one hand, the importance of involving local decision makers in establishing WUAs and building upon existing organizational capacity has been observed repeatedly (Wade, 1988). In many cases, WUAs have failed or remained merely legal constructs without having the intended impact on water management, because traditional forms of organization were neglected (Gastineau, 2006; Mosse, 1999; Sokile and Koppen, 2004). For example, the failures of WUAs in the Office du Niger irrigation scheme were linked to the lack of support from community leaders (Vandersypen et al., 2007). The involvement of the local authorities perhaps explains why WUAs in northern China have been actively managing irrigation activities after establishment.

On the other hand, some scholars are concerned that the dominance of local leaders might result in elite capture, where the benefits of participatory projects are appropriated by elite members of the village, who are often community leaders (Mansuri and Rao, 2004; Platteau, 2004). There are reasons to believe that elite capture is not a serious problem in most areas of China. In rural China, land is allocated somewhat equally among households, both in terms of land size (per household) and soil quality (Benjamin et al., 2005). The egalitarian nature of the allocation of land decreases the probability of capture. Furthermore, most WUAs share information regarding water fees, the volume of water delivered and the size of irrigated area, which makes it difficult for WUA board members to obtain greater benefits than those specified in the contract.

Evidence suggests that WUAs are not reaching the expected level of "broad-based participation" envisioned by advocates of participatory programs (Mansuri and Rao, 2004). Although farmers still participate in irrigation activities, mostly in the form of their cash and labor contributions, their involvement in management is minimal, or at most an input supplementary to WUA management in providing irrigation services. Establishing WUAs has not improved the control of farmers over the irrigation system—which is one of the key motivations for promoting farmer participation in management transfer programs (Meinzen-Dick, 1997). The limited participation of farmers in decision-making is also found in other countries. For example, in the Office du Niger irrigation scheme in Mali, in only 53% of the WUAs did farmers elect WUA members (the canal chief) freely (Vandersypen et al., 2007). The limited participation of farmers may be partly explained by of the small farm size in rural China. On average, the farm size in our sample areas is about 0.6 ha per household and the average number of households within the command areas of canals is 400. Given the small farm size and the large number of households, the benefit of participation that accrues to each farmer likely exceeds the cost.

Although not achieving broad-based participation, WUAs in northern China have been successful in improving the performance of the irrigation systems. Perhaps in a place like China, where farmers are busy with wage-earning jobs and other off-farm, outside-the-village employment, efficient system operation is the more important goal of institutional reforms. Water management institutions have evolved substantially in the past, and it seems likely that they will continue to evolve in the future. Researchers and policy analysts will need to follow these trends as they unfold.

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