

12 Water Pricing Policies and Recent Reforms in China: The Conflict between Conservation and Other Policy Goals*

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Introduction

In response to growing awareness of water shortages and associated problems, China is debating and establishing a variety of policies to encourage water conservation. Among the policies under consideration is water price reform. Until recently, water in China was viewed as an easily accessible resource that could be harnessed to boost industrial and agricultural production. Thus, water prices were low, if they existed at all. While water shortages have been acknowledged since the early 1980s and local measures to conserve water were established in some areas, it was not until the late 1990s that China embarked on a concerted effort at the national level to promote water conservation and improve the overall productivity of China's relatively scarce water resources. In principle, the ultimate goal of water pricing is not only to generate funds to maintain and improve water delivery systems, but also to conserve water so that it can be allocated to areas where society places a higher value on it.

*The statements made in this chapter are those of the authors and do not reflect the views of the US Department of Agriculture or the China Ministry of Water Resources.

Such areas may be the environment, other sectors of the economy or future water users. Devising mechanisms for doing so, however, is not easy and is rarely achieved. In many areas of the world, including China, water fees are often insufficient to fund operations and maintenance, let alone encourage conservation.

The realization of the need for stricter water conservation and higher water prices, however, comes at a time when one of the primary policy goals for China is increasing rural incomes. This creates a fundamental conflict facing water policy makers: encouraging water conservation while reducing the effect that higher water fees and lower water deliveries have on farm incomes. While this conflict has hindered attempts to increase water prices, it has caused China to search for creative ways to encourage conservation without adversely affecting incomes – in some cases even leading to an increase in incomes. However, there are other issues that reduce the effectiveness of increases in water fees to promote water conservation such as a general lack of farm-level volumetric measuring for surface water deliveries and rigid water delivery mechanisms that limit farmers' capacity to adapt to reduce the burden of higher water charges.

In this chapter we provide an overview and synthesis of China's irrigation water pricing policies. We review the history of China's agricultural water policies to provide a context and background for discussion of current policy issues. We also describe how agricultural water prices are determined, applied and collected. We conclude by discussing a series of issues that confound further reform and the effectiveness of pricing policies in promoting water conservation and farmers' capacity to adapt to higher water prices.

The findings and observations in this chapter are based on extensive fieldwork on irrigation management practices carried out by the authors over the past several years. Collectively, the authors have interviewed hundreds of farm households, village officials and local irrigation managers. These interviews mostly took place in the more water-scarce areas of northern China, but parts of southern China are also represented. In addition, China is a large and diverse country, and agricultural practices vary widely. Thus, we try to convey this variation in practices, but cannot always provide estimates of the extent to which any given practice is more, or less, common than the others.

Irrigation Policy in China: Background

Agriculture was critical to the development plans of China's new leaders in 1949. Agriculture not only provided employment for roughly 80% of the labour force in China at the time, but agricultural goods were also among the few products that China could export to earn hard currency to invest in industrial capital. Moreover, increasing agricultural production allowed China to provide inexpensive food to urban industrial workers and facilitate industrial development.

Because of the desire to develop quickly, policies adopted in the socialist period between 1949 and the late 1970s sought to harness China's water resources to boost agricultural and industrial production without regard to the opportunity costs of the water. During this period, irrigated area

expanded rapidly as the command area for existing irrigation districts (IDs) was expanded and new districts were established. The People's Communes, or collective groups under the communes such as Production Brigades, organized much of the expansion of surface water infrastructure during this period. The projects were often short on capital and were completed by mobilizing large amounts of collectively managed labour. In addition to surface water IDs, local officials increasingly tapped groundwater aquifers with the adoption of electric pumps, particularly in areas of northern China such as the Hai river basin. The number of tube wells in China grew from 150,000 in 1965 to more than 2.3 million by the late 1970s (Shi, 2000). Because of the collective nature of the irrigation assets and the intent to boost agricultural production without regard to costs, the water channelled to agricultural fields (which were also farmed collectively during this period) was delivered without charging any fees. For groundwater, the communal entities that established the wells would pay the cost of electricity, but prices were also set below the actual cost of producing and delivering electricity.

In the late 1970s and early 1980s, China's agricultural policy underwent a major transformation with the adoption of policies together referred to as the Household Responsibility System (HRS). Instead of farming land collectively, local leaders allocated each farm household individual plots of land to farm by themselves. In return, farm households were obligated to (or 'responsible' for, hence the name) delivering a fixed quota of grain to the state-owned Grain Bureaus at a predetermined, but generally below-the-market, price. This system not only restored households as the primary production unit in agriculture but also ended the collective institutions that formerly built, managed and maintained much of China's irrigation infrastructure.

However, by restoring the household as the primary production unit and allowing them to earn profits on their production, households became responsible for purchasing their own agricultural inputs. Thus, water

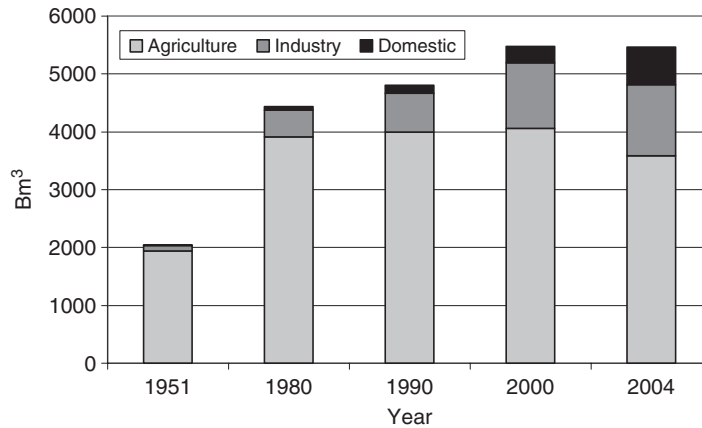


Fig. 12.1. Structural changes in China's water use, 1951–2004 (in Bm³).

fees were introduced for households with irrigated land. The fees were set by the local Price Bureaus in accordance with guidelines set out by the national Price Bureau. While prices in water-scarce northern China were higher than in water-abundant southern China, these bureaucratically set prices still served to subsidize irrigation water (Lohmar *et al.*, 2003; Tsur *et al.*, 2004, Chapter 8). Irrigation water fees in this period were generally below the costs of recovery, storage and delivery of the water, not to mention the opportunity cost of the water in other uses. The operating costs of IDs are often high due to payroll and other obligations. Moreover, a lack of incentives to provide services (which, in part, arises from low water prices) generally led to poor irrigation delivery services and subsequent inadequate water fee remissions, exacerbating the problem of cost recovery. In some IDs, managers resorted to establishing the so-called multibusiness enterprises (such as fish farming or tourism enterprises) using ID assets to maintain payrolls (Lohmar *et al.*, 2003; Easter and Liu, 2005).

Despite the shortcomings of the system with regard to efficiency of pricing and cost recovery, it is important to note that a system of pricing with the intent to generate self-financing IDs was established in China after the reforms in the early 1980s. This system served as a base for subsequent reforms,

and differs from some systems in other parts of Asia where irrigation is funded directly through government departments.

Before long, the policies that actively sought to harness water resources appeared to be reaching and surpassing availability constraints as signs of acute water shortages began to occur with increasing frequency. Water use growth doubled during the period 1949–1951, then doubled again between 1950 and 1980. After 1980, China's total water use growth slowed, and grew from around 4.4 Bm³ to around 5.4 Bm³ (Fig. 12.1). Moreover, water allocated to irrigation actually decreased from 1980 to 2004, primarily within the last 5 years, with water allocated to industry and domestic use driving the growth in water consumption over the period 1980–2004. Water in important river basins, notably the Yellow and Hai river basins, was increasingly used up entirely before reaching the ocean. In part because of the overexploitation of surface water, the exploitation of groundwater accelerated. By the 1990s, in some areas, the groundwater table was falling by over 2 m a year (Lohmar *et al.*, 2003).

To address the situation of tighter water supplies available for agriculture, the national government embarked on a series of water policy reforms to encourage water conservation in the 1990s. Since agriculture is still by far the largest user of water, these reforms generally targeted agriculture. Reforms were established

at all levels of the water delivery system including river basin management reforms, ID management reforms, regulations on groundwater withdrawals, and village- and household-level incentives to adopt water-saving conveyance and delivery technologies (Lohmar *et al.*, 2003; Wang *et al.*, 2004).

Two factors that confound sound water resource policy making are a lack of clear jurisdictional control over water policy and a lack of sufficient property rights to water for users to benefit from using it more efficiently. In China, water is owned by the state, with the very limited exception of water in some local ponds and delivery systems owned by the local collectives that built them. The primary state agency charged with managing the state's water is the Ministry of Water Resources (MWR) and its provincial counterparts. However, several other agencies have some jurisdiction over water resources such as the Urban Construction Bureaus (accessing and delivering mostly groundwater for urban consumers), the Ministry of Land and Resources (measurement and evaluation of groundwater resources), the Price Bureaus (determining pricing guidelines) and others. The MWR administers the state's agricultural water resources through a system of IDs and withdrawal permits, which, in principle, cover all water diversions including those from groundwater. Each ID is given the right to withdraw a fixed amount of water from a surface source (river, reservoir or aquifer) and distribute this water to irrigators in their district. IDs are given substantial leeway to determine how to distribute the water allocated to them, but neither an ID nor the MWR has the right to determine water prices, which is done at the Price Bureaus. The disjointed nature of the right to determine price versus the right to determine delivery schedules results in poor incentives for the MWR to monitor withdrawals from surface sources into IDs, and to monitor local users' withdrawals from the irrigation system under the existing permit system. Groundwater is also owned by the state but, in practice, the villages that sit on top of the aquifers have de facto rights

to the water. These are the most unencumbered water rights and, because of this, groundwater managers and users face stronger incentives to use water more efficiently, although the price is generally below its actual value in agriculture.¹

How Water Is Priced in Agriculture

A variety of agencies, policies and local institutions affect agricultural water pricing in China. Water pricing differs by whether the water is diverted from a surface water system or pumped up from a groundwater aquifer. In addition, local policies and institutions also affect water pricing since many areas have established mechanisms to improve services, water fee collection or both.

Surface water

The most common form of irrigation water in China is surface water, which is generally less expensive than groundwater. As is well known, China has a history of surface water irrigation systems that dates back several thousand years. On top of this, China has greatly expanded surface water irrigation, and improved ageing systems in the years since 1949. Volumetric pricing for surface water at the village level began in the 1980s and prices have increased somewhat since that time, but to date volumetric pricing at below the village level is very uncommon. Prices for surface water vary substantially by locality, ranging from 0.01–0.05 Renminbi(RMB)/m³ in the south to 0.05–0.15 RMB/m³ in the north, and these have been rising over the past two decades and will likely continue to rise.² However,

¹In cases where the groundwater table is very deep, the costs of pumping can be greater than its value when used to irrigate wheat. In these cases, farmers may forgo wheat production, rely on rainfall for wheat production, or invest in cash crop production in combination with a more efficient irrigation delivery system.

²One RMB is equal to about \$0.12 at current exchange rates.

because farmers and sometimes village water managers can often neither choose when their irrigation water is delivered nor decide how much they receive, surface water management policies confound efforts by farmers or local leaders to respond and adapt to price changes. Moreover, additional pumping costs and voluntary labour requirements may increase the actual costs of the water as well (Webber *et al.*, 2006).

Surface water irrigation in China is delivered by IDs that vary significantly in size and management. Currently, there are 402 large IDs in China that have command areas exceeding 20,000 ha. Within larger districts, there is generally an array of smaller reservoirs and farm ponds to store water closer to irrigated areas. In addition, there are over 5000 'medium sized' IDs in China with command areas between 667 and 20,000 ha. Most of China's irrigated area, however, is serviced by the hundreds of thousands of small IDs, with a command area less than 667 ha and they service roughly half (55.3%) of China's irrigated land. These smaller IDs interact with local villages and are sometimes owned by a village or township. Larger IDs are generally segmented into smaller sub-districts that interact with the villages in their command area.

Traditionally, collection of surface water fees at the farm level is managed by the village, sometimes referred to as the collective. Every village has a person assigned as the primary water manager.³ That person may be either a member of the village government itself or someone selected from outside the government to manage the irrigation deliveries and fee collection in return for a small stipend. Either way, the water manager is often in charge of informing farmers of water deliveries by the ID, particularly in more water-scarce areas in northern China. Sometimes, the irrigation manager interacts with the ID to arrange for timely deliveries as well.

³In larger villages, managers may interact with a group of subordinate water managers representing subgroups of households in the village.

Surface water prices in China are largely determined by bureaucratic decree rather than by any market mechanisms. The primary agency responsible for determining water prices is the Price Bureau, which sets national guidelines and is guided not only by the demand for water in the specific sector in question but also by general economic and political considerations. Water price guidelines established by the Price Bureaus differ according to the user of the water, with industrial users paying a higher price than agricultural water users.⁴ Local Price Bureau offices then determine pricing guidelines for their local users, based on the national guidelines, and usually work with the relevant ministries (such as the provincial MWR office) in determining the local pricing guidelines.

Once water pricing guidelines are established and forwarded to the local ID, it determines how to price its deliveries. Local practices vary and in some areas the ID delivers water to villages at certain times throughout the irrigation season without carefully measuring the quantity. In return, the village is expected to remit to the ID a water fee assessed per mu of irrigated land.⁵ In the past, this fee was often bundled with other fees and paid once or twice a year, and sometimes even paid in kind when farmers deliver their grain quota obligations. When this happens, farmers may not even know how much they pay for water because the water fee is bundled together with other payments (see Chapter 7, this volume, for a similar situation in Vietnam). However, since grain quotas are far less pervasive today than in the past, water fees are generally paid in cash. Recent policy initiatives also discourage the bundling of fees so that water fees are increasingly paid

⁴Within industry and within agriculture water prices can vary. Often water used as coolant for electricity generating plants is priced lower than water for other industrial uses, and sometimes even lower than for agriculture. Within agriculture, farmers growing cash crops may pay more for water than those growing grain.

⁵A mu is a Chinese unit of land area equivalent to 1/15th of a hectare.

independently of other local taxes and fees, which are being phased out (Gale *et al.*, 2005). When the water fees are collected independently, the village irrigation manager who coordinates deliveries typically collects the fee payments as well.

In addition to paying a per-mu fee for irrigated land, farm households also contribute labour to maintain and construct new irrigation infrastructure. This 'volunteer' labour contribution is a carry-over from the collective period when most rural infrastructure was constructed using teams of collectively managed labour under the communes and the communal subunits. Indeed, farmer labour during and after the collective period, coupled with investments made by collective contributions, largely built and maintained surface water infrastructure, giving farmers a sense of ownership and a natural stake in how these assets are managed.

IDs generally measure water flows at some point (usually at the branch or lateral canal) in the delivery process, and it is not uncommon that the volume of water delivered to a village is measured. In this case, it is possible to introduce some volumetric water charge at the village level. When irrigation deliveries are volumetric at the village level, many villages split the charges into two components: a fixed component generally intended to maintain the delivery system and a volumetric component intended to cover the operations and management costs of the ID. With the volumetric component, villages can find ways to reduce their water use and save money, giving them an incentive to conserve water. However, a limitation on this incentive is that it occurs primarily at the village level since even the village volumetric charge is typically divided into charges to individual households according to their irrigated land size rather than according to some measure of their water use. Thus, either the village leadership must initiate conservation practices or the individual farm households must organize to collectively establish conservation practices. Given the lack of incentives faced by the village leadership (they do not gain from reducing water charges) and the costs of organizing a collective effort, the incentives to establish

water conservation practices under this system are not particularly strong.

Village payments for irrigation water do not go to the ID directly, but instead to the next higher level of the Water Resource Offices affiliated to the Ministry of Water Resources. IDs are under the authority of the Water Resource Office in the jurisdictional level that encompasses the entire command area of the ID. Smaller IDs may be under the authority of the township-level Water Resource Office, or the county-level office, and larger ones may be under the prefecture or even the provincial office. Payment made by farmers and collected by the village for irrigation water deliveries goes through these levels of bureaucracy before being remitted to the ID that delivered the water. In general, each level of bureaucracy will charge a fee for the service of handling these payments, further reducing the amount ultimately remitted to the ID. Moreover, the fees retained by the various levels of bureaucracy are typically tied to the amount collected, which in turn is often tied, to some degree, to the amount of water delivered to villages. This results in an incentive for local Water Resource Offices to maintain or increase water deliveries rather than an incentive to promote conservation. These water fee remittance practices may also serve to generate resistance to reform by local governments.

The system of pricing and fee payment outlined above leads to a number of inefficient practices and consequent problems. A primary problem is the low water price set under the Price Bureau guidelines. Low prices are a problem not only because they provide poor incentives to conserve water but also because the revenue received under these low prices are often insufficient to maintain delivery infrastructure (Lin, 2003). Because of low prices and poor infrastructure, IDs face few incentives to put energy into delivering the water in a timely manner. This leads to poor and untimely water deliveries that can reduce the value of water in agriculture (MWR, 2006). The poor delivery services then result in farmers refusing to pay their water fees, which exacerbates the problem of low-income generation for IDs.

To address these problems, China has begun to establish various types of irrigation management reforms. The goal of these management reforms is to improve water fee collection, water delivery services and ID fee remissions and, in some cases, to reduce water allocated to farmers. These reforms are most common in larger IDs in water-scarce areas of northern China, where the disconnection between irrigators and water delivery decisions and also directives to save water are greatest. Reforms take a variety of different arrangements, but generally they try to turn over management of local irrigation assets to individuals or groups that have a stronger incentive to provide services and collect fees. Moreover, the fees collected by these agents are remitted directly to the ID. For larger districts, they are remitted to companies established by the ID to manage deliveries in sectors of the district. These reforms can also be effective at reducing water applications when managers can earn income by reducing the water they deliver to irrigators.

Water user associations

The establishment of Water User Associations (WUAs) is a major movement to improve irrigation management in China. Originally promoted by the World Bank in the mid-1990s, in many respects, WUAs are similar to some of the progressive irrigation management institutions that already existed in China. Theoretically, a WUA is a farmer-based, participatory organization set up to manage the village's irrigation water. The idea is that farmers come together to elect a board to manage irrigation water issues such as fee collection, scheduling deliveries and negotiating volumetric pricing with the ID. In larger IDs, Water Supply Companies (WSCs) are established by the ID to sell volumetric water deliveries to the WUAs in their command area and also occasionally to other users. This management structure is very similar to the institutions in some IDs where the ID has established smaller-scale management groups to sell water volumetrically to local villages. In addition, under WUAs, water resource fee remission circumvents the local Water Resource Offices, increasing the actual amount received by the

ID. By the early 2000s, more than 500 World Bank-sponsored WUAs and over 40 WSCs had been established in China, and roughly 1500 WUAs established outside World Bank-sponsored projects (Lin, 2003). The number of WUAs has almost certainly increased since Lin's study.

The motivation behind promoting WUAs is generally to improve services and fee remissions to the ID rather than promoting water conservation at the farm level. The idea is that farmers will have a greater stake in the system and, therefore, will be more willing to invest in water-saving conveyance infrastructure and remit water fees in return for improved irrigation services. Theoretically, it is only by way of increasing the potential for collective action, via regular WUA meetings, that the WUA may serve to promote water conservation. In addition, it is at the collective meetings that the irrigators discuss the amount of water they want to purchase from the WSC and how much it would cost. These discussions may also encourage farmers to reduce water use at the farm level and cut costs.

In practice, WUA management varies considerably and many, perhaps most, are not participatory. Indeed, the leadership of WUAs sometimes does not differ significantly from the village leadership. In a recent survey of WUAs, primarily in Ningxia province, Wang *et al.* (2004) found that the governing board for 70% of the WUAs surveyed was the village leadership itself, and of the 30% where the leadership appointed a manager, one half of the managers were former village leaders. Other researchers found similar close relationships between the village and the WUA leaderships (Gao and Li, 2002; Mollinga *et al.*, 2005). However, there are also indications that some WUAs allow for more participation via direct elections, etc. (Lin, 2003; Lohmar *et al.*, 2003; Easter and Liu, 2005). In a recent survey of village leaders throughout northern China, roughly half reported that WUA leadership was elected by villagers in areas with WUAs.⁶

⁶Unpublished results from the 2004 China Water Institutions and Management survey by the Center for Chinese Agricultural Policy, Chinese Academy of Sciences.

WUAs, whether participatory or not, may still be effective in improving water management, fee remission and promoting water conservation. Wang *et al.* (2004) argue that it is the incentives of the water manager appointed by the WUA that matter for a WUA to be successful. Under this criterion, managers appointed by the village government may effectively improve water management and fee remissions, and reduce water use when they have the right set of incentives to do so, regardless of whether they are selected by farmers or not. Initial evidence presented by the authors indicates that farmers' participation is not an important factor in a WUA's capacity to reduce water use and maintain yields. However, since nearly all the WUAs in the study are newly established, these results may be only short-term effects. Longer-term, and possibly more substantial, savings made via investments into infrastructure, system maintenance and agricultural practices, may be more likely to occur when farmers have a greater role in management decisions. In addition, some argue that since irrigation assets were largely built with farmers' volunteer labour and some investment from collective savings, farmers have earned a right to be involved in irrigation management decisions.

When WUA managers can claim profits generated by activities in implementing policies that achieve the goals of the WUA, the institution is most likely to be effective at achieving policy goals (Wang *et al.*, 2004). The main way WUA managers can do this is by working on the margins of the price of the volumetric deliveries and the per-mu fees paid by farmers. Essentially, WUA managers can allocate funds to line canals or other investments that reduce the water loss and improve water deliveries to fields. The amount of water saved (which can be as high as 40–50% from a lined canal) can be deducted from the planned amount of water purchased from the WSC and reduce the volumetric component of the fee payment.⁷ Moreover, with increased effort in monitor-

ing and supervision, water can be allocated to farmers more efficiently so that irrigators receive better irrigation services even though less water is being drawn from the system. Since the fees farmers pay are set in advance and generally fixed per-mu payments, if managers can reduce water deliveries but keep irrigators happy with timely service, the payments they make to the WSC for volumetric deliveries are reduced and water managers can then earn money. This system gives managers strong incentives to reduce water purchases from the WSC, yet maintain effective irrigation deliveries to the field to keep farmers satisfied so that they pay their irrigation fees. Often, as an inducement for farmers to accept more limited (but timelier) water deliveries, WUA managers will pass some savings on to the farmers by charging lower per-mu water fees. Thus, when effective, this management system can both reduce water withdrawals from the surface system and decrease farmer's water fees.

The establishment of WUAs, however, does not appear to have greatly improved the ID's ability to be financially self-sufficient. Lin (2003) notes that prices in Hunan and Hubei provinces where WUAs were established early are still well below the costs of deliveries and, in some cases, as low as 20% of costs. These shortfalls are due to the continuation of rigid pricing policies since the WUA reforms do not liberate local officials from pricing water outside the guidelines established by the Price Bureaus. The establishment of WUAs, however, does improve irrigation services and the timeliness of deliveries, and reduces conflicts between irrigators (Lin, 2003; Easter and Liu, 2005), which have increased farmers' willingness to pay water fees. But since these fees are still set at a low level, improvements in water fee submission do not seem to have improved the ability of the IDs to be financially self-sufficient. Some also argue that the lack of participation and the 'privatized' nature of WSCs and some WUAs cause them to forego needed investments in order to appear more solvent and pay bonuses to managers, an effect that could cause them to seek far more govern-

⁷These savings are not 'real water saving', a point addressed in the conclusion of this paper.

ment support in the future than they appear to be 'saving' at present (ICID, 2004).

Contracting canal management

Related to WUAs, canal contracting is an officially advocated reform in surface water management. It is similar to WUAs in that it turns irrigation management over from village officials to a specified manager, but instead of a whole village's irrigation infrastructure being turned over, just a lateral canal which may service only part of a village, is turned over to the manager. In addition, these managers are generally not appointed by the village leadership or selected by farmers but rather selected by some other process, sometimes via open bidding. The selection process generally stipulates a ceiling price for water that managers can charge, and often also a minimum investment that managers must put into the irrigation system to qualify for the right to manage the system. In some cases, managers can pocket the difference between the fees they collect, a stipulated return on their investment, and the volumetric-based payments they must make to the ID, although the terms of this arrangement vary.

Similar to managers in some WUAs, canal managers have incentives to improve management and reduce water allocations when they can earn money by doing so. Also as with WUAs, the incentive usually comes by reducing volumetric purchases from the ID or WSC while maintaining effective irrigation deliveries by improving conveyance infrastructure and management techniques. When canal managers reduce volumetric purchases of water from the ID, they may reduce farmers' water fees in order to pass some of the savings on to irrigators and maintain their support. While farmers have little control over how the manager implements these policies, widespread disapproval, particularly if it affects agricultural production, would likely bring about the intervention of higher-level officials. Improvement in service and conveyance also allows for less water to go into the irrigation system and, via reduced conveyance losses, still allows for sufficient water to

reach the fields and keep farmers satisfied with their delivery services. Considering these factors, canal contractors can earn money by reducing water purchases and improving services and fee collection.

Concluding note

China's investments in surface water infrastructure over the last 50 years have provided many farmers with irrigation water and, through this, increased rural incomes and agricultural production. Recent reforms have also improved services and help assure that water revenues go to improving local management and infrastructure. However, management reforms vary greatly in their effectiveness and have yet to become widespread throughout China. Most surface water systems in China still suffer from a lack of volumetric pricing mechanisms, poor management incentives and bureaucratic fee remission practices. These practices result in poor services and inadequate fee remissions to the ID. Moreover, increasing competition for surface water resources, occasional water scarcity due to year-to-year variation in rainfall and various fiscal issues still plague surface water systems and exacerbate the problems of timely deliveries and services.

Groundwater

Groundwater prices which vary considerably more than surface water prices, are generally higher, and there are important quality differences as well. Because the Price Bureaus do not determine groundwater prices, the cost of groundwater deliveries can be as high as 1 RMB/m³ in areas in the Hai river basin where wells can be more than 100 m deep.⁸ Since groundwater prices vary with well depth, and well depth varies

⁸We use the term 'cost of deliveries' here because the water is generally free and other than paying for pumping and conveyance costs, only a small percentage of villages charge an additional 'water resource fee' on top of these costs.

Table 12.1. The cost of water, depth to water and water use per unit of land in Hebei province's groundwater-using communities, 2004. (From 2004 CWIM data, reported in Huang *et al.*, 2007.)

Percentile of the cost of water		(1) Depth to water (m)	Average cost of (2) water (RMB/m ³)	(3) Volume of water use per unit of land (m ³ /ha)
	Wheat			
1	Average	31	0.24	4608
2	0–25%	14	0.08	6433
3	26–50%	21	0.20	5285
4	51–75%	52	0.30	2934
5	76–100%	53	0.56	2154
	Maize			
6	Average	34	0.24	2019
7	0–25%	20	0.06	2255
8	26–50%	34	0.16	2094
9	51–75%	57	0.26	1463
10	76–100%	68	0.52	1119

significantly, the variation in groundwater prices can be high even within smaller regions like the Hai river basin, where wells vary in depth from 10 to over 100m. In Table 12.1, the implied pumping costs for groundwater in northern China range from 0.06 to 0.56 RMB/m³, depending on well depth. In addition, groundwater may have a high saline content, especially the shallower groundwater tables. However, the water in deeper groundwater tables might be far colder than surface water and stress the crops when applied, particularly when the crop is in the seedling stage.⁹

Despite the higher prices and potential quality problems, groundwater is an increasingly important source of irrigation water in China, particularly in northern China where water is scarcer. In the past few decades, many areas in the Hai river basin have tapped into groundwater aquifers with diesel or electric pumps to irrigate their fields, allowing them to produce winter wheat and a second crop of maize, or sometimes cotton. Farmers also increasingly use groundwater as a buffer stock of irrigation water to be drawn when surface water is scarce and replenished (via seepage from surface irriga-

tion) when surface water is available. Farmers often prefer to use surface water because it is cheaper and, sometimes, because of saline or temperature problems referenced above. Generally speaking, groundwater levels are continually falling in China. However, the groundwater levels in areas where groundwater is used conjunctively with surface water are falling at a slower rate than in areas without access to surface water.

Groundwater pricing policies vary from surface water pricing policies. One primary difference is that groundwater is increasingly priced volumetrically since the pumping necessary for groundwater makes it easy to measure the volume delivered (or at least extracted) and this volume is directly related to operating costs as well. Another difference is that there are no large IDs delivering groundwater. Groundwater resources are managed at the local level, most often at the village level. Groundwater systems are much smaller, often organized around a single well with just a few dozen households receiving water from that well. Thus, groundwater users have greater opportunities than surface water users to interact with the person managing the irrigation deliveries. In addition, proceeds collected by groundwater managers are, in general, remitted directly to the entity (the village committee or the well owner) that provides the services and infrastructure for the

⁹On several occasions, the authors have heard from farmers in China the complaint that cold groundwater stresses young crops.

groundwater and not used to support a larger bureaucracy as is the case with many surface water systems. Groundwater irrigation services and fee remission mechanisms are also improving as groundwater assets are increasingly managed by private interests rather than by collectives.

Collective groundwater services

As with surface water, rural collectives generally managed groundwater pumps and conveyance systems after the reforms in the late 1970s. Commonly, smaller collectives, known as village groups (*cunzhuang xiaozu*) and made up of 30–50 households (but sometimes as large as 100 or more households), work together to maintain the wells and infrastructure they inherited from the former communes to provide groundwater for members of the group. This arrangement works particularly well since village farmland is largely allocated to households via the village groups so that households belonging to the same group tend to have contiguous plots of farmland.

When groundwater irrigation assets are owned and managed collectively, prices paid by irrigators may not be based on water volume. Instead they are often collected on a per-mu basis much like fees collected for surface water. These fees are used to cover the costs of maintaining the well, paying for electricity and paying back any loans taken out for any additional investment. The person selected by the group to manage all this may also receive a small stipend from the fees collected. In many cases, the village itself rather than the village group manages groundwater pumping and delivery assets. Under these arrangements, they also generally collect water fees based on irrigated land; however, they may sell water volumetrically to village groups or to farmers themselves.

Non-collective groundwater services

Much like the case with surface water, some groundwater assets became inoperable due to the groundwater table falling below the depths of the wells or the well structure

collapsing. This induced a need to re-establish wells, often deeper and more powerful, but without the communal institutions that first established them. The collective parties that became responsible for their maintenance had either unclear rights to the system or found it difficult to garner the fiscal resources necessary to rebuild the system. Thus, in the era after the HRS reforms, non-collective institutions rose to re-establish wells and groundwater irrigation in many regions where farmers had come to rely on this resource (Wang *et al.*, 2005b; Zhang *et al.*, 2005). These included private well owners and operators, as well as joint ventures, often with local governments as partners, in companies that supply groundwater to irrigators. This trend accelerated in the late 1990s as transfers from higher levels of government were reduced and villages had to find their own funding for local investments. According to data from field surveys reported by Wang *et al.* (2005a), private, rather than collective, interests established 80% of the new wells in the Hai river basin in the 1990s, an area that is particularly dependent on groundwater for irrigation.

With the increasing role of private funding for groundwater irrigation deliveries, water pricing practices became more rational and increasingly based on volumetric deliveries. For the most part, the newer, mostly privately financed, groundwater companies sell water volumetrically to irrigators. In addition to investments into the wells and pumps, managers also often invest in underground pipes to deliver water to spigots that may be a few hundred metres away from the well itself, thus reducing the amount of water lost in conveyance to the field. Generally, the fee charged to irrigators is based on the electricity used rather than on the volume of water, but electricity used is highly correlated with the volume of water pumped and the depth of the well. Importantly, the companies delivering groundwater for irrigation generally do not pay any resource extraction fees; the water is free to them once they pay the costs of accessing and delivering it to farmers' fields. To the extent that local governments invested

in these ventures, they too have mostly turned to volumetric pricing to recover the investment. These companies possess no formal ownership rights to the water they sell to farmers since groundwater resources theoretically belong to the state.

Issues with Price and Irrigation Reform in China

The current reforms in agricultural water management and pricing in China are the beginnings of a movement away from the former policies that harnessed water as a cheap and readily available means to promote economic growth. However, the current reforms fall short of policies that actually price water to achieve efficient allocation. Instead, policy reforms serve primarily to trim the bureaucracy in irrigation water management, clarify incentives to improve services and streamline the path of fee remittances to improve the capacity for local IDs to be self-sufficient. Thus, there is still substantial capacity to improve upon the current reform efforts. A better understanding of a number of important relationships may help water pricing policies to be successful politically as well as economically.

Water price reform

Effective irrigation water price reform in China is hamstrung with the debate over how higher water prices might affect agricultural producers. Currently, improving the income and welfare of farmers is the number one policy goal of China's leaders. Several policies are geared toward achieving this goal, including the abolishment of age-old agricultural taxes, the introduction of direct subsidies for agricultural producers, and increased investments into rural health care and drinking water purification systems (Gale *et al.*, 2005). Irrigation water fees were once commonly bundled with the various taxes and fees that are now being abolished. Raising water fees is diametrically opposite to the policy of abolishing all

the other fees farmers pay and serves to cancel out the effectiveness of the current policy. Indeed, some observers are concerned that, if water fees are increased, local officials will not lower the local taxes and fee payments but instead simply call them 'water fees'.

While there is concern over how water prices might affect rural livelihoods some also argue that price policy will not be effective at reducing water use in agriculture. Yang *et al.* (2003) argue that water demand is relatively inelastic so that raising prices would not serve to reduce water use but rather only to increase the revenues of the IDs. Estimates of the price elasticity of irrigation water vary, and certainly water use is more inelastic in the short term than over a longer period when farmers can adjust themselves by adopting conservation technologies or practices or changing cropping patterns altogether. However, estimated inelastic price responses are due, in large part, to a legacy of very low prices so that farmers face the inelastic portion of the water demand curve. Farmers' water deliveries are also often constrained so that even at the low prices they face, the quantities used do not represent the value of the marginal product of water.

If prices rise substantially, farmers will become far more responsive to price changes. Huang *et al.* (2007) and Liao *et al.* (2005) have found that farmers would reduce water applications significantly if the price of water is raised to a level that reflects the value of the marginal product of water. Both these studies used cross-sectional data, so they are likely to take longer-run adjustments into account. For example, from a survey of farm households in northern China, Huang *et al.* (2007) show that deeper water tables are associated with higher pumping costs and thus higher water costs (Table 12.1). For wheat, maize and cotton, farmers use significantly less water per hectare in areas where the pumping costs are higher than in areas where the water is less costly.

In addition, the share of production costs due to water charges varies significantly by crop and by water depth. Again,

Table 12.2. Cost of groundwater in total production cost.^a (From 2004 China Water Institutions and Management.)

By crop: Cost share of inputs in total production cost (unit: %)				
		(1) Water	(2) Fertilizer	(4) Other inputs ^b
1	Wheat	24	49.6	26.4
2	Maize	12.9	50.7	36.4
3	Cotton	10	37.3	52.7

By depth of groundwater				
Percentile of water depth		(1) Average water depth ^a (m)	(2) Total cost of water per hectare (RMB) ^a	(3) Share of water cost in total production cost ^a (%)
4	0–25%	6	471	13
5	26–50%	21	454	16
6	51–75%	58	622	21
7	76–100%	91	834	23

^aThe sample here is the plots that have detailed input information and have used groundwater in irrigation.

^bOther inputs including labour and capital cost.

data from the survey of households in northern China carried out by Huang and the Centre for Chinese Agricultural Policy, Chinese Academy of Sciences indicate that, on average, groundwater applied to irrigated wheat is 24% of total production costs, while for cotton it is less than 10% because cotton uses less water and more labour, pesticides and other inputs (Table 12.2). For fruits and vegetables, the share of water in production costs is likely even less, but this is, in part, due to investments made into water-saving technologies for fruit and vegetable production. Given the low values and constrained water deliveries, Huang *et al.* (2007) show that doubling of water prices results in only an 8% fall in crop income. In addition, having begun a programme to subsidize farmers, China is well positioned to offer farmers a lump sum water conservation subsidy to replace the income loss when farmers adjust to higher water prices.

To understand the effect that water prices have on rural incomes, it is important to know that farm households in China today have sources of income other than agriculture. Roughly half the farm household income in China is from non-farm sources such as local wage labour, self-

employment enterprises or migration.¹⁰ In addition, of the remaining half that comes from agriculture, less than 20% is from growing grain, the rest from raising livestock, aquaculture and cash crops which bring a much higher return to water (NBS, 2005). Thus, a substantial increase in water prices may cause farmers to earn less producing grain, but it may also induce farmers to make investments and develop the marketing channels necessary for more lucrative cash crop or other agricultural operations. Indeed, Huang *et al.* (2007) found that as well depth rose from less than 10 to over 60m, the sown area committed to non-grain crops rose from 15% to more than 30%. If higher prices induce conservation and the water is freed up to be reallocated to industrial use, and the increased water availability

¹⁰Migration in China is internal, primarily rural-to-urban migration and is largely temporary because migrants are not given permanent residential rights in urban areas. They typically return home at least once a year and often return to their native villages permanently after saving a sum of money working in urban areas. Since the migrants are still considered members of the rural household, their income is considered part of the rural household's income.

for industry increases industrial output and demand for labour, then this reallocation could serve to increase the fastest growing segment of farm household income: non-farm employment. There are, however, income distribution issues with increasing irrigation water prices since households most reliant on agricultural production generally have lower incomes than households with substantial off-farm income.

Farmers' response to scarcity

Given the recent reforms and price incentives in some areas, and the incentives offered at the local level, farmers are increasingly making choices that reflect increasing water scarcity (Liao *et al.*, 2005; Blanke *et al.*, 2006; Huang *et al.*, 2006a). As outlined above, such choices include reducing irrigation water applications to traditional and staple crops (intensive margin), and shifting into crops that bring higher returns to water (extensive margin). However, such behaviour is tempered by another important policy goal encouraged by local-level cadres: maintaining domestic grain production. With surface water, water conservation decisions are sometimes, perhaps often, made at levels above the farm household, such as wet-dry rice production, or reducing wheat irrigation deliveries from four to three times a year. Even with management reforms, water conservation decisions are often made at the WUA or canal manager level and farmers must act accordingly. With groundwater irrigation, however, increasingly lower water tables coupled with more private interests in the groundwater market serve to induce changes in agricultural practices on both the intensive and extensive margins that could affect the production of important grains and threaten self-sufficiency in these crops.

When water prices get high enough that it becomes unprofitable to irrigate staple grains or cotton, then farmers are faced with the choice of foregoing irrigation entirely or adapting to other crops that can bring a higher return to the water. Rising incomes

and rapid urbanization in China have brought about a rise in the demand for fruits and vegetables, and these are often the crops farmers choose when faced with higher water prices. While these products tend to be more water-intensive than field crops, they are better suited to effective water-saving irrigation technologies such as greenhouses and drip irrigation systems, lowering the water withdrawal requirements to grow these crops.

The movement into higher-valued fruits and vegetables, however, does not come without risks. These risks, coupled with initial investments required to change crops, partly explain why farmers often do not move into cash crop production unless pushed by forces such as rising water costs. Markets for many cash crops tend to be fairly thin so if large numbers of producers decide to move into production of these crops, prices can drop dramatically. These swings can be even more pronounced with orchard crops where the lag-time between the decision to plant the orchard and production of the first crop can be several years. Fruit and vegetable crops are also more susceptible to spoilage than staple grains, increasing the risk of a loss unless expensive cold chain or other modern marketing infrastructure is in place. The fact that many of these crops require some, and sometimes substantial, initial investment increases farmers' exposure to these various risks.

Movement into higher-valued fruits and vegetables using water-saving irrigation technology may be constrained by growth in domestic demand for these products and problems in selling them on international markets. China has enormous production potential in these products and this potential likely outstrips the projected increases in domestic demand due to increasing incomes and urbanization. However, fruits and vegetables can often be problematic export commodities in that they are more likely to be subject to sanitary and phytosanitary (SPS) restrictions. This problem is even more acute in China due to the excessive use of pesticides by farmers in China, and the wide range of products it could potentially export (each product must go

through SPS reviews in each importing country) (Huang and Li, 2005). Together, these policy and institutional constraints could serve to reduce farmers' capacity to increase the allocative efficiency of water by using it in the production of higher-valued crops.

Farmers' capacity to continue movement into high-value and labour-intensive crops may also run into conflict with other policy goals. China's long-standing insistence on maintaining near self-sufficiency in staple grains, particularly food grains like wheat, may serve to induce policies that discourage movement out of wheat production. Self-sufficiency of food grains conflicts with the goal of increasing rural incomes since wheat tends to be a low-income crop, and it is also threatened by increasing water scarcity since wheat production in water-scarce areas is almost entirely dependent on irrigation. But if large numbers of farmers move out of wheat production and into other crops that bring higher returns to scarce water and other inputs, China's wheat production may fall to levels below their self-sufficiency goals. Trade, in such a situation, would be beneficial and allow farmers to produce and export relatively labour-intensive crops and import relatively land-intensive wheat, while also reducing water withdrawals for agriculture. However, if self-sufficiency of wheat is threatened, China may establish policies that discourage movement out of wheat production and constrain farmers' capacity to adapt to water shortages.

Property rights

Policies that increase water prices will more effectively induce efficiency improvements and potentially benefit farmers and others in the rural economy if property rights to water are more clearly defined. Currently, the debate over the role of water property rights is as heated as the debate over water prices and there is no consensus over how to determine or allocate these rights (Liu, 2003; Huang *et al.*, 2006b; Jia and Duan, 2006). A variety of projects that examine ways to allocate

water rights and promote water conservation are also being carried out in China, but there are institutional barriers that restrict the adoption of these practices such as state ownership of water resources and the lack of authority to transfer this ownership. In some projects, non-agricultural users (such as electric-power-generating companies) directly fund water-saving investments, such as canal lining, then maintain rights to the water these investments save (Xu, 2006). In other projects, officials are experimenting with policies that grant farmers the use rights to water at a low price and then allow them to sell these rights to other users or back to the water management authorities at a higher price (Jia and Duan, 2006).

While the debate over formal allocation of rights continues, norms and practices at the local level indicate that a set of de facto rights already exists and understanding these de facto rights will help determine how price changes might affect farm households. For example, withdrawal permits represent a partial right to water, but the rights are generally not sufficient to provide incentives to monitor and enforce the withdrawals. Villages and farmers have de facto rights to water as well, but these are very limited. In a recent survey of 130 farm households in China's Ningxia province, only 2% responded that they had the right to decide when to take (surface) water deliveries.¹¹ Thus, for some important rights such as the right to determine when to apply water to irrigation crops, someone (either the canal manager or, more likely, an entity above the canal manager that the households are unaware of) has the right to make that decision regardless of whether they have formal ownership rights to the water. Such a situation has implications for farmers' capacity to adjust to higher-priced or more restricted water deliveries. If farmers are limited in their ability to choose irrigation timing in order to increase the marginal return of more limited deliveries, or to apply it to different crops than the canal manager is taking into consideration, then farm households will bear a

¹¹Unpublished survey results from a survey carried out by the Center for Chinese Agricultural Policy, Chinese Academy of Sciences.

greater burden from higher water prices than they would if they had more control over irrigation deliveries. Giving farmers more control over deliveries, however, can be done without granting them formal ownership rights to water.

Given the high transaction costs to measuring and monitoring water use at the farm level, and the desire for water management agencies to maintain control of such a valuable resource, local-level rights to water in surface water systems are few. In general, households only have the right to allocate water to their fields at times determined by others, and for which they pay a fixed fee. This arrangement limits their capacity to adapt by switching to crops that may use water more effectively but that require more timely and secure supply.

Real water savings

The changes in water management and pricing policies outlined in this chapter may reduce irrigation water applications but that does not mean they induce 'real' water savings. 'Real water savings' have different definitions but, in general, it refers to reducing non-recoverable water losses that result from excessive, non-essential evapotranspiration or water flows into the ocean or non-recoverable seepage. The Hai river basin in northern China, where water scarcity is most acute, is already a largely closed river basin in that very little water flows into the ocean; the Yellow river basin is effectively closed in that the flows in recent years have been due to policy decisions to maintain minimal flow through the estuary; and nearly all water beyond the minimum flow water is diverted to other uses. Thus, real water savings in these areas come primarily from reducing non-essential evapotranspiration, or ET. However, reducing ET is far more difficult, and in general, costly, than simply reducing withdrawals and field-level water deliveries (Kendy *et al.*, 2003).

Irrigation management reform efforts, investments into water-saving technologies and price-induced reductions in irrigation

withdrawals all primarily serve to reduce water application rather than promote real water savings. Still, there are likely some real water savings that do come out of these policies by reducing evaporation of water from excessively irrigated fields and the adoption of some irrigation practices that reduce non-essential evapotranspiration in the process of delivering water to fields more effectively. This is an area that beckons more careful research and will play an important role in determining how effective policy measures are actually reducing water losses rather than reducing 'losses' that would otherwise be recovered and used elsewhere in the system.

Conclusion

Water pricing can be one of the most important policy tools for managing the demand for water (Dinar, 2000; Tsur *et al.*, 2004). The objective of water pricing is to signal to users the relative scarcity of water so as to provide them with incentives to save water. In addition, water prices serve to fund the diversion, storage and delivery systems that allow the water to be brought to the fields for irrigation uses. However, in China as in almost all other countries, water prices are set at such low levels that they do not reflect relative scarcity and are well below the value of water to agricultural users, making water pricing policy much less effective and inducing conservation. In China, it is only when groundwater is very deep that one observes high enough costs, coupled with volumetric pricing, and farmers respond to these costs by adopting conservation practices or switching to production of other crops. Water pricing policies may also have a significant effect on agricultural production and rural welfare, which are also important policy objectives in China. Therefore, understanding how farmers respond to changes in water prices and how these changes affect their livelihoods will help policy makers understand the impact that price reforms will have on rural incomes and agricultural production.

China is also burdened because irrigation water has been heavily subsidized in the past, and thus charging prices that reflect relative scarcity will come as a shock to farmers and will be difficult to promulgate. Water deliveries to agriculture (and other sectors) are often below the cost of deliveries and well below the value of water in agriculture and other sectors. The experiences in other countries reveal that transition from subsidizing irrigation deliveries to pricing water to the level that induces conservation is difficult in itself. This transition is often made more complex by other policy goals, namely to reduce farmers' overall fee payments and other locally assessed fiscal burdens. Moreover, China is undergoing a transition to a more market-oriented economy and rapid industrialization and development. Seeking to establish mechanisms to induce water conservation is, in part, due to these changes; yet it is made more complex by the rapidly chang-

ing environment, and the desire to do so while maintaining agricultural production; and reducing the negative effect such policies have on farm households is even more ambitious.

Given the legacy of inexpensive and available water for irrigation in China, there is substantial capacity to use water more efficiently both in agriculture and in other sectors. While price reforms to date have not established economically efficient prices, the benefits of further price reforms would be enhanced if complemented with policies that give farmers more decision-making power over how the water is used in agriculture. Current pricing projects, although confined to limited remote areas, may reveal mechanisms to advance reform in ways that do not conflict with other policies, including allocating water rights to farmers and allowing them to sell water to downstream users that will pay higher prices.

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