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Understanding the water crisis in northern China

How do farmers and the government respond?

Jinxia Wang, Jikun Huang, Scott Rozelle, Qiuqiong Huang and Lijuan Zhang

Increasing evidence indicates that China is facing serious water shortages, especially in the north of the country. These shortages are a result not only of falling water supplies, but of rising water demand. There is evidence of falling supplies of surface-water resources and the related closure of rivers. Because of climate change and human activity, in the past two decades, run-off in some major river basins in northern China has declined significantly, resulting in the decrease of available surface-water resources. For example, run-off in the Hai River Basin has decreased by 41 per cent (Ministry of Water Resources 2007). Run-off in other river basins has also decreased—from 9–15 per cent in the Liao, Yellow and Huai River Basins. Because of declining surface-water supplies and increasing competition for water among regions, the water in some river basins (such as those of the Yellow and Hai Rivers) in northern China cannot flow to the lower regions (Wang and Huang 2004).

With declining surface-water resources, farmers in northern China have begun to explore ground-water resources and ground water has become the dominant source of water for irrigation in northern China. In the early 1950s, ground-water irrigation was almost non-existent in northern China (Wang et al. 2007a); in the 1970s, it rose to 30 per cent of the total irrigation water. After the economic reforms in the late 1970s, ground-water irrigation continued to expand, reaching 58 per cent in 1995. In 2004, most irrigation in northern China came from ground-water resources, and the share of ground-water irrigated areas increased to nearly 70 per cent.

Unfortunately, the development of the use of ground water has resulted in an overdraft of these resources and many environmental problems. According to a comprehensive survey completed by the Ministry of Water Resources in 1996, the overdraft of ground water was one of China's most serious resource problems (Ministry of Water Resources and Nanjing Water Institute 2004). In the late 1990s, the annual rate of overdraft exceeded 9 billion cubic metres. More than one-third of the volume of overdraft is from deep wells, many of which might not be renewable. Ground-water overdraft also causes many environmental problems. The most obvious effect of ground-water overdraft is the falling water table. For example, based on our research in Hebei Province, the shallow water table has dropped about 1 metre per annum (Wang and Huang 2004); the deep water table has also dropped quickly as a result. The drop rate of the deep water table was more than 2 metres per annum. Overdraft of ground-water resources can also cause other environmental problems, such as land subsidence, the intrusion of seawater into freshwater aquifers, desertification and the depletion of stream flows previously supplied by natural ground-water discharge (Wang et al. 2007a).

The rapidly growing industrial sector, an expanding farming sector and an increasingly wealthy urban population also compete for China's limited water resources. Between 1949 and 2004, total water use in China increased by 430 per cent, which was similar to the global average increase of 400 per cent, but greater than the average for developing countries (Wang et al. 2005a). Rising industrial and urban growth rates have caused China's water allocations to be directed increasingly to non-agricultural uses. From 1949 to 2004, the share of water use for irrigation declined from 97 per cent to 65 per cent of total water use (Ministry of Water Resources 2004). At the same time, the share of industrial water use increased from 2 to 22 per cent; the share of domestic water use increased from 1 to 13 per cent.

Faced with the decline of water availability and increased water demand, many people think China has a water crisis—at least, this is the perception of some scholars and policymakers within and outside China. For example, even back in 1999, Chinese Prime Minister Wen Jiabao warned of the dire water situation in China and of looming water shortages (McAlister 2005). Senior officials from the Ministry of Water Resources pointed out that China was fighting for every drop of water, and the water crisis was threatening national grain production. Brown (2000) predicted that falling water tables in China might soon raise food prices everywhere. Nankivell (2004) demonstrated that China was now at a point where critical decisions must be made to resolve water issues. Although some other observers have made more moderate predictions, they also suggest that many agricultural producers will have to forgo irrigation (Crook and Diao 2000).

Despite many existing discussions and dire predictions, some researchers (including ourselves) are not sure whether China is facing a water crisis. The major problem is that most discussions about water are based on observations of producers or users in a single location, not on large-scale field-level data. It is difficult to judge, based only on these observations, the seriousness of water shortages and it is also difficult to conclude whether China is facing a water crisis. In addition, relying only on some observations does not allow us an overall picture of water-shortage issues, especially regional differences.

The overall goal of our research is to establish the facts about whether there is a water crisis in China, especially in the north of the country. In order to realise our overall goal, we will pursue the following objectives. First, we will identify the status and trend of water shortages. Second, we want to understand the response of government and its effectiveness in addressing the water crisis. Third, we want to understand the responses of farmers and whether their role is helping or hurting.

This chapter is organised as follows. In the next section, based on our large field survey in northern China, we provide some facts about the water crisis by measuring several indicators relevant to water shortages. In the following section, we discuss the response of government to the water crisis, including ground-water policy and irrigation management reform of surface-water resources. In section four, we will further discuss farmers' responses to increasing water scarcity, focusing on the following issues: the digging and privatisation of tube-wells, developing ground-water markets, behavioural change to increasing water charges and the adoption of water-saving technologies.

Data

Our analysis is based on the data we collected as part of two recent surveys designed specifically to address irrigation practices and agricultural water management. The first, the China Water Institutions and Management (CWIM) survey, was conducted in September 2004. Enumerators conducted surveys of community leaders, ground-water managers, surface-water irrigation managers and households in 80 villages in Hebei, Henan and Ningxia Provinces. The villages were chosen according to geographic location (which, in the Hai River Basin, often correlated with water-scarcity levels). In Hebei, villages were chosen from counties near the coast, near the mountains and in the central region between the mountains and the coast. In Henan and Ningxia Provinces, villages were chosen from counties bordering the Yellow River and from counties in irrigation districts varying distances from the Yellow River. The 2004 CWIM survey was the second round of a panel survey, the first phase of which was conducted in 2001.

We conducted a second survey, the North China Water Resource (NCWR) survey, in December 2004 and January 2005. This survey of village leaders from 400 villages in Inner Mongolia, Hebei, Henan, Liaoning, Shaanxi and Shanxi Provinces used an extended version of the community-level village instruments of the CWIM survey. Using a stratified random sampling strategy for the purpose of generating a sample representative of northern China, we first sorted counties in each of our regionally representative sample provinces into one of four water-scarcity categories: very scarce, somewhat scarce, normal and mountain/desert. We randomly selected two townships within each county and four villages within each township. Combining the CWIM and NCWR surveys, we visited a total of six provinces, 60 counties, 126 townships and 448 villages.

The scope of the surveys was quite broad. Each of the survey questionnaires included more than 10 sections. Among the sections, there were those that focused on the nature of rural China's water resources, the common types of wells and pumping technology. There were several sections that examined the most important water problems, government water policies and regulations and a number of institutional responses (for example, tube-well privatisation). Although sections of the survey asked about surface and ground-water resources, we will focus mostly on those villages that have ground-water resources (in some cases, whether they are using them or not). The survey collected data on many variables for two years: 2004 and 1995. By weighting our descriptive and multivariate analysis with a set of population weights, we are able to generate point estimates for all of northern China.

Facts about water shortages

The water-shortage situation can be gauged by examining some relevant indicators, in addition to the assessment of farmers, who are directly influenced by water. In this section, we will examine the water situation in northern China from the following three aspects. First, we will examine the overall situation of water shortages through farmers' judgements based on their intuition. Second, we will examine this issue by checking the status and changes of the supply reliability of surface and ground-water resources. Finally, we will analyse changes in the water table over time.

Farmers' judgements of water shortages

During our field survey, enumerators asked village leaders to characterise the nature of water resources in their village in 1995 and 2004. The leaders chose one of three answers: water is not short (at least currently); water is short but the shortage is not severe; and water is short and frequently constrains agricultural production (or water scarcity is very severe). Based on the responses of village leaders, we can make a preliminary judgement of the situation and trend of water shortages in northern China.

Based on farmers' judgements, most villages in northern China are facing water shortages, and the outlook is not positive. Survey results show that in 2005, 70 per cent of villages in our samples reported that they were facing water shortages—at least, farmers in these villages felt there were problems with water availability (Table 13.1). Only 30 per cent of villages did not have water-supply problems. In addition, among those villages where farmers reported water shortages, 16 per cent of villages were facing severe water shortages.

More importantly, water shortages have become more serious in the past decade. Survey results show that from 1995 to 2004, the degree of water shortage continued to increase, and the share of villages short of water increased by 5 per cent. The share of villages with severe water shortages also increased, by 2 per cent. Therefore, based on the farmers' judgements, water shortages were very serious. Though not all villages are facing such problems, most are. In some villages, the water shortage is so serious it has become one of the important constraining factors on agricultural production.

Changes in surface and ground-water supply reliability

The reliability of the water supply is another indicator that can measure the degree of water shortages in rural areas. If the surface-water supply is reliable, water will not be a constraining factor on agricultural production in the short term.

Survey results show that surface-water reliability is very low in northern China. Presently, most villages in northern China do not have a reliable surface-water supply (Table 13.2). During the period 2001–04, 61 per cent of villages did not have reliable surface-water resources.

In the past 10 years, water reliability has declined remarkably. From 1991 to 1995, surface-water supplies in most villages were very reliable; 64 per cent of villages reported that they could access a reliable water supply at that time (Table 13.2). From 2001 to 2004, however, the share of villages with a reliable supply of surface water declined to 39 per cent—a decrease of 25 per cent.

At the same time, the share of villages without a reliable supply of water also increased significantly—from 36 to 61 per cent. The decline of surface-water reliability represents an increase in the degree of water shortage.

The reliability of ground-water supplies has also declined (Table 13.2). Unlike surface-water resources, ground water has always been considered a reliable water resource. Ground water has, however, become a less reliable resource for farmers. For example, from 1991 to 1995, 91 per cent of villages reported that their ground-water supplies were very reliable, and only 9 per cent indicated that there were problems with the reliability of their ground-water supply. From 2001 to 2004, however, villages with a reliable ground-water supply declined by 5 per cent. The villages without a reliable ground-water supply increased—from 9 to 15 per cent. The reliability of supply has therefore worsened—for surface and ground-water resources—which indicates that there is an increasing shortage of water in northern China.

Table 13.1 **Farmers' judgements of water shortages in villages in northern China**

Water-shortage situation	Share of sample villages (%)	
	1995	2004
No shortage	35	30
Shortage	65	70
When short, severly short	14	16

Source: Authors' survey in 2004 (NCWR survey data set).

Table 13.2 **Water-supply reliability in villages in northern China**

Water-supply reliability	Share of sample villages (%)			
	Surface-water reliability		Ground-water reliability	
	1991–95	2001–04	1991–95	2001–04
Reliable	64	39	91	85
Not reliable	36	61	9	15
Total	100	100	100	100

Source: Authors' survey in 2004 (NCWR survey data set).

Decline of the water table

Field surveys reveal that not all regions in northern China are experiencing falling water tables (Wang et al. 2007a). According to our data, there was no fall in the water table in 25–33 per cent of the villages in northern China using ground water in 1995 and 2004.[1] In 8.5–16 per cent of villages (one-third to one-half of villages reporting no fall in the water table), respondents told the enumerators that the water table was higher in 2004 than in 1995. In another 10–17 per cent of villages, the average annual fall in the water table was less than 0.25 metres. In other words, in more than one-third to one-half of northern China's villages using ground water in the past decade, ground-water resources have shown little or no decline since the mid 1990s.

Although, based on our data, most villages are in, or are nearly in, balance, we are not arguing that ground-water problems do not exist. In fact, there are still a large number of villages in which the water table is falling. Before classifying these villages as inappropriate ground-water resource exploiters (although some of them might be), it is important to remember that a village's water resources might not be overexploited, even if the water table is falling. Even under the most rationally planned ground-water utilisation strategy, therefore, there will be a share of villages in China in which we can expect the water table to be falling. In addition, if we follow the Ministry of Water Resources' definition of serious overdraft, only 10 per cent of villages using ground water in the past decade had water tables falling at a rate greater than 1.5 metres per annum. Of course, such a rate of decline is not just serious; it is a crisis.

In summary, then, the point we want to make is that in many places—indeed, in most places in northern China—it is possible that water resources are not being misused. We do not, however, want to minimise the problems that are occurring in some places. There are a large number of rural areas in which the water table appears to be falling at a dangerously fast pace. Where the resource is being misused, steps will eventually be required to protect the long-term value and use of the resource. It is, however, important to realise that many of the required measures (discussed in the next section) will have a number of associated costs in their adoption, affecting productivity and perhaps reducing incomes. Because measures to counter overdraft are not needed in all villages, leaders should not take a 'one-size-fits-all' approach; doing so could inflict unnecessary costs on producers in communities where overdraft conditions do not exist.

Government responses

Faced with increasing water shortages, the Chinese government has taken many steps to improve the management of surface and ground-water resources. It has responded not only by issuing many laws, regulations and policies, it has tried to encourage local regions to reform their water management. In this section, we will focus on two major responses that the government has made: its ground-water policies, and reform of the management of surface-water resources for irrigation. We will also try to examine the effectiveness of the implementation of these responses in resolving water-shortage problems in northern China.

Issuing ground-water policies

Government officials in China have put some effort into issuing laws, regulations and policies to manage ground-water resources, although they have been limited (Wang et al. 2007b). For example, according to China's National Water Law, which was revised in 2002, all property rights to ground-water resources belong to the State. This means that the right to use, sell and/or charge for water rests ultimately with the government. The law does not allow ground-water extraction if pumping is going to be harmful to the long-term sustainability of ground-water use. Beyond the formal laws, a number of policy measures (such as regulations controlling the right to drill tube-wells, the spacing of tube-wells and the collection of water-resource fees) have been set up, in part to rationally manage use of the nation's ground-water resources. Compared with regulations concerning other issues, however, such as flood control, the construction of water-related infrastructure projects and surface-water management initiatives, the number of regulations relevant to ground-water management is very small. More importantly, at the national level, there is not one water regulation that is focused specifically on ground-water management issues.

Even more important than the lack of official laws and policy measures for ground-water management has been the insufficient effort put into implementing existing laws (Wang et al. 2007a). Certainly, part of the problem is a history of neglect. In fact, at the ministerial level, the division of ground-water management is still relatively small. There are far fewer officials working in this division than in other divisions, such as flood control, surface-water system management and water transfer. Moreover, unlike the case of surface-water management (Lohmar et al. 2003), there has been no effort to bring management of aquifers that span jurisdictional boundaries under the ultimate control of an authority covering government and private entities that use water extracted from different parts of the aquifer. According to Negri (1989), without a single body controlling the entire resource, it becomes difficult to implement policies that attempt to manage the resource in a manner that is sustainable, or optimal, in the long term.

Whether due to lack of personnel or other implementation-related difficulties, few regulations have had any affect within China's villages (Wang et al. 2007b). For example, according to our survey data, less than 10 per cent of well owners obtained a permit before drilling, despite the nearly universal regulation requiring a permit. Only 5 per cent of village respondents believed that well-drilling decisions required consideration of the spacing between wells. Even more tellingly, water-extraction charges were not charged in any village, and there were no quantity limits put on well owners. In fact, in most villages in China, ground-water resources are all but completely unregulated. This does not mean, however, that policy and governance do not have an impact, at least indirectly, on agricultural ground-water use.

Reforming management of surface-water resources for irrigation

Since the early 1990s, faced with increasing water shortages, Chinese leaders have begun to consider community-level irrigation management reform as a key part of their strategy to combat China's water problems. According to our survey in Ningxia Province, since the early 1990s and especially after 1995, reform has successively established Water User Associations (WUAs) and contracting systems in place of collective management (Figure 13.1) (Wang et al. 2007c).[2] The share of communities that manage water by collective. declined from 91 per cent in 1990 to 23 per cent in 2004. Contracting has developed more rapidly than WUAs. By 2004, 57 per cent of villages managed their water under contract and 19 per cent managed theirs through WUAs. Our survey in six provinces also found a similar reform trend for irrigation management (Figure 13.2) (Huang et al. 2007). From 1995 to 2004, collective management declined from 90 to 73 per cent, while at the same time, WUAs increased from 3 to 10 per cent and contracting management increased from 5 to 13 per cent.

Although reforming the institution in name might be important, the nature of incentives within the institution might be more important (Wang et al. 2005c).[3] According to our data, not all reformed management institutions (WUAs or contracting management) can establish incentive mechanisms. For example, in 2001, on average, leaders in only 41 per cent of villages offered WUA and contracting (or non-collective) managers with incentives that could be expected to induce them to save water in order to earn excess profit. In the remaining villages, although there was a nominal shift in the institution type (that is, leaders claimed that they were implementing WUAs or contracting), in fact, from an incentive point of view, the WUA and contracting managers were operating without imposed incentives. In these villages, managers are similar to leaders in a collectively managed village in that they do not have a financial incentive to save water.

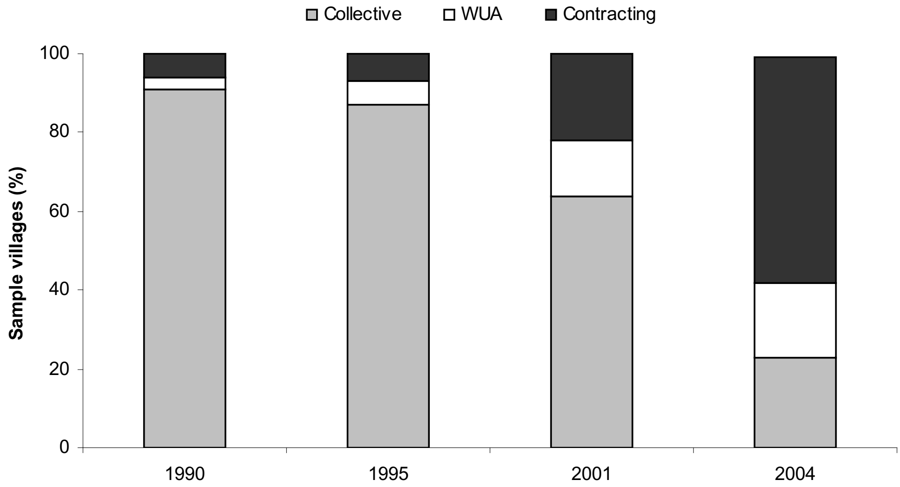
Research results show that nominally reforming irrigation management has no significant impact on water use; however, when irrigation managers face effective incentives, they are able to reduce water use (Wang et al. 2005c). Our results, based either on descriptive statistics or econometric analysis, show that there is no significant relationship between water use and nominal irrigation management reform. We found, however, that in villages that provided water managers with strong incentives, water use fell sharply. The incentives must also have improved the efficiency of the irrigation systems since the output of major crops, such as rice and maize, did not fall, and rural incomes and poverty remained unchanged statistically. Although our study needs to be undertaken in other areas before the results can be generalised to the rest of China, at least in the sample sites that provided their managers with incentives, water management reform has been a win-win policy in resolving water shortage problems.

Farmers' responses

Although the government response has not been very effective in resolving water shortages, this does not mean that farmers will not respond on their own. In fact, farmers have already begun to act. In this subsection, we will examine farmers' responses to increasing water shortages. These include digging tube-wells, privatisation of tube-wells, the emergence of ground-water markets, behavioural changes to increasing water prices and the adoption of water-saving technologies.

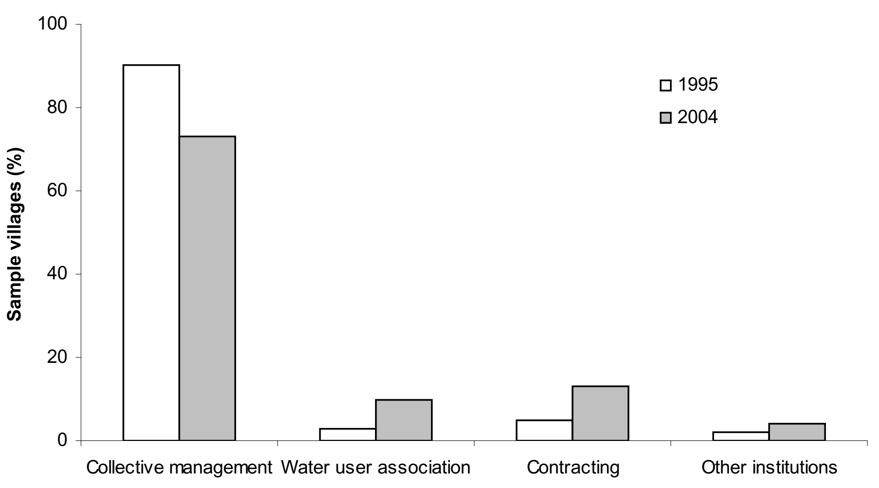
Digging tube-wells. The most obvious response by farmers to increasing water shortages is to dig tube-wells. According to national statistics, the installation of tube-wells began in the late 1950s (Wang et al. 2007a). Since the mid 1960s, the installation and expansion of tube-wells across China has been nothing less than phenomenal. In 1965, there were only 150,000 tube-wells in all of China (Shi 2000). Since then, the number has grown steadily. By the late 1970s, there were more than 2.3 million tube-wells. After stagnating during the early 1980s, a period when the area of land under irrigation—especially that serviced by surface water—fell, the number of tube-wells continued to rise. By 1997, there were more than 3.5 million tube-wells; by 2003, the number rose to 4.7 million.

Figure 13.1 **Evolution of irrigation management in Ningxia Province, 1990–2004**



Source: Authors' survey in 2001 and 2004 (CWIM survey data set).

Figure 13.2 **Changes in water management institutions, 1995–2004**



Note: 'Other institutions' includes the four types of mixed institutions: 1) Water User Association combined with collective management; 2) Water User Association combined with contracting; 3) contracting combined with collective management; 4) Water User Association, contracting and collective management.
Source: Authors' surveys in 2001 and 2004 (CWIM and NCWR surveys data sets).

While the growth of the use of tube-wells reported by the official statistical system is impressive, we have reason to believe that the numbers are significantly understated (Wang et al. 2007a). According to the NCWR survey, on average, each village in northern China had 35 wells in 1995. When extrapolated regionally, this means that there were more than 3.5 million tube-wells in the 14 provinces in northern China by 1995. According to our data, the rate of increase in the number of wells has also grown rapidly. By 2004, the average village in northern China had 70 wells, suggesting that the rise in tube-well construction since the mid 1990s has risen even faster than indicated in the official statistics. We estimate that, by 2004, there were more than 7.6 million tube-wells in northern China. At least in our sample villages, the number of tube-wells grew by more than 12 per cent annually between 1995 and 2004. According to our data, a significant share of the new wells are located in areas that are making allowances for the expansion of cropping area, increased intensity of cropping and rising yields. While the rise in tube-wells will not necessarily result in increased consumption of water in all areas, in some cases it will. The digging of new tube-wells is therefore one reason for increasing water shortages.

Privatisation of tube-wells. Faced with increasing water shortages, farmers respond not only by digging new tube-wells that can sustain their production, they demand changes to institutions that can improve their water management. Among all the institutional responses, the privatisation of tube-wells is perhaps the most prominent response by farmers in more than two decades. According to our survey, since the early 1980s, the ownership of tube-wells in northern China began to shift sharply. For example, in Hebei Province, collective ownership of tube-wells diminished from 93 per cent in the early 1980s to 56 per cent in the late 1990s (Wang et al. 2006). At the same time, the share of private tube-wells in the total increased from 7 to 64 per cent. Data from the NCWR survey largely support these findings (Wang et al. 2006). In 1995, collective ownership accounted for 58 per cent of tube-wells in the average ground-water-using village. From 1995 to 2004, however, collective ownership of tube-wells diminished and accounted for only 30 per cent of wells in 2004. In contrast, during the same period, the share of private tube-wells in the total increased from 42 to 70 per cent.

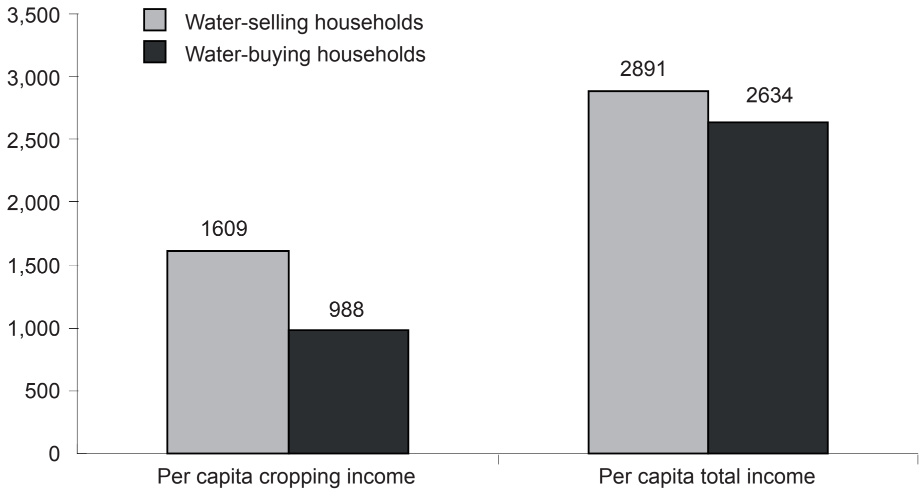
Our findings also demonstrate that the privatisation of tube-wells has promoted the adjustment of cropping patterns while having no adverse impacts on crop yields; more importantly, privatisation has not accelerated the drop of water tables. Econometric results show that, after privatisation, farmers expanded the area of land sown with water-sensitive and high-value crops, such as wheat and non-cotton cash crops (which are mainly horticultural crops)

(Wang et al. 2006). It is perhaps because of the rising demand for horticultural crops that some individuals have become interested in investing in tube-wells. Such results are consistent with the hypothesis that when tube-well ownership shifts from collective to private and water is managed more efficiently (as shown in Wang and Huang 2002), producers are able to cultivate relatively high-value crops, which in some cases demands greater attention from tube-well owners. In addition, our research indicates that the shift from collective to private tube-well management does not accelerate the drop in water tables. With the expansion of private ownership of tube-wells, however, and ground-water markets, water table levels will continue to decline. How farmers choose to respond can, therefore, contribute to the water crisis. Effective management of ground-water resources is needed urgently.

The growing importance of ground-water markets. In response to demand for water in an environment increasingly dominated by private and privatised wells, ground-water markets have begun to emerge in recent years as a way for many producers in rural China to access water (Zhang et al. 2008a). While this is new in China, it appears to be following a pattern similar to that observed in parts of South Asia (Shah 1993). In the 1980s, ground-water markets were all but non-existent in China and, even by the mid 1990s, according to the NCWR survey data, only a small share of villages (21 per cent) had ground-water markets. By 2004, however, tube-well operators in 44 per cent of villages were selling water. Across all villages, about 15 per cent of private tube-well owners sold water. Although ground-water markets exist in less than half of northern China's villages, the numbers are still significant: we estimate that farmers in more than 100,000 villages are accessing water through ground-water markets. Moreover, in villages that have them, these markets play an important role in transferring large volumes of water to a large share of households.

Our research further indicates that ground-water markets have not only improved the equity of water use, they have improved the efficiency of water use in northern China. According to the survey data, ground-water markets have provided poorer farmers with opportunities to access water and have therefore reduced potential income gaps (Zhang et al. 2008b). Specifically, households in the sample that buy water from ground-water markets are poorer than water-selling households (Figure 13.3). In addition, when farmers buy water from ground-water markets, they use less water than those who have their own tube-wells or those who use collective wells (Zhang et al. 2008b). Crop yields, however, do not fall because of this. In addition, our results show that ground-water markets in the North China Plain do not have a negative effect on incomes.

Figure 13.3 **Differences of per capita cropping income and total income between water-selling households and water-buying households, 2004** (yuan)



Source: Authors' surveys in 2001 and 2004 (CWIM survey data set).

In summary, ground-water markets help farmers access water (that is, they do not need to invest in their own well) and, when they do so, their water use is reduced, but crop yields and income are not negatively influenced. With increasing water scarcity, increasing water-use efficiency is a very important issue and has been addressed by policymakers. The emergence of water markets is therefore an effective way to provide irrigation services.

Farmers' responses to increasing water prices. As the water table falls, prices in the ground-water market increase. For instance, according to the CWIM survey data, when the level of the water table in our Hebei villages declined from 4.4 metres below the surface to 77.5 metres, the price of ground water for wheat-producing households increased from 0.08 to 0.56 yuan per cubic metre (Wang et al. 2007b). Since pumping costs rise as the water table falls, this indicates that, to some extent, ground-water prices reflect the scarcity value of water resources. Across our CWIM survey sample of Hebei wheat producers, we estimated that pumping costs rose by 0.005 yuan per cubic metre of ground water extracted for each additional metre of pumping depth.

More importantly, as ground-water prices rise and water becomes scarce, farmers respond by reducing their water use and changing their cropping patterns. Analysis of the behaviour of Hebei wheat farmers in the CWIM survey data set indicates that, when ground-water prices increased from 0.08 to 0.56 yuan/cubic metre, water use per hectare decreased from 6,433 cubic metres to 2,154 cubic metres (Wang et al. 2007b). In addition, we found that, as water tables fell, there was an increase in the share of cash crops (such as horticultural crops, cotton and peanuts). That is, when the depth of the water table increases from 4.7 to 79 metres below the surface, the area's share of cash crops increases from 13 to 41 per cent. Our results therefore imply that as the water table falls, water becomes increasingly scarce and the costs of acquisition rise, farmers consider not only how much water to use, but how much value can be produced by that water use.

Despite potential resource conservation benefits, the rise of water prices (or costs to farmers for acquisition of self-pumped water) will have an inevitable negative impact on farmers (Wang et al. 2007b). In other work that we have undertaken using the same data set, we estimate that doubling the price of ground water in Hebei Province causes 75 per cent of wheat-producing farmers to lose money on cropping activities and has a negative effect on agricultural output (Huang et al. 2006). Given the government's interest in maintaining rural incomes, any use of a pricing policy must be accompanied by complementary policies that can offset the negative effect of price increases.

Adopting water-saving technologies. Another possible response to water shortages is the adoption of water-saving technologies (Blanke et al. 2007). The NCWRS survey covered three sets of water-saving technologies: traditional, household based and community based. Traditional technologies—such as border, furrow and levelling technologies—are agronomy based, highly divisible and have generally been used by farmers in China even before the establishment of the communist State. Household-based technologies—such as surface piping, plastic film, conservation tillage and drought-resistant plant varieties—are highly divisible, require low fixed costs and little collective action. Community-based technologies—such as ground pipes and lined canals—require not only collective action for adoption and maintenance, they require high fixed costs.

Results show that although water-saving technologies for agriculture have been emphasised by many policymakers and researchers, the adoption rate is still very low. Despite a relatively high initial level of adoption (35 per cent in the 1950s), in 2004, only 52 per cent of villages adopted traditional water-saving technologies (Table 13.3). Household-based and community-based water-saving technologies have been adopted mainly since the 1980s. In 2004, half of all villages adopted household-based water-saving technologies and only 24 per cent of villages adopted community-based water-saving technologies. Comparing the adoption rate with the share of sown areas, the adoption rate of these three kinds of water-saving technologies is even lower. For example, the share of sown areas adopting community-based water-saving technologies was only 7 per cent; even traditional water-saving technologies reached only 25 per cent. The low adoption rate of water-saving technologies also indicates that in China, there is still much policy space in which to promote such technology uptake. How to effectively promote the adoption of water-saving technologies is one of the important challenges for policymakers.

The increase in the rate of adoption of household-based water-saving technologies is much higher than for the other two types of technologies. Since the 1980s, the share of villages adopting household-based water-saving technologies increased 669 per cent (Table 13.3). Although not very low, the increase in the rate of adoption of community-based water-saving technologies was only 64 per cent of household-based water-saving technologies. During the reform period, the adoption of traditional technologies grew slowly compared with the other two technologies—only 16 per cent. The low increase in the rate of adoption of traditional water-saving technologies was possibly due to their already high adoption rate in the pre-reform and early reform eras. The high increase in the rate of adoption of household-based water-saving technologies implies that, faced with increasing water scarcity, farmers are more responsive than communities in general and government in China.

Based on these descriptive contours, it is unclear what is driving the path of adoption of community-based technologies; however, work by Blanke et al. (2006) suggests that it is likely that there are two sets of forces that are both encouraging and holding back adoption (Wang et al. 2007b). On the one hand, the increased scarcity of water resources is almost certainly pushing up demand for community-based technologies. On the other hand, the predominance of household farming in China (Rozelle and Swinnen 2004) and the weakening of the collective's financial resources and management authority (Lin 1991) has made it more difficult to gather the resources and coordinate the effort needed to adopt technologies that have high fixed costs and that involve many households in the community. In contrast, household-based technologies might be adopted more widely because of their relatively low fixed costs, divisibility and minimal coordination requirements.

Table 13.3 **Adoption rate of water-saving technologies over time in northern China's villages**

	Traditional water-saving technologies	Community-based water-saving technologies	Household-based water-saving technologies
Adoption rate (%)			
Share of villages			
1950	35	0	4
1980	45	5	7
1995	49	15	27
2004	52	24	50
Share of sown areas			
1995	20	3	8
2004	25	7	21
Increase in rate of adoption (%)			
Share of villages			
(2004/1980)	16	433	669
Share of sown areas			
(2004/1995)	25	133	163

Source: Authors' survey in 2004 (NCWR survey data set).

Conclusion

The primary goal of this chapter was to sketch a general picture of China's water-shortage situation, and to establish the facts, especially for northern China. Our findings show that, based on farmers' judgements, 70 per cent of villages are facing increasing water shortages. Among the villages short of water, 16 per cent find their agricultural production severely constrained by the shortage. Supplies of surface and ground water have become less reliable than before. In more than one-third to one-half of China's villages using ground water in the past decade, ground-water resources have shown little or no decline since the mid 1990s. Though most villages are in, or are nearly in, balance, there is still a large number of villages in which the water table is falling. If we follow the Ministry of Water Resources' definition of serious water overdraft, 10 per cent of villages using ground water in the past decade have water tables that are falling at a rate greater than 1.5 metres per annum.

There is, therefore, a water crisis in northern China; however, the crisis does not affect all areas. There are many parts of China in which water resources have not deteriorated, but half of northern China is suffering from rapidly falling water tables. Policies to address water-shortage problems should therefore be targeted carefully.

Faced with a water crisis, the Chinese government has begun to make a number of policy responses, but implementation has not been very effective. It has responded to the issue with many laws, regulations and policies, and has also tried to encourage local regions to reform water management. Whether due to a lack of personnel or other implementation-related difficulties, few regulations have had any effect within China's villages. Although there has been some progress in the reform of surface-water irrigation management in northern China, much of this has been nominal. Nominal reform cannot realise the policy goal of increasing water-use efficiency. Only those reforms that provide managers with incentives can reduce crop water use. Unfortunately, only a small percentage of reform can establish effective incentive mechanisms. In the future, the water crisis will continue to grow, especially as competition among water users increases, and if there is no effective implementation of water policies and management reform.

Where water is becoming scarce, farmers and community leaders have been responding. The most obvious response from farmers is the digging of new tube-wells. In addition, farmers have taken control of most of the well and pump assets; and farmers are increasingly taking on responsibility for transferring water from those who have wells to those who demand water. Farmers also are increasingly figuring out ways to conserve this scarce resource. Farmers do not, however, always respond in a manner that conserves water. Why? The major reason is that farmers do not always face good incentives. Our research shows that when they are given good incentives, they do save water. The government therefore cannot ignore the response of farmers; in fact, it needs to use this responsiveness to reduce the adverse effects of the water crisis and encourage conservation.

Finally, we think most of the blame for the water crisis should be put on the government, because its response has been largely ineffective. It has not created the institutions and infrastructure that will provide the incentives to make farmers save water. We believe a sustainable environment needs to be built on effective water pricing and water rights policies; to make these work, a huge commitment is needed to set up the institutions and infrastructure to implement them. Although this is a huge job, we believe it will be more effective and much cheaper than the South to North Water Transfer Project.

Notes

1 In our survey, we asked village leaders about the average ground-water depth during the year and the 'static' ground-water level. We told village leaders that the static level of the water table was the level that existed at a time immediately before the irrigation season (for example, in the North China Plain this would be about March). According to our respondents, there were differences in the statistics for the changes in the water table when using average or static ground-water levels. According to our data, the static level produced numbers that suggested there were fewer villages in which the water table was falling.

2 'Collective management' implies that the village leadership takes responsibility directly through the village committee for water allocation, canal operation and maintenance and fee collection; WUAs are theoretically a farmer-based, participatory organisational system that is set up to manage the village's irrigation water; 'contracting' is a system in which the village leadership establishes a contract with an individual to manage the village's water.

3 When managers have partial or full claim on the earnings of the water management activities (for example, on the value of the water saved by water management reform), we say that they face strong incentives (or that the manager is managing 'with incentives'). If the income from their water management duties is not linked to water savings, they are said to manage 'without incentives'.

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