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A Study of the Irregation Water Pricing System in China

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Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements for the Degree of Master of Environmental Studies 2010.

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Abstract
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China is currently using a mix of volumetric-based, area-based and quota allotment water pricing systems. For irrigation use, water pricing varies in different provinces and the pattern turns out to be somewhat random. This capstone is based on existing information of the eight Yellow River Basin provinces. It studies current water price systems and irrigation situation in the provinces and independently provides thoughts and recommendations on a proper irrigation water pricing system that fits China.

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Spring 2010

Primary Reader: Stanley L. Laskowski
Secondary Reader: Michael Kulik

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Xizi Wang

ABSTRACT

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Stanley L. Laskowski

Feeding 22% of the world's population with 6% of the renewable water resource, China is undoubtedly facing severe water scarcity. Since agriculture uses most of the water in China, it is important to discuss whether irrigation water is well controlled.

China is currently using a mix of volumetric-based, area-based and quota allotment water pricing systems. For irrigation use, water pricing varies in different provinces and the pattern turns out to be somewhat random. This capstone is based on existing information of the eight Yellow River Basin provinces. It studies current water price systems and irrigation situation in the provinces and independently provides thoughts and recommendations on a proper irrigation water pricing system that fits China.

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INTRODUCTION

Statement of the Problem

Worldwide water scarcity suggests a need for more rational use of irrigation water, which takes a large portion of the total fresh water available. As the most populous country with a large and rapidly growing demand for water and food, China is one of the countries with the most severe water problems. Many studies indicate that lack of water poses an increasing constraint to agricultural production (Brown & Halweil, 1998; Yue & Wang, 2000).

In the late 2009, hearings on increasing the water price have been held in almost all the major cities in China. The action of the government casts some doubts on whether the water price reform is the proper way to stimulate conservation of irrigation water, and what is the reasonable pricing system of irrigation water in the current situation in China.

The initial purpose of this study is to study the current irrigation water pricing system in China, and to find out if there is an irrigation water pricing system that better meets the social, economic, and environmental needs of the country.

Feeding 22% of the world's population with 6% of the renewable water resource, China is undoubtedly facing severe water scarcity. However, it is argued by some researchers and politicians that under-pricing of irrigation water is currently leading to severe abuse of irrigation water. Therefore, there is an increasing need for research that evaluates the current irrigation water pricing system to determine if the water is truly under-priced.

Hypothesis and Research Questions

This research project will test the following two speculative statements: (1) The most efficient irrigation water pricing system for China is Volumetric Pricing. (2) The irrigation water price currently adopted in China is too low to adequately indicate the shadow price or manage the water use.

The research questions being investigated are: (1) What are the social, economical and environmental impacts of the irrigation water pricing system in China? (2) Which pricing method will be better adopted in China: Volumetric Pricing, Non-volumetric Pricing, Quota, or Water Market? (3) What's the adequate irrigation water price in China?

Literature Review

Research has been done on irrigation water pricing systems. Among various policies in dealing with the intensifying water stress, pricing mechanism has been given a high priority (Bjornlund & McKay, 1998; Berbel & Gomez-Limon, 2000; Ahmad, 2000). However, opinions of an optimal water pricing policy differ among economists as well as policymakers (Kim & Schaible, 2000). In the case of China, the water pricing system as well as the elements and methods used to determine the irrigation water price have to be considered carefully.

The current water allocation policy in China is a combination of volumetric pricing, quota and pricing on area. Price varies between regions according to water scarcity (Yang et al, 2002).

Several models are used in estimating the shadow price of irrigation water in China. Although the results are different, some conclusions are shared by researchers (He et al, 2007; Liu et al, 2009; Han & Zhao, 2007): (1) The water scarcity in China will become much more severe in the next several decades, and the shadow price of water resources will also rise accordingly; (2) The current water price, especially the irrigation water price cannot properly reflect the dynamic shadow price; and (3) Water price reform in China should be assisted by other methods, such as the technology investments and stronger irrigation district management.

This capstone is based on the research mentioned above, and independently provides thoughts and recommendations on an irrigation water pricing system that fits China.

Eight Yellow River Basin Provinces

Provinces in the Yellow River Basin are used as an example to look into water pricing issues in China. Since that the Yellow River goes through 8 of the 23 provinces in China, with rich ones, poor ones, wet ones, dry ones, agriculture-dominated ones and industry-dominated ones in them at the same time, it is a good area of China to be a sample. Figure 1 is a map of China, with the Yellow River and the provinces to be studied. These provinces are: Qinghai, Gansu, Ningxia, Shaanxi, Shanxi, Henan, and Shandong.

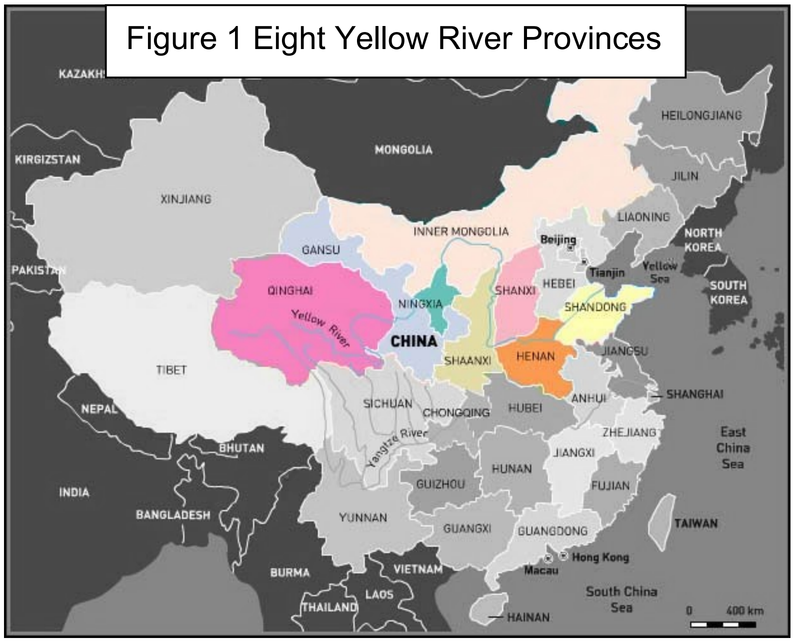


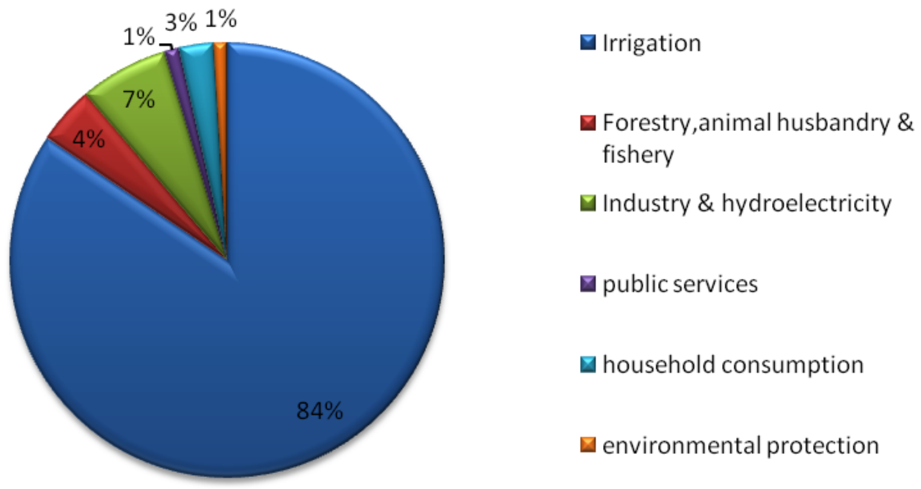
Figure 1 Eight Yellow River Provinces

Table 1 Water Use in the Eight Provinces

Province	Irrigation	Forestry, animal husbandry & fishery	Industry & hydroelectricity	public services	household consumption	environmental protection
Qinghai	20.36	3.24	0.63	/	1.09	/
Gansu	97.25	1.30	12.58	2.42	4.62	1.90
Ningxia	76.03	11.98	2.74	0.21	0.77	2.51
Inner Mongolia	158.84	9.78	5.92	1.00	0.65	0.65
Shaanxi	54.62	4.20	4.54	1.28	3.60	1.23
Shanxi	35.50	1.11	5.60	1.42	1.96	0.15
Henan	145.74	3.03	15.34	1.59	5.00	0.96
Shandong	188.27	4.89	13.36	1.84	6.00	1.53
Total	776.61	39.53	60.70	9.76	23.68	8.93

Water use between agriculture, forestry, animal Forestry, animal husbandry & fishery, industry & hydroelectric, public services, household consumption and environmental protection is shown in table 1. As is shown by Figure 2, as a total of the eight provinces, agriculture takes a large majority of total water consumption (84%). Industry and hydroelectricity take the second largest portion, which is 7%.

Figure 2 Water consumption for different purposes



PRACTICES AND EVALUATION

Practices of Different Pricing Systems

Four different kinds of irrigation water pricing systems are adopted in practices all over the world: volumetric pricing, non-volumetric pricing, quota, and water market.

Volumetric pricing systems charge for irrigation water based on the quantities of water used. This mechanism is widely used all over the world, and pricing is based on the total costs, including the environmental externalities and the future scarcities (Easter & Welsch, 1986). The main concern about this mechanism is that it considers little about the equity problem. For example, if the flows decrease during cropping season, the price of water per unit should rise accordingly. This price inflation and water supply cut-down will largely affect lower-income groups because prices based on costs are often too high for low farm incomes, especially when farm production is limited by water scarcity (Dinar et al., 1997).

In order to avoid the high measurement cost, many countries have adopted non-volumetric pricing systems. In a global survey, Bos and Walters (1990) found that 60% of farmers in the world face per-unit area water charges. The advantage of this method is that it is easy to implement and administer and is best suited to continuous flow irrigation.

Quota allotment, which means a fixed amount is set for water use, is often used for the purpose of mitigating equity issues. Within the fixed amount, water is free of charge for farmers and the costs are paid by governments. Most of the time, they are implemented with a water market or marginal cost pricing. Since low-income groups are more willing to control water use within the quota allotments in order to save money, quota allotments are more beneficial for low-income groups than for high-income ones. By allowing quota allotments to be traded, the government can address equity concerns as well as efficiency concerns (Dinar, Balakrishnan, & Wambia, 1998).

Water markets, which rely on market pressures to determine the price for irrigation water, are also more flexible than centrally-controlled allocation mechanisms. For formal water markets to work, there first need to be well-defined, tradable water rights and the appropriate infrastructure and institutions for distributing water (Marino & Kemper, 1999).

Efficiency and Equity

The widely-accepted goals of governments are efficiency and equity (Sampath, 1992). There are many ways to define efficiency in water allocation. An efficient allocation of water resources is one that maximizes net benefits to society using existing technologies and water supplies (Sampath, 1992). On the other hand, equity of water allocation is concerned with the "fairness" of allocation across economically disparate groups in a society and, since water pricing mechanisms are not very effective in redistributing income (Tsur & Dinar, 1995), it may not be compatible with efficiency objectives (Seagraves & Easter, 1983; Dinar & Subramanian, 1997). However, it may be in a government's national interest to increase water available for certain sectors or regions.

Efficiency in allocating irrigation water is accomplished by adjusting the amount of water provided in order to equate the marginal benefit of a single unit of water to the marginal cost of supplying that unit. This proves to be extremely difficult because of the various distortions in the market data related to irrigation water (Spulber & Sabbaghi, 1998; Easter, Becker, & Tsur, 1997). Therefore, several frameworks are established to evaluate water policies, which can be divided into two kinds, partial equilibrium and general equilibrium (GE) frameworks. Partial equilibrium analyses focus on the irrigation unit (farm, district, sector) assuming the rest of the economy operates in a given way, whereas GE analyses consider other regions or sectors to determine the economy-wide effects of a policy (Easter, 1999). In my research, these frameworks will be used to evaluate the water policies in China.

Concerns

Water is often an open-access good with a finite total amount. According to Game Theory, this kind of resource often has an overuse problem which is referred to as the "tragedy of the commons" (Hardin, 1968). This occurs when users exploit the resource according to their self-interest, without considering the total amount or the interests of other users. Economics always introduces the mechanism of privatization in order to get rid of the tragedy. In this sense, irrigation water pricing is an efficient solution.

Implementing a pricing method requires proper institutions and as such entails costs. Sometimes, the implementation or transaction costs are high enough to render certain policies as impractical and narrow down the list of methods available. Effects of implementation costs on the performance of different pricing methods are significant in the sense that small changes in costs can change the order of optimality of those methods (Tsur & Dinar,1997).

Sometimes farmers have the incentive to underreport their usage of irrigation water if it is priced volumetrically. In many cases, high cost of a meter system is a main reason against the per unit irrigation water pricing due to incomplete information (Bos &

Walters, 1990; Smith & Tsur, 1997). This phenomenon is called a “moral hazard” by economists (Laffont & Tirole, 1993).

When flows are uncertain, such as the seasonal difference, some arrangements are often made to address the situation of water scarcity. Some formal or informal systems have worked well for decades in different countries that are based on the scarcity: the Warabandi System in India (Perry & Narayanamurthy, 1998); the Subaki System in Bali (Sutawan, 1989), and the Entornador System in Cape Verde (Langworthy & Finan, 1996).

Allocation of irrigation water can also be measured by shares rather than volume (Seagraves & Easter, 1983).

WATER PRICING SYSTEM IN CHINA

For Habitants and Industrial Use

The State Council of China passed "Regulations on Management of Water Abstraction Licenses and Water Resources Charges" by 2006. According to the "Regulations", all the organizations and individuals that plan to take water directly from rivers, lakes or underground water resources should apply for Water Abstraction Licenses except for those in the following five categories: (1) Members of agricultural collective economic organizations using water from ponds and reservoirs possessed by the organizations; (2) Sporadically-raised livestock drinking and using tiny amounts of water; (3) Emergency using of water in underground projects to ensure safety of construction; (4) Emergency using of water to eliminate public damage; (5) Emergency using of water to combat a drought or protect environment and ecology.

For industrial use, Water Abstraction Licenses are issued by local governments at a level of county or above. Charge of water is *volume-based*, with the price determined by the water departments of province governments. For different industries, water prices may be different in a province.

For habitants use, supply of tap water is normally managed by state-owned companies. With their Water Abstraction Licenses issued also by local governments, the price they use to charge households is also determined based more on the consideration of feedback from the society than on the concern of costs and benefits. According to the result of a study on the financial statements given by several water supply companies in different provinces, most of them have less revenue from water charge than the cost of supplying tap water. It may be presumed that most of these water supply companies in China are living on the supports of local governments.

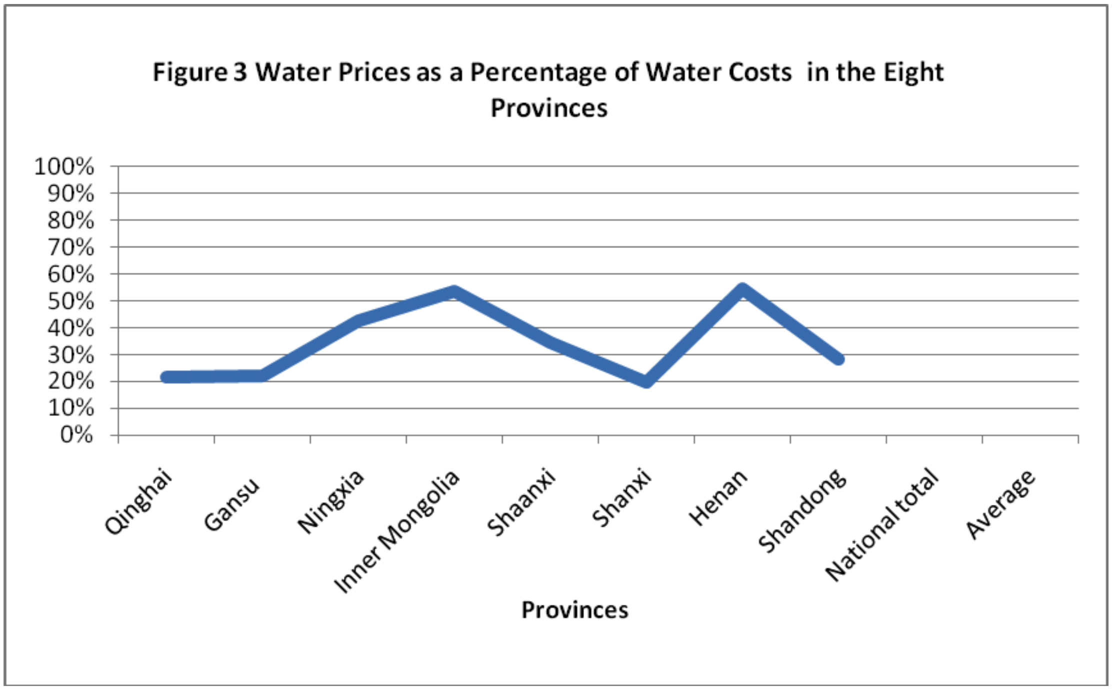
Based on the tap water prices collected by the Chinese Water Information Website[1] from over ten thousand households all over the country, I estimated the water price for habitant use in the selected eight provinces (as listed in Table 2) by calculating the average of the prices given by dwellers in the provinces. On the other hand, a research conducted by Pei (2003) working at the Institute of Water Conservancy and Hydroelectric Power Research of China (IWHR) gives the estimated costs for water treatments and transportation in the eight provinces.

Table 2 Costs and Prices of Habitants Water in Eight Provinces

Province	Water Price (RMB/100m3)	Water Cost (RMB/100m3)
Qinghai	1.3	6.0
Gansu	1.8	8.0
Ningxia	0.9	2.0
Inner Mongolia	2.9	5.5
Shaanxi	6.4	18.3
Shanxi	4.5	23.3
Henan	0.6	1.1
Shandong	1.7	6.2
Average	2.5	8.7

As is shown by Figure 3, tap water prices take only somewhere between 19% and 54% of the water costs in the eight provinces. The average percentage is 28%. Charging merely less than one third of the cost, Chinese state-owned water supply companies obviously tend to determine a lower price of tap water than companies in most of the developed countries would do.

1 The website is www.h2o-china.com/, last checked available by Apr 10, 2010

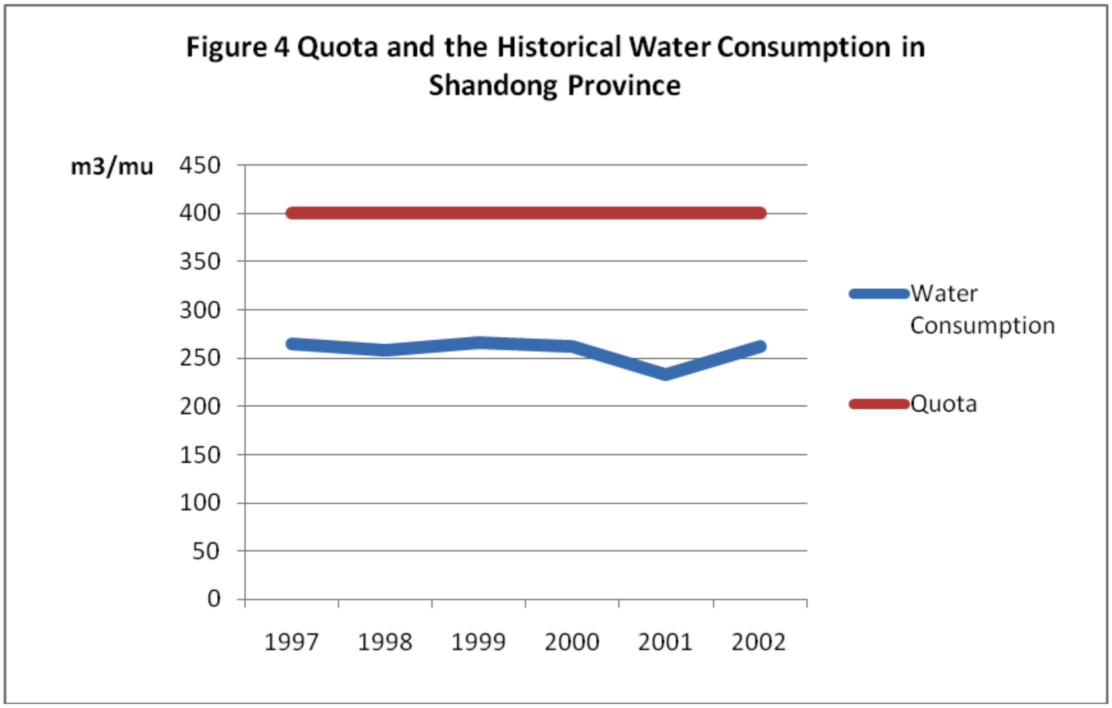


For Irrigation Use

According to the "Regulations", how to charge water for irrigation use is largely a decision of province and local governments. There are basically two types of irrigation water pricing systems currently in China: quota allotments and pricing by farming area.

For example, Shandong is a province currently using quota allotments, and the quota is, according to a government announcement on newspaper, 400 m3 per mu (1 mu equals to 797.3 sq. yd.). This number is determined by the water department of province government. However, in the announcement, they say that any use of water exceeding that quota will be charged a fee without mentioning how much the fee is.

Figure 4 shows the difference between the quota and the historical water consumption in Shandong Province from 1997 till 2002. Shandong Province has an effective irrigation area of 71,961 k mu. From the total irrigation water consumption



amount recorded in the *"Shandong Statistical Yearbook"*, historical irrigation water consumption per mu is calculated and shown in Figure 4. From the figure, the fact is undoubtedly indicated that the quota determined for irrigation water in Shandong is far more than what would be possibly used in normal case. As a matter of fact, the quota is 55% more than the average water consumption in the 6 years.

Conclusively, water "technically" is charged in Shandong Province but actually is free, when used for agriculture.

Pricing by farming area is also used by some of the provinces where water is scarcer. However, the price can vary considerably. Jiangxi is a typical province charging irrigation water by farming area. According to a research did by Zhou (2003), a large part of Jiangxi Province has a fixed annual water charge of 16.9 RMB (1 dollar equals to 6.8 RMB) per mu, regardless of land type, crop type or output.

According to *"Jiangxi Statistical Yearbook"*, Jiangxi has an effective irrigation area of 28,098 k mu, and irrigation water consumption was 13.68 billion m3 in 2002. On an average bases, the annual charge of 16.9 RMB per mu basically pays for 190.1 m3. In other words, for a single farmer, the water charge is approximately equivalent to 8.9 RMB/100m3, much higher than the tap water prices for habitants use (as shown in Table 2).

From the examples above, a conclusion can be made that the pricing system for irrigation area is largely random. There are several reasons for this phenomenon.

Firstly, tradition plays a significant part in this scene. From 1958 to the beginning of 1980s, all farmers in China were organized into communes, which were called People's Communes. Assets including farmlands, houses, ponds and reservoirs were considered collectively owned by the communes and are free to use by all the members in the commune following a distribution plan made every year. In the years of People's Communes, a farmer's income was determined by the collective performance of their communes instead of their own performance. In that case, the farmers had less incentive to overuse water even if not charged because it may harm their neighbors that belong to the same commune. Therefore, the tradition of irrigation in China was "water is free". Until now, as is mentioned before in this paper (p10), water owned by agricultural collective economic organizations is still determined to be free by the law.

Secondly, the cost of metering is high enough for the governments to give up volume-based systems. In rural areas of China, people mostly channel the river water and pump from the underground water for irrigation. In both situations, measuring how much water is used in certain piece of land is difficult. In the past ten years, there was much research done by IWHR on how to lower implementation costs technically (Xie et, al, 2001). However, few practices were conducted.

Thirdly, Chinese government put much emphasize on agriculture. Different types of premiums are offered to farmers in order to encourage them to stay on their land instead of moving to the cities. For example, in 2008, the government issued 40 RMB/ mu to farmer households that cultivated their land. Initially, free irrigation water was a kind of premium and in most parts of China, it still is. However, since the price of irrigation water is a decision of the province governments, places such as Jiangxi began to charge for water as a method to gain government income.

IRRIGATION IN CHINA

Basic Information of Irrigation in China

The most widely used irrigation method in China is still soil channel irrigation, which is digging soil channels to bring in water from rivers to farmlands. Therefore, water efficiency of irrigation is only 0.4, compared to 0.7-0.8 in developing countries (Pei, 2003). Nowadays, the following water-saving irrigation techniques are gradually developed in different provinces.

The most popular water-saving irrigation method would be canal seepage control. Since that canal seepage is the major reason of losing water, farmers use stone, concrete and plastic to build water-proof canals in order to prevent losing water in the way. Areas that widely use this irrigation system can have a transportation efficiency of around 0.6, two times higher than the soil channel irrigation.

The second method would be water pipe. Well controlling seepage and evaporation of water, this method is adopted widely by developed countries. In China, water pipes are mostly used in the northeast China where people use underground water to irrigate. Technically, water pipes can make transportation efficiency as high as 0.95. As is estimated by the IWHR, construction cost of water pipes, regardless of the water source construction, is 100-150 RMB/mu. The number varies with length of pipe needed per mu, according to different crops, landform, etc.

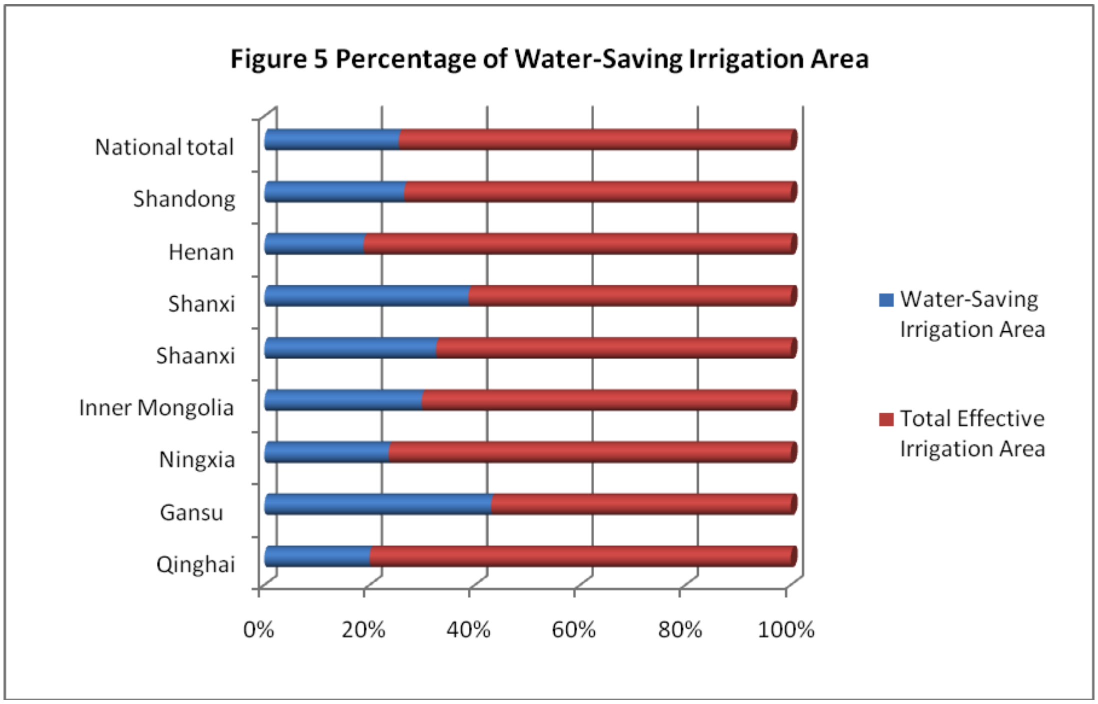
In terms of field irrigation improvement, several farming areas around cities begin to use sprinkling irrigation, such as the Shunyi County in Beijing. They use fixed underground pipes to transport water and spray it out with sprinkler heads that are able to be taken down and used in different places. Compared to ground irrigation, half the water can be saved with sprinkling irrigation. And with the sprinkler heads able to be reused, construction cost is around 200-250 RMB/mu. However, the technique is used only in limited areas where people have spare money to invest on irrigation.

The most precise and developed irrigation technique that is used in farmlands in China is micro irrigation. Water is transported into plastic pipes with a diameter of merely 10 mm to the roots of the plants, and wet only the part of soil near the roots. And sometimes they put fertilizer in the water. The technique can make sure that 95% of the water can touch the roots and is the most ideal irrigation method to use in dry areas in the west. Cost per mu for instruction of the system regardless of the water source instruction would be 700-1400 RMB. Because of the high cost, the technique is only used in very limited areas where the Chinese government pays for the construction.

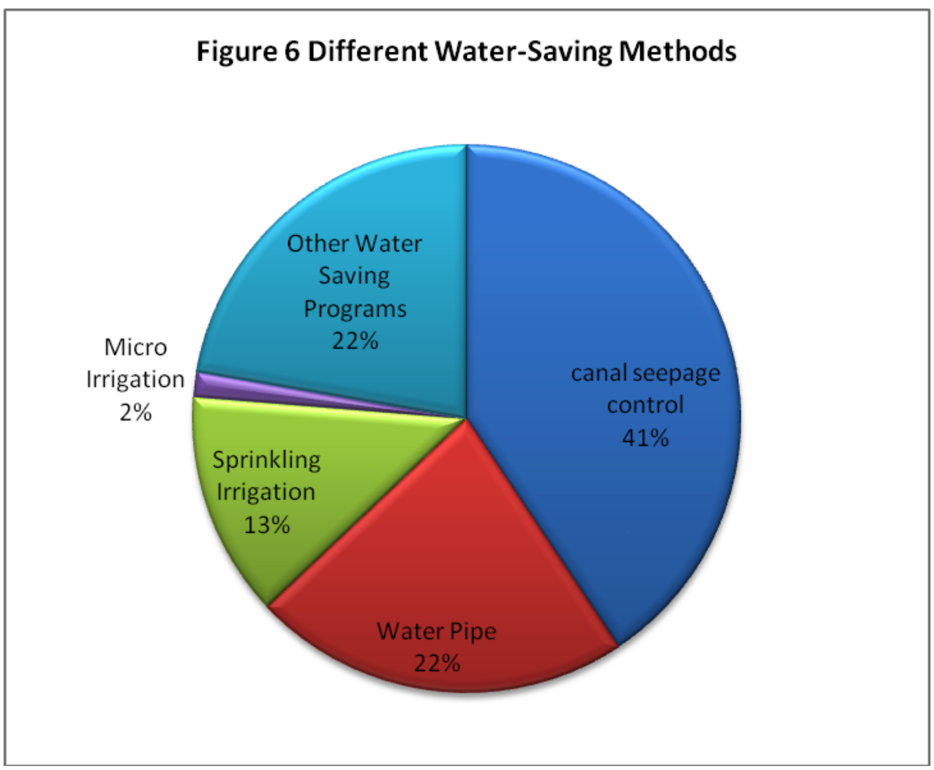
There are other water saving methods such as irrigation on plastic membrane, control of water use according to seasons, etc.

Numerical Facts

Total effective irrigation area in China was 54,354.8 hectares in 2002, while the water saving irrigation area is 18,627.1 hectares. That means only 34.3% of the effective irrigation area in China has ANY form of water-saving irrigation mentioned above. Figure 5 shows the percentage of water-saving irrigation in the 8 Yellow River provinces compared to the national data. From the figure we can tell that water-scarce provinces such as Shanxi, Gansu, and Shaanxi have better use of water in terms of water-saving irrigation areas.



Among the water-saving areas, the most popular water-saving method would be canal seepage control, which takes 41% of the total area. Figure 6 is a pie chart indicating the percentages of different water-saving methods nationwide.

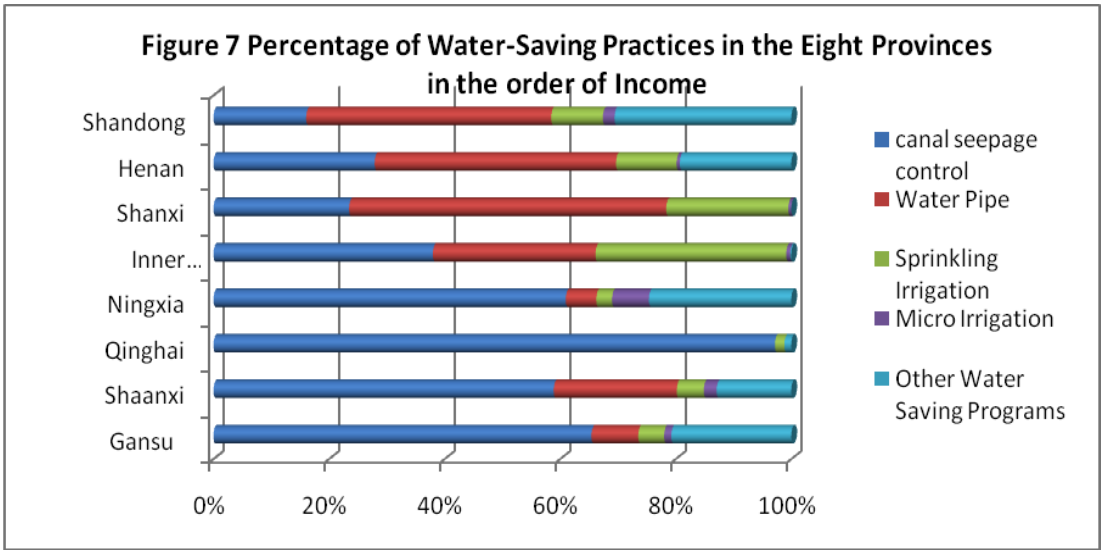


In order to find out whether the economic situation is the key factor in choosing which water-saving technique to use, I compared the farmers' income per capita in the eight Yellow River provinces. Table 3 shows the income per capita and area of different practices.

Table 3 Farmers' Income and Water-Saving Practices in the Eight Provinces

Provinces	Farmers' Income Per Capita	canal seepage control	Water Pipe	Sprinkling Irrigation	Micro Irrigation	Other Water Saving Programs	Total Water-Saving Area
Shandong	2948	278.03	734.89	154.96	35.11	530.01	1733
Henan	2216	310.75	465.4	116.93	6.22	214.87	1114.17
Shanxi	2150	163.95	383.35	147.66	3.55	0	698.51
Inner Mongolia	2086	410.86	304.67	357.17	7.5	1.89	1082.09
Ningxia	1917	77.18	6.7	3.46	8.07	31.2	126.61
Qinghai	1669	45.95	0	0.77	0	0.57	48.29
Shaanxi	1596	374.78	135.46	29.79	14.13	82.23	636.39
Gansu	1590	489.32	60.7	33.43	9.26	155.38	748.09

The provinces are in the order of their farmers' income per capita, from high to low. Figure 7 shows the percentage of different water-saving practices mentioned above of the eight provinces in the order of income. In lower-income provinces, canal seepage control is more widely used than high-income provinces and water efficiency is less than that in high-income provinces as a whole. As a conclusion, use of different water-saving methods is highly affected by the economy. In rich provinces, farmers and local governments have the spare money to invest on water-saving constructions. However, it is obvious that water-saving is not one of the most emphasized issues among farmers in China since the highest income province along the Yellow River and, one of the highest income provinces in China, Shandong Province, has only 36% of its total farmlands equipped with ANY type of water-saving constructions.



On the other hand, the situation of irrigation in China can also be observed from yield from water. Again, take the eight provinces as an example. Total agriculture water consumption for the eight provinces was 77.6 billion m3 in 2002. While total agriculture output was 120,158 million tons and the output value was 4,056.7 billion RMB during the same year. Therefore, the calculation is the following:

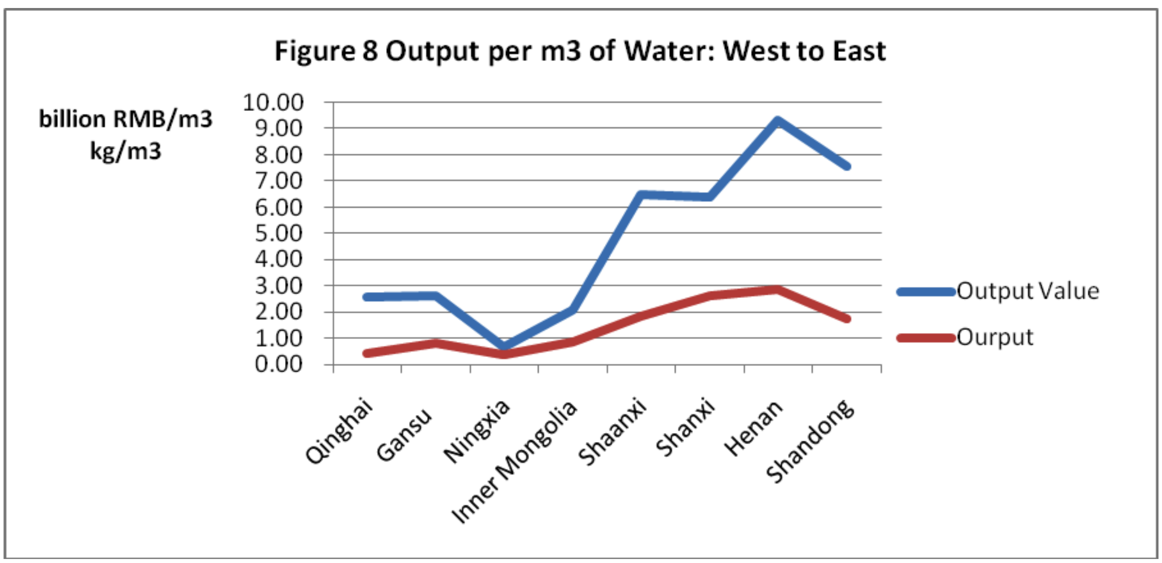
Output per m3=Total Output/Agriculture Water Consumption

Output Value per m3= Total Output Value/Agriculture Water Consumption

From the calculation, output from every m3 of water was 1.55 kg and the output value was 5.22 RMB. Detailed information is shown in Table 4 and Figure 8. In Table 4 and Figure 8, provinces are in the order of locations, from west to east. There we can see that generally, eastern provinces have better use of water, which means have more output value with the same amount of water, than western provinces, whether regarding or regardless of the product price differences.

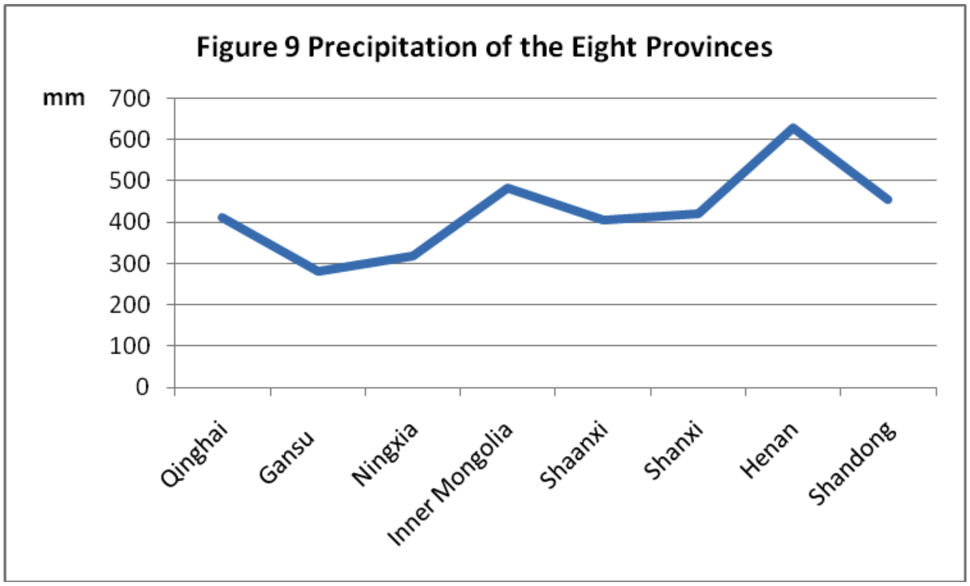
Table 4 Output Value From Irrigation Water in 2002

Province	Agriculture Water Consumptio n(billion m3)	Output Value (billion RMB)	Output Value per m3 of Water	Agriculture Output (k ton)	Output per m3 of Water(kg)
Qinghai	2.04	5.29	2.60	913.00	0.45
Gansu	9.73	25.73	2.65	7827.00	0.80
Ningxia	7.60	5.29	0.70	3019.00	0.40
Inner Mongolia	15.88	33.21	2.09	14061.00	0.89
Shaanxi	5.46	35.32	6.47	10056.00	1.84
Shanxi	3.55	22.71	6.40	9255.00	2.61
Henan	14.57	136.03	9.33	42100.00	2.89
Shandong	18.83	142.09	7.55	32927.00	1.75
Total	77.66	405.67	5.22	120158.00	1.55



There can be two reasons for this phenomenon. Firstly, eastern provinces have wetter weather than western ones. As is shown by Figure 9, average precipitation of major cities in the 8 provinces tends to rise from west to east. Secondly, eastern provinces have higher personal income than western ones do. As is indicated before, higher-income farmers tend to use better water-saving irrigation methods.

All in all, Chinese irrigation has a comparatively low efficiency in using the water.



DISCUSSION AND RECOMMENDATIONS

Discussion of Existing Problems

Irrigation water management system in China hasn't changed ever since the People's Communes time. Big reservoirs, pumping station and main channels are directly managed by water departments of local governments, while tributaries and facilities on them are managed by local communities. The system worked well in the People's Communes time since everything was collectively owned including living costs and income. However, the system cannot fit modern Chinese economy.

Water-saving facilities are constructed and managed by water departments and local communities, both of which have little money and/or passion to change the current situation. On one hand, concerning the costs and benefits, water departments of governments in most of rural areas in China are much more interested in hydroelectric generation, if possible. On the other hand, villages are facing very limited budget every year and would rather focus on fertilizer or farming equipment that can increase output, since that water is far from the most emphasized part of their concern whether it is free or charged by farmland area.

The "tragedy of the commons" is actually happening in rural areas in China. On the issue of preparing irrigation facilities, farmers would consider their own interests and wait for others to do the work. Since that no clear responsibilities are divided within the villages, irrigation facilities in many parts of China have seepage because of aging. The most popular grain cultivated in China is rice, which relies largely on water. More irrigation water can normally cause more rice output on a certain piece of farmland. Therefore, farmers, especially on the upper stream of a river, tend to dig a lot of channels and wells, while those on the lower stream lack irrigation water because of the overuse on the upper stream.

In the provinces where irrigation water is charged by area, the water prices were determined by city governments and haven't changed for years. Basis of pricing procedure is mostly the financial situation of the governments and the annual water charge has somehow negative impacts on managing water use. In traditional understanding, water is collectively owned and free to use. Now, because water is charged by area, farmers feel that they paid for something that should be free and thus tend to use more water than needed without a sense of guilt that they may have if water isn't charged. Because the price stays stable for every year regardless of water scarcity, in the years with less flow, farmers on the upper stream tend to overtake and store water for irrigation. In that case farmers on the lower stream may have very limited or even no water for irrigation.

Recommendations

My recommendations for the irrigation water pricing and managing system would be the following.

Firstly, farmers can be organized into farmers' water-using committees based on hydrology. Irrigation facilities can be managed by the committees and let the farmers jointly make the decision of water permits and prices. Farmers can negotiate over water distribution between different parts of rivers and the inequity can be solved with compensation. Since farmers are the actual user and demander of irrigation water, it is always good to let them make the decisions.

Secondly, based on the farmers' water-using committees, a pricing system for irrigation water can gradually be changed to volume-based. Since that the free-of-charge or area-based pricing is the biggest reason for water overuse, volume-based pricing is very attractive. Considering the implementation costs of measuring water consumption, people can consider putting meters only on the water entrance and exit of the committees and charge them based on the volume. Within the committees, farmers can negotiate over water charge distribution or simply divide it up with farmland areas. In this system, farmers are expected to have much more incentives to save water in their own land.

Thirdly, water definitely should be charged and the price should be updated frequently enough based on careful studies. Water prices should reflect water scarcity, and be used only on construction and repair of water facilities. During the dry seasons, irrigation water should be more expensive to make sure that some of the water is left for lower stream farmers. If a quota is determined, the quota should be close to the least amount of water to be used without harming agriculture output in that area.

Lastly, water protection should be one of the criteria to examine performance of a local government and education should be conducted to remind the public of water scarcity.

BIBLIOGRAPHY

Ahmad, M. (2000). Water pricing and markets in the Near East: policy issues and options. *Water Policy* 2 (3), 229–242.

Berbel, J. & Gomez-Limon, J. (2000). The impact of water-pricing policy in Spain: an analysis of three irrigated areas. *Agricultural Water Management*. 43, 219–238.

Bjornlund, H. & McKay, J. (1998). Factors affecting water prices in a rural water market: a south Australian experience. *Water Resources Research* 34 (6), 1563–1570.

Bos, M. G. & Walters, W. (1990). Water charges and irrigation efficiencies. *Irrigation and Drainage Systems*, 4, 267–278.

Brown, L. & Halweil, B. (1998). China's water shortage could shake world food security. *Worldwatch,* No. 7/8, Online.

Dinar, A. (1998). Water policy reforms: Informational needs and implementation obstacles. *Water Policy,* 1(4), 367–382.

Dinar, A. & Subramanian, A. (1997). Water pricing experience. World Bank Technical Paper #386.

Easter, K. W. (1999). The transition of irrigation management in Asia: Have we turned the corner yet? Paper Presented to the Proceedings of the Sixth Conference of the International Water and Resource Economics Consortium, Hawaii

Easter, K. W., Becker, N., & Tsur, Y. (1997). Economic mechanisms for managing water resources: Pricing, permits, and markets. In A. K. Biswas (Ed.), Water resources: Environmental planning, management and development. New York: McGraw-Hill.

Easter, K. W., & Welsch, D. E. (1986). Priorities for irrigation planning and investment. In K. W. Easter (Ed.), Irrigation investment, technology, and management strategies for development. Boulder, CO: Westview Press.

Han, H., & Zhao, L. (2007). Chinese agricultural water resource utilization: Problems and challenges. *Water Policy,* 9, 11-28.

Hardin, G. (1968). The tragedy of the commons. *Science,* 162, 1243–1248.

He, J., Chen, X., Shi, Y., & Li, A. (2007). Dynamic computable general equilibrium model and sensitivity analysis for shadow price of water resource in china. *Water Resources Management,* 21(9), 1517-1533.

Kim, C. S., & Schaible, G. D. (2000). Economic benefits resulting from irrigation water use: Theory and an application to groundwater use. *Environmental and Resource Economics*, 17, 73–87.

Laffont, J. J., & Tirole, J. (1993). A theory of incentives in procurement and regulation. Cambridge, MA: MIT Press.

Langworth, M. W., & Finan, T. J. (1996). Insititutional innovation in small-scale irrigation networks: A Cape Verdean case. In J. B. Mabry (Ed.), Canals and communties. Tuscon: University of Arizona Press.

Liu, X., Chen, X., & Wang, S. (2009). Evaluating and predicting shadow prices of water resources in china and its nine major river basins. *Water Resources Management*, 23(8), 1467-1478.

Liu, C.M., (2000). Water-saving potential and measures to deal with water scarcity, *Agriculture Machines*. (9), 6–8.

Marino, M., & Kemper, K. E. (1999). Institutional frameworks in successful water markets. World Bank Technical Paper #427, Washington, DC.

Pei, Y., Fang, L. & Luo, L. (2003). Price elasticity of agricultural water demand in China. *Resources Science,* 6, 25-30.

Perry, C. J., & Narayanamurthy, S. G. (1998). Farmer response to rationed and uncertain irrigation supplies. Research Report #24, IIMI, Colombo, Sri Lanka.

Sampath, R. K. (1992). Issues in irrigation pricing in developing countries. *World Development*, 20, 967–977.

Seagraves, J. A. & Easter, K. W. (1983). Pricing irrigation water in developing countries. *Water Resources Bulletin*, 4, 663–671.

Spulber, N. & Sabbaghi, A. (1998). Economics of water resources. Boston: Kluwer.

Sutawan, N. (1989). Farmer-managed irrigation systems and the impact of government assistance: A note from Bali, Indonesia, selected paper at the Conference on public intervention in farmer-managed irrigation systems. Kathmandu, Nepal, proceedings published by IIMI, Colombo, Sri Lanka.

Tsur, Y. & Zemel, A. (1995). Uncertainty and irreversibility in groundwater resource management. *Journal of Environmental Economics and Management*, 29, 149–161.

Wei, B. (2001). Suggestions on the reform of water supply pricing systems. Speech at the Water Rights and Water Market Forum, March 19–22, Beihai, China.

Yang, H., Zhang, X. H. & Zehnder, A. J. B. (2003). Water scarcity, pricing mechanism and institutional reform in northern China irrigated agriculture. *Agricultural Water Management*, 61(2), 143-161.

Yue, X., Wang, Y., (2000). A discussion on the water levy standard in Hebei. *Hydrology Economics.,* (2), 51–54.