Chinese Agricultural Water Resource Utilization in 21st Century

Han hongyun, Postdoctor/Associate Professor (Nanjing Agricultural University)
Visiting Scholar (the Australian National University)

Abstract: Firstly, the present situation of China’s water resources and its implications are discussed. As a large country, China is nonetheless resource poor on a per capita basis. With the development of industrialization and urbanization, more and more water resources will be transferred from low-value agricultural use to high-value industrial and residential uses. The challenge now facing irrigated agriculture is how to resolve the contradiction between increasing food demand and decreasing water supply without undermining the growing cities and industrial sector. Secondly, the problems of agricultural water utilization in China are presented: low efficiency, severe water pollution, inequitable distribution, and severe land erosion. Shortage and waste coexists in Chinese irrigated agriculture. Thirdly, an analysis of the causes of inefficient Chinese agricultural water utilization is provided: attenuated property rights, artificially low water prices, lack of user participation in irrigation districts management, fragmented government management, and lack of a compensating mechanism between upstream and downstream users. Against the background of a transitional economy, the lack of economic incentives is because of the inadequately institutional settings, so it is necessary to allocate the water resource through the market. Finally, feasible measures for addressing the problems are given: to establish non-attenuated property rights, to establish an effective price system, and to foster the main body of the market.

Keywords: water resource, property rights, water market

Contact details:
Telephone: 61253906
E-mail: hongyun.han@anu.edu.au
Mailing address: National Centre for Development Studies, Australian National University, Canberra ACT 0200, Australia

Chinese Agricultural Water Resource Utilization in 21st Century

Han hongyun, Postdoctor/Associate Professor (Nanjing Agricultural University)
Visiting Scholar (the Australian National University)

Present Situation of Chinese Water Resources and its Implications for Agriculture

As a large country, China is nonetheless resource poor on a per capita basis. China ranks fourth in the world in terms of total water resources, but is second lowest in terms of per capita water resource availability (World Resources Institute, 2001). With 22% of the world’s population, China possesses only 8% of world’s fresh water. The total water resource in China is about 2,812 billion cubic meters, which is less than the water resources of Brazil, the former USSR, and Canada. The water resource per capita is only 2,350 cubic meters, which are only 27% of the world average. In 2000 the total obtainable
water resource was 6,678 million cubic meters, while the total projected demand was 7,096 million cubic meters. Thus the annual shortage reached 418 million cubic meters (the Bulletin of the Water Resources in 2000). As these figures indicate, China is one of 13 countries severely short of water.

Feeding China’s vast population is a continuing major challenge for the government of China. Irrigated agriculture nowadays faces two kinds of pressures: the increasing demand for agricultural products and the decreasing water supply for agriculture. With the development of industrialization and urbanization, many changes will take place in the food structure and the living patterns of Chinese people. As incomes rise, people are consuming more pork, poultry, beef, and eggs, and therefore feedgrain demand will grow fast. Maybe as a growing open economy China can import more food to support the people. According to Brown et al.(1998), China’s water shortages will shake world food security. However, because of the differences in living patterns, food structure between China and developed countries, I cannot agree with the standpoint of Brown et al., but their prediction can provide a warning to Chinese people and the government should pay more attention to food security.

Chinese irrigated agriculture accounts for about one-half of the cultivated land, and 70% to 80% of the agricultural output depends on irrigated agriculture. Irrigated land plays an important role in the Chinese food supply. Historically agriculture has been always the main water user in China. Although the percentage of water used by irrigated agriculture has dropped from 98% in 1949 to somewhere around 63% today, by contrast to the developed countries, the rate of water usage in agriculture is still very high (in most of the developed countries it is 50%). With the development of market-oriented economy, market mechanism will play a basic role in the allocation of resources. Because of the big different value between industrial, agricultural, and domestic water use, more and more water resources will be transferred from low-value agricultural use to high-value use in the future. Now the residential share is increasing as China’s population urbanizes. The demand for water use in industry is growing even faster. The challenge now facing irrigated agriculture is how to resolve the conflict between increasing food demand and decreasing water supply without undermining the growing cities and industrial sector.

The Problems in Chinese Agricultural Water Utilization

In order to alleviate the pressure of water shortage on irrigated agriculture, the Chinese government has adopted many technological and policy instruments to increase
the productivity of irrigation water. However, there are many crucial problems in Chinese agricultural water use.

1. Low efficiency

Whilst water availability for Chinese agriculture is falling, technical efficiency is also poor. In China, the water use rate in unlined canals is only 30% to 40%, compared with a rate of 70% to 90% in most developed countries. In 1995 the use rate in China was only one-eighth of the rate in America in 1990, and one-twenty-fifth of the rate in Israel in 1989. The water average productivity of food crops is only 0.87kg/m³ in China now; by contrast it is 2.32kg/m³ in Israel. Thus, shortage and waste coexists in Chinese irrigated agriculture.

2. Water pollution

Water quality in China is poor. A large amount of wastewater is discharged into lakes and rivers without any treatment. This has severely damaged the water quality. The total amount of wastewater is shown in Table 1.

Table 1 Total amount of wastewater in China 1991-2000

<table>
<thead>
<tr>
<th>Year</th>
<th>The total amount of wastewater</th>
<th>Industrial wastewater</th>
<th>Residential wastewater</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>33.6</td>
<td>23.6</td>
<td>10.0</td>
</tr>
<tr>
<td>1992</td>
<td>36.7</td>
<td>23.3</td>
<td>13.4</td>
</tr>
<tr>
<td>1993</td>
<td>35.6</td>
<td>22.0</td>
<td>13.6</td>
</tr>
<tr>
<td>1994</td>
<td>36.5</td>
<td>21.6</td>
<td>14.9</td>
</tr>
<tr>
<td>1995</td>
<td>39.0</td>
<td>23.0</td>
<td>16.0</td>
</tr>
<tr>
<td>2000</td>
<td>62.0</td>
<td>40.9</td>
<td>21.1</td>
</tr>
</tbody>
</table>


Because of the difficulties in collecting data on agricultural pollution, there are no statistics available. However, in China, agriculture is a primary and important source of pollution. Industrial pollution tends to be concentrated in a limited area, but agricultural pollution is predominantly non-point and hence will spread over a large area. So agricultural pollution management tends to be more expensive than industrial pollution management. Wastewater from agricultural use will pollute the groundwater through the underground conveyance system. In China, there are no measures to deal with the run-off water in agriculture. So nitrogen, phosphorus, and pesticide are directly discharged into the lakes and rivers. And the lakes and rivers have become overloaded with nutrients. All of China’s water bodies are polluted to various degrees of severity. Serious pollution has been documented in the country’s seven major watersheds: Huai, Hai, Liao, Songhua,
Chang, Zhu and Huang (the Bulletin of Water Resources in 2000). Half of China’s population consumes drinking water contaminated with animal and human waste that exceeds the applicable maximum permissible levels (World Resource Institute, 2001).

3. Inequitable distribution

Owing to differences in climate and geography, the distribution of the water resource in China is naturally uneven. In the geography of water, there are two Chinas: the humid south and the arid north. While four-fifths of the water is in the south, two-thirds of cropland is in the north. As a result, the water per hectare of cultivated land in the north is only one-third that in the south.

Table 2: Comparison of water resource between north and south in China

<table>
<thead>
<tr>
<th>Region</th>
<th>Ratio of water resource</th>
<th>Water resource per capita</th>
<th>Ratio of population</th>
<th>Water resource per hectare</th>
<th>Ratio of cultivated land</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>1/5</td>
<td>1127 m³</td>
<td>2/5</td>
<td>9645 m³</td>
<td>3/5</td>
</tr>
<tr>
<td>South</td>
<td>4/5</td>
<td>3383 m³</td>
<td>3/5</td>
<td>28695 m³</td>
<td>2/5</td>
</tr>
<tr>
<td>North/South</td>
<td>1/4</td>
<td>1/3</td>
<td>2/3</td>
<td>1/3</td>
<td>3/2</td>
</tr>
</tbody>
</table>


More especially, northeast of China, where the main industrial cities of China are, and where the population density is very high, accounts for 26% of the total population of China, but it receives only 20% of the total water resource. The naturally uneven distribution of water resources constitutes a severe threat to Chinese economic and social sustainable development.

Meanwhile there is considerable inequality resulting from the water distribution systems. According to the water law passed in 1988, water resources usually belong to the government, and water resources in ponds and reservoirs built by the collective organisations belong to the collective organisations. In order to control water extraction and to implement state water resource ownership, the government began to implement a license permit system in 1994. Because of the lack of water gauging devices, it is expensive to measure the amount of water used by a farmer. The water resource in a rural area is a kind of open access resource and therefore the tragedy of the commons inevitably applies. Especially in the northwest region, rainfall occurs outside the crop growth season. If crops cannot be irrigated in the crucial growth period, there will be no harvest. Based on their concerns over this natural risk, farmers will use more water than is really needed. Thus the water resource in rural areas is in anarchy. Disputes between upstream and downstream users break out over and over.
The following example reveals some information on the uneven allocation of water resulting from the water distribution systems. Hei River flows through Qinghai Province, Gansu Province, and the Neimenggu Autonomous Region. The area of the basin of the inland river is 143,000 Sq. km. The watercourse is 821km long. Since the 1960s the water from Hei discharged into the lower reaches has decreased year after year. At the Lang Xinshan Hydrometric Station, the runoff has been reduced from 534 million cubic meters to 3.05 million cubic meters since the 1960s. The watersheds of the upstream, mid-stream, and downstream area of the Hei River are at Ying Tiaoxia and Zheng Yixia in the region of Gansu Province. The upstream area is sited in the mountain area of Qilian. The middle stream area is sited in the region of Zhangye in Gansu Province, including the Zhangye county, Linze County and Gaotai County, which have a prosperous agricultural economy. The downstream area is sited in the Jiuquan Autonomous Prefecture and Alashamengejinaqi in the Neimenggu Autonomous Region.

The total water resource of the Hei River is 2.81 billion cubic meters, the obtainable amount is 1.63 billion cubic meters, and the projected demand is 2.04 billion cubic meters. The responsible departments have done much coordination work since the 1960s on the distribution of the water of the Hei River, but the water distribution schemes between Gansu and Neimenggu province and among the different regions in Gansu have not been carried out. From 1993 through 1999, there have been 152 disputes about water distribution and 123 law cases about water distribution, most of them resulting from competition for water use. In 1999, the total amount of water used by the whole river basin was 2.62 billion cubic meters, 2.45 billion cubic meters of it used in the mid-stream area. In addition to the water used by National Defense Base and the conveyance loss, the water left for the downstream was only 300 to 500 million cubic meters. Meanwhile, owing to the uneven distribution of the water conservancy project, there were 66 outlets and 40 sets of reservoirs in the main watercourse. The ratio of water used by the upstream, mid-stream and downstream areas was 1.2:93.3:5.5. Under government regulations, the contracts for water distribution have been established in Heihe, Huanghe, and Talimuhe Rivers, but the contract cost is high.

Because of the difficulty of obtaining statistics, it is not possible to provide concrete data on contract costs. However, the following material will give some information. From June 19 to October 20 in 2000, the administrator of the committee of the Hei River Basin convoked 5 conferences for the coordination of the Hei River
resource, drew up 4 sets of monthly distribution schemes, and implemented arduous coordination work. It is expensive to establish distribution contracts, and the government cannot establish a contract for every river basin; therefore there is severely inequitable distribution in other river basins. Meanwhile over-interference from government will cut off the relationship between demand and supply.

4. Severe land erosion

Owing to natural limitations and human activities, the percentage of land covered by forests in China is 12.5%; it is ranked equal 120th in the world, so the land erosion is severe. According to the statistics, the area of land erosion was 25.7 million square km in 2000, which was 38% of the total land. Land erosion results in salinity of rivers, silting of reservoirs, and shrinkage of the reservoirs and lakes. It will be expensive to recover the ecological environment in the regions of land erosion. For example, Changjiang River Basin invested more than 90 million yuan in the scheme of the Sanxia Reservoir ecological recovery in 2000; 4,800 million yuans had been invested in the recovery of the Sanxia ecological environment until the end of 2000. Loess Plateau, which covers an area of 6.4 million square km, will invest more than 200 billion yuans to establish a natural protection screen.

Causes of Inefficient Chinese Agricultural Water Distribution

1. Attenuated property rights

"Property rights form an open-ended bundle of rights to possess, to use, to benefit from and to dispose of valuable and scarce assets" (Kasper, 1998). In China, the water resource belongs to the state or the collective community. Owing to the lack of integrated management organisations, in practice the administrations concerned with water use, such as Water Conservancy Department, Agriculture Department, Environment Department, will carry out the control rights of the water resource on behalf of the state, so the water resource does not belong to anyone. The lack of real owners of the water resource inevitably results in low efficiency of water use. To correct inefficiency in water resource distribution, the government began to implement a license permit system in 1994. In the absence of a water resource price or low water resource prices, the ownership of the water resource cannot be fully realized.

Owing to the lack of water gauging devices and the situation of fragmented land, a license permit system cannot be implemented in agriculture. There are two kinds of intrusions: there is no water resource price for agricultural water, which results in low
realization of the ownership, and then this leads to a lack of government ability to protect water resource. Meanwhile, administrations collecting water fees on behalf of the state can transfer their administration expenditures to the farmers. According to the present license permit system, the government strictly prohibits the exchange of property rights.

2. Low water prices

At present, the water price for agriculture is low compared to industrial and residential water use. The water price does not include the water resource price, labour cost, and depreciation. After the establishment of the People’s Republic of China, the Chinese government provided many subsidies to the people.

To alleviate the heavy financial burden of the government, reform of water prices was put onto the government agenda. In October 1965, the method of use and collection of water fees was passed by the State Council. This was the first system for water fee collection after the establishment of the People’s Republic of China. There is no consideration on supply cost of water, the price level at that time was very low: the water fee was only 0.3-1cents /m³ for industry, 0.2-0.5cents /m³ for residents. The provincial government would determine the water fee for agriculture¹.

In 1985, the government created a new method for the accounting, collection and management of the water fee. Under this new method, water fees were accounted on the basis of cost. Where the price of water for agriculture was concerned, there should be little profit from industrial crops, and the financial balance should be kept between costs and benefits to food crops.

In 1992, the State Council attempted to establish a new management method for the price of water supplied by the water conservancy system. Because of many difficulties in practice, it could not be introduced. However it pushed forward the reform process for water prices considerably. Since then the water fees have been called water prices. This was not playing with words; it signaled the start of water being treated as an economic good.

In 1999, the prices for water supplied by water conservancy projects were 2.7cents /m³ on average, 8cents/m³ for industry, 5.5cents/m³ for residents, and 2.7cents/m³ for agriculture. The water price for agriculture incorporated only the operation cost of water conservancy projects; it did not include labour cost, depreciation and management expenses, so the water used by agriculture attracted many subsidies. More problematic is
that the subsidies were paid directly to the enterprise supplying the water resource, not to
the users. The beneficiaries of subsidies were the enterprises not the consumers.
Meanwhile, the water prices were not collected by enterprises themselves, but collected by
the administrations of counties or towns on behalf of the enterprises. For a long time, the
water prices were regarded as a fee for administration, not the prices of economic goods.
So the administrations could collect more money in terms of water prices.

On average, the water price only accounts for half of the full supply cost. This
means that the government has to make up the deficit of water supplying enterprises by
financial subsidizes. Although the state spends much money for subsidizes, in fact the
farmers pay higher prices than they should, sometimes four times as much as they should.
The water price exerts a heavy burden on the farmers, especially in the poor countryside.
Meanwhile, because the water price is decided by the amount of cultivated land not by the
amount of water used by a farmer, there is low transparency in water price collection. The
water price is a kind of ‘big pot’ water; the burden of water price is uneven between
different farmers.

In sum, the problems of pricing agricultural water use are as follows. Firstly, the
water price does not reflect the true economic cost. Secondly, there are too many links in
the process of water price collection and many opportunities for free-riding in the local
administration. Thirdly, the water price does not reflect the actual amount used by farmers.
Fourthly, at present the pattern providing subsidies to every farmer exerts a heavy burden
on government. Finally, there is no economic incentive for enterprises to provide water
efficiently

3. Lack of user participation in irrigation district management

Historically, most of the water conservancy projects in China were built in the
1950s, and were constructed through government investment, collective community
investment, and peasant labour investment. After the Home Responsibility System (HRS),
the farmer owned relatively independent land use rights. As to the property rights to water
conservancy systems, because of the characteristics of specificity and integrity, the water
conservancy projects belong to every one in the rural community. No one can claim the
property rights to the physical infrastructure. Rational economic behavior of such un-
owned resources must result in poor maintenance and management of the infrastructure. In
order to alleviate the government financial burden of water supply, the management

1 Cent, the unit of Renminbi, 1 Chinese yuan equals 100 cents. 1 US$ equals 8.27 Chinese yuan.
responsibility of irrigation districts (IDs) is now being transferred to the enterprises and water users associations (WUAs); the objective of the IDs reform is to establish financially autonomous enterprises and self-service WUAs. Many irrigation and drainage systems are several decades old, and have suffered from inadequate maintenance. In addition, many were built to relatively low design and construction standards, and for most, the secondary and tertiary systems were never fully completed. Owing to such poor quality infrastructure, the WUAs are unwilling to take over the responsibility for management, and the units supplying the water to consumers are unwilling to give up their monopolistic position too.

4. Fragmented government management

According to the Water Law, water resources belong to the State or collective organisations. In practice, the administrations at different levels implement the control rights of the water resource on behalf of the government. In China, water conservancy, electric power, land, forestry, agriculture, environment, and communication departments all have some management responsibilities for river basins, although the government has established many river basin committees, such as Huanghe Water Conservancy Committee, Changjiang Water Conservancy Committee. All these committees are not the organs of authority and only partly own control rights. Different departments will seek their interests as far as possible and pay little attention to the public interest.

5. Lack of compensating mechanism

Low prices for products made from a resource and no price for the resource, this traditional idea constrains the efficient utilization and effective management of water resource. For a long time, there was no compensating payment for the inter-regional and intra-regional redistribution of the water resource. Because it is relatively easy to obtain water for upstream users, the characteristics of open access to the water resource lead to overuse by upstream users. Given the amount of water resource, there is little water left for downstream users. Downstream users are unwilling to pay for the opportunity cost, which comes from the reduction of upstream water use. All this aggravates the conflict between the upstream users and downstream. Research has been carried out on farmers’ behaviors in IDs and the conclusion of this research is that the water used by upstream users is not highest value but the lowest risk (Han, 2000). In other words, if an upstream user reduces water use to some degree, maybe there is no opportunity cost for him/her. A compensating mechanism between upstream and downstream users can lead to better social welfare.
6. Inadequate institutional environment

To establish water property rights, reinforce the integrity of river basins, and facilitate user participation in IDs management, all these must be supported by proper institutional environment. According to present laws concerned with water use, there is no limit on the amount of water extraction for some purposes, such as the water used for agriculture against drought, the water used for mine security, and the water used for public security. Especially in agriculture, there is no license permit system for agricultural water use against drought. Drought often takes place continually in a large range and lasts for long time periods. If there is no limit on the amount of water used, sometimes this will cause congestion in water uses.

Challenges to Future Agricultural Water Use---the Establishment of a Quasi-market for water

Shortage and waste coexists in Chinese agricultural water utilization. An increase in agricultural water use efficiency is a necessary condition not only for future agricultural development, but also for Chinese social and economic development. Against the background of a transitional economy, the lack of economic incentives is the fundamental cause of inefficient Chinese agricultural water use. It is necessary to allocate the water resource through the market mechanism. However, owing to the characteristics of the water resource, such as public goods, high uncertainty, and the natural monopoly in production, a simple market must result in a low supply of water. There are multi-use of the water resource, for agriculture, industry, resident, environment protection, or flood control. The government should play an important role in environmental protection and flood control. Water market is a quasi-market. More work must be done to establish a quasi-market for water resources.

1. To establish non-attenuated property rights

It is a precondition quasi-market for water to establish non-attenuated property rights. The market exchange is only the exchange of rights pertaining to the goods and services. Property rights are the rights implemented by society to choose a kind of economic good, and property rights will prescribe how people are to benefit or lose from the use of goods and services and how they will compensate each other. The establishment of non-attenuated property rights is a precondition for market development, which assures the market will be predictable, stable, and certain. Meanwhile, through the establishment
of non-attenuated property rights, the relationships between government, consumer, and producer will be accurately defined. Hence the two-way intrusions will be alleviated.

2. **To establish reasonable price system**

   The market mechanism is the price mechanism. Under the guide of the price rule, reasonable economic human beings will maximize their welfare and fulfill the Pareto optimality in resource use. Agriculture faces two kinds of risks, natural risk and market risk. However, agriculture is not a naturally weak industry. Through structural adjustment of the product and the establishment of a collective organisation to improve their market position, farmers can achieve more profitability. It is unnecessary to worry heavily about agricultural endurable capacity for the water price increase. It is not only necessary but also feasible in the present agricultural process to lower the level of subsidies to agriculture. The Chinese government should follow market principles, decrease subsidies to agriculture, and transform the indirect subsidies to direct subsidies to farmers.

3. **To foster the main body of market**

   The market is the exchange of goods and services produced by producers and consumers. For a long time, the units supplying water to users were a kind of economic organisation governed by government. On the one hand, they supplied water to the farmers at low price subsidized by government; on the other hand, they owned the monopolistic position in water supply. Water supply units achieved two kinds of benefits, the benefit from government subsidies and the benefit from market monopoly. Meanwhile, the dispersed farmers had little power in the bargaining process. It is necessary to establish WUAs in irrigated agriculture development. In the process of ID reform, the establishment of Water Supply Companies (WSCs) and WUAs are the basis of water market development.

4. **To improve the present institutional settings**

   To establish water rights separated from land use, and reinforce river basin integrated management, all these must be supported by the institutional settings. The law must accurately prescribe the amount of water extraction and the sequence of water distribution, and cancel the prohibition of the water use right exchange. Through institutional reform, integrated management authorities are likely to be established.

   Water shortage, deterioration of water quality, and the inequitable distribution of the water resource between different users are common in the world. In China, the
problems are very severe. The potential conflict between decreasing water supply and increasing demand will become more prominent in the near future.

Reference: