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HIGHLIGHT

Irrigation Modernization: Chinese Style

Report on a Field Visit to Shijin Irrigation System, Hebei Province

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China's irrigation systems suffer from years of deferred maintenance. Most systems were constructed during the Mao Era. During 1980-2010, the tempo of irrigation investments as well as of maintenance, repair and rehabilitation slowed down. In recent years, as China's water scarcity has deepened and food demand soared, there is growing concern for rehabilitating and modernizing old irrigation infrastructure. China has now launched a 10 year program to modernize its irrigation systems at a total investment of USD 600 billion. An IWMI mission visited China to get a glimpse into China's irrigation modernization program.

This Highlight reports on the trip, which included a field visit to newly-modernized Shijin irrigation system in Hebei province. If the Shijin system is any guide, three elements of China's irrigation modernization strategy are: [a] total rehabilitation of old, earthen systems into modern, lined canals for high-efficiency irrigation; [b] institutional reform of irrigation management; and [c] total recovery of irrigation fees levied at rates varying from USD 70 to 400/ha. On all these fronts, canal irrigation in India has much ground to cover: our systems are falling apart; our irrigation institutions have declined; and most states fail to recover even token irrigation service fees (ISF). China presents a bold contrast to the Indian scene on irrigation reform.

Irrigation Modernization: Chinese Style

Report on a Field Visit to Shijin Irrigation System, Hebei Province[1]

Research highlight based on a paper with the same title[2]

Introduction and overview

China has 6 percent of the world's water, 9 percent of the world's cultivated land but 20 percent of the world's population. To overcome this adverse land:man ratio, China has achieved 20 percent of the world's irrigated area. At the global level, 18 percent of agricultural areas are irrigated but in China this ratio is 48 percent. In India and Pakistan, this ratio is 45 percent and 80 percent respectively. Of China's 85400 reservoirs, 6400 have a height exceeding 25 meters. Their total storage is 634 Billion Cubic Meters (BCM) and these irrigate some 41 million ha of crop lands. In addition, 4.4 million tube wells irrigate 16.9 million ha of crop lands taking total irrigated area to 57.8 million ha. Over half a million pumping stations lift water from surface sources for irrigation supply.

Spatial imbalance in water and land resources is a critical issue in China. South China has only 20 percent of the country's farm land, but 80 percent of total precipitation. In contrast, North China has 62 percent of China's farm land but only 20 percent of its precipitation. China intends to overcome this imbalance with the help of its South-to-North water transfer project under progress. We visited the middle of the three routes of this ambitious South-to-North water transfer project (see Figure 1). This route will receive some 13 BCM of water/year by gravity, traveling over a distance of 1450 km. At present, it receives water from Danjiang Kou reservoir in Hebei province via an underground tunnel in Hunan province. From here, water is transported to Tianjin and then to Beijing. The advantage of the middle route is that it provides clean water over a wide area by gravity flow. Beijing has already received this water twice and has paid Hebei at a rate of Yuan[3] 2/m^3 of water supply.

With rapid economic growth, China's food grain demand is projected to increase from 450 million MT per year today to 664 million MT in 2020. Against this, arable land is expected to decline from 131 million ha to 120 million ha. Increasing food demand and growing water scarcity make it imperative for China to improve the efficiency of water use in agriculture. Most of China's irrigation infrastructure was constructed during Chairman Mao's time and earlier. For several decades, lack of investment in irrigation infrastructure and its maintenance led to deterioration in irrigation performance. From 2010, China has embarked on a ten-year plan for massive investment in the modernisation of irrigation infrastructure to achieve high water use efficiency. China will invest USD 60 billion per year for ten years to rehabilitate and modernize 402 large irrigation systems. This will mean investing roughly USD 1.5 lakhs[4]/ha of existing irrigation area to improve irrigation efficiency. To put things in perspective, China will invest every year more than what India has been investing in the entire 11th Five Year Plan; and the focus of much of this investment is in improving efficiency and saving water.

Figure 1 A picture of the middle route (near Shijianhuang) of the three canals of South-to-North Inter-basin water transfer project

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[2]This paper is available on request from p.reghu@cgiar.org
[3]One Chinese Yuan = 0.16 USD = 8.6 INR.
[4]1 Lakh = 0.1 million

During 12-17 June, 2011, an IWMI mission, consisting of senior researchers from Pakistan and India and three Pakistani farmer leaders, visited China's National Centre for Efficient Irrigation Engineering and Technology Research (NECI) to learn about and understand China's new program for improving the efficiency of public irrigation systems. The visit was managed by Zhanyi Gao, Director of NECI and involved, besides intensive briefings by NECI, visits to several other research centres and meetings with leading policy makers in Beijing. During this discussion an overview was provided on China's agricultural water management challenge.

Figure 2 A CC lined branch canal

China has invested a lot in lining canals to save water and deliver water to tail ends. What has been the result? Our assessment was that the opinions were mixed. There are some doubts expressed about the extent of ultimate water savings possible in medium to long run. Some experts believe that cement concrete lining develops cracks after a few years and thus fails to reduce seepage as expected. In the Shijin system, we saw a branch canal that was lined with cement and concrete. In a few years, however, cracks developed and water loss through seepage increased. In some other branch canals, polythene lining was provided underneath the cement and concrete lining. Investment in canal lining was done for three purposes:

[a] improve water delivery uniformly over the canal;

[b] reduce seepage losses; and

[c] reduce the land taken up by earthen canals.

Lining the canals reduces groundwater recharge; but by offering improved water control, lining also reduces the need for groundwater irrigation which farmers prefer for its availability on-demand. Farmers' demand for canal water in China is highly price elastic; since water delivery to WUAs is measured at the head of the canal and charged based on volume, lining significantly reduces farmers' irrigation cost.

However, focusing only on irrigation efficiency of an irrigation system may often be limiting and sometimes counter-productive when the socio-ecology of the entire basin is considered. The Hetao irrigation system, China's third largest, off-taking from the Yellow River in Inner Mongolia, is cited by Professor Gao as an example. Earlier, inefficient water use in the Hetao system led to the outflow of surplus drain water in a large lake at the tail end of the system. This was a celebrated wetland which attracted a wide variety of migratory birds from Siberia. Efficiency improvements in the Hetao system choked off water supply to this wetland, generating a hue and cry from environmental lobbies and tourism industry. Now, the system managers feed the lake with fresh water directly supplied from the reservoir and questions are being raised about the net impact of massive investments made in improving the efficiency of canal irrigation and water saving.

With this massive investment in irrigation infrastructure, China is also modernizing its water governance structures and institutions. Water governance in China is fragmented with several agencies and departments - the so called 'nine dragons' - controlling water management. But the growing effectiveness of the Yellow River Conservancy Commission has pointed to new directions for integrated water governance at basin level.

The Chinese idea of irrigation system modernization involves 'the use of scientific management concepts and relying on advanced technologies and means, to reform management system, innovate operation mechanism, reduce operation cost, raise irrigation water use efficiency and water productivity, expand irrigation area, better serve the farmers and achieve the established management objectives' (Xuehui n.d.). According to Professor Gao, it is guided by several triads of principles. The macro-economic strategy strives towards a balance among economic growth, social harmony and environmental sustainability. Modernization strategy seeks to balance: capital investment, new technology and professionalism. Planning of infrastructure involves balancing three tasks: appraisal of existing infrastructure, design of modernization plan and the implementation of modernization plan. Infrastructure management emphasises: improved operation and maintenance, performance monitoring against benchmarks, and periodic evaluation of system performance. Infrastructure policy emphasises: infrastructure development, institutional development and capacity building. In managing irrigation system, differentiated roles are assigned to:

Provincial Water Bureaus as governance agencies, Irrigation District Management Bureaus as the management agents, and water users' association (WUA) in charge of water management at the farm level.

Shijin Irrigation System, Hebei Province

After getting a national overview, our mission travelled to Shijianzhoung, the capital of Hebei province. Here we visited the Shijin Irrigation System which was first established in 1937. The system was rehabilitated during the 1950s and 1960s. But for nearly 40 years thereafter, little investment was made in its upkeep until it was thoroughly modernized recently to improve irrigation efficiency. Shijin irrigation district is spread over three prefectures. It covers a total area of 4144 km^2, but has an irrigation command of 1.2 lakh ha. The system has a main canal, 9 branch canals and 29 distributaries. It has a total of 14000 structures and 11000 large and small canals. Between 1950 and 2009, the Shijin irrigation system delivered an average of 0.68 BCM water per year. However, over time, the water delivered/ha has declined. During 1978-90 periods, the average delivery/ha was 6600 m^3 which has now been brought down to 2500 m^3. The system delivers water only for irrigating winter wheat, while summer corn crop is totally rainfed. Winter wheat yields average 7.5 MT/ha whereas summer corn yield ranges from 9 to 10.5 MT/ha. High quality seeds, very high fertilization and proper frequency of irrigation are key determinants of high crop yields in the Shijin irrigation command.

The modernization plan has improved irrigation efficiency of Shijin irrigation system from 0.5 to 0.54. Investments in canal lining to the farm level improved farm water management and water control. This in combination with land leveling helped to achieve improved efficiency. Volumetric pricing of irrigation services is the bedrock of irrigation system management in China. ISF charged varies from Yuan 450/ha (USD 70/ha) for gravity-flow irrigation to Yuan 3000/ha (USD 450/ha) for pump irrigation of vegetable and orchard crops. Significantly high volumetric ISF has also obliged farmers to economize on canal water use and improve water use efficiency.

The management structure for the Shijin irrigation system has three levels: at the head is the Irrigation Management Bureau which is accountable to Hebei Water Bureau for efficient management of the system. The Irrigation Management Bureau has 11 offices located at different places in the command area. Below the Irrigation Management Bureau is a Participatory Irrigation Management Committee (PIMC) which consists of members from the Irrigation Bureau, Provincial Water Bureau, the governor/ mayors of cities and counties falling with the command area and several representatives of WUAs. The major role of the PIMC is making water management decisions on branch and tertiary canal levels. At the bottom of the management structures are 29 WUAs.

The WUA is a new institutional development in Chinese irrigation. For a long time, national, provincial and local governments could commandeer farmers to work on periodic repair and maintenance of the irrigation system without wages during winter months when there was little farming. However, a new law in 2002 banned such forced labor. This necessitated the formation of WUAs which could mobilize farmers for managing the distribution system.

There is some conjunctive use of ground and surface water in the Shijin irrigation command. In many villages, bore holes are owned and managed by village committees. In most others, farmers get a license from Provincial Water Bureau to own and operate their own private wells.

The Shijin Irrigation Management Bureau has a major role in ensuring efficient management of the irrigation system. We visited one of its 11 offices housed in a modern, impressive looking building. The office was located in the eastern part of the command area, covered 12 counties, 250 villages and a potential irrigation area of 5 lakh *mu*[5] (33000 ha). Of this potential irrigation area, 3.3 lakh *mu* (22000 ha) were registered as designed command area.[6] However, 5 main canals actually served a total area of 2.5 lakh *mu* (16000 ha). The remaining area remained non-command either because farmers had private irrigation source or because canal water could not reach them. There were 8 WUAs each under this office; each WUA has 2000 to 4000 farming households as members.

The main role performed by this office of the Irrigation Management Bureau includes:

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[5] One ha = 15 *mu*

[6] In addition, there are units of electricity bureaus operating small hydel power plants within irrigation systems. We visited Tutong, a small hydel plant installed on the Shijin main canal where there is a 6.5 meter drop in the flow. The Tutong power station was built at a cost of Yuan 24 million in 18 months. It has three turbines each of 1250 kW, making total capacity of 3750 kW. Last year, the station generated 3 million kWh of power valued at Yuan 1.8 million using an average canal flow of 14 cumecs. The average cost of generation is Yuan 0.4/kWh. The power plant is operated for 3 months of the wheat irrigation station and remains idle for the remainder of the year. The station has a permanent staff of 24 which also remains idle 9 months of the year. It is unlikely that the power generated can cover the full staff cost.

[a] day to day management of the main canal, its operation and periodic maintenance;

[b] water delivery to WUAs and its volumetric measurement; and

[c] volumetric water fee collection from WUA committees.

Many farmers find canal irrigation costlier compared to groundwater. As a result, the irrigation bureau as well as WUA committees constantly struggle to ensure that farmers continue using canal water. Indeed, the irrigation bureau staffs' incentives are aligned against conjunctive use of ground and surface water. Increase in groundwater use reduces the income of the Irrigation Management Bureau from canal water supply; therefore the Irrigation Bureau staff actively discourages groundwater use and promotes canal irrigation.

An elaborate structure of rules and regulations keeps the Irrigation Management Bureau staff and WUAs highly responsive to farmers' needs. A breach in the canal due to human error or neglect results in pinning the responsibility on specific individuals who are then penalized. Strict norms are in place about quick repair of breaches. A breach in a branch or lower canal has to be repaired within 48 hours; and a breach in the main canal, however small, has to be fixed within 20 hours.

Figure 3 Canals CC lined up to farmers' fields

The Irrigation Management Bureau has no authority with respect to groundwater irrigation; however, their staff view groundwater wells as their competitor. The Irrigation Bureau Staff, therefore, show little or no interest in groundwater recharge works or in canal irrigation return flows, and are very keen on lining canals down to the field levels so that they can provide farmers tube well-quality irrigation service, and increase their business at the expense of groundwater irrigation.

Water Users' Association

To understand how a WUA functions, we visited Cui sun village and met Mr. Su, the WUA president. This remarkable man was elected to the presidentship of the WUA every two years since 1990 when the WUA was first established. The WUA covers 26 villages, a population of 4800 households and 9600 farmer members.

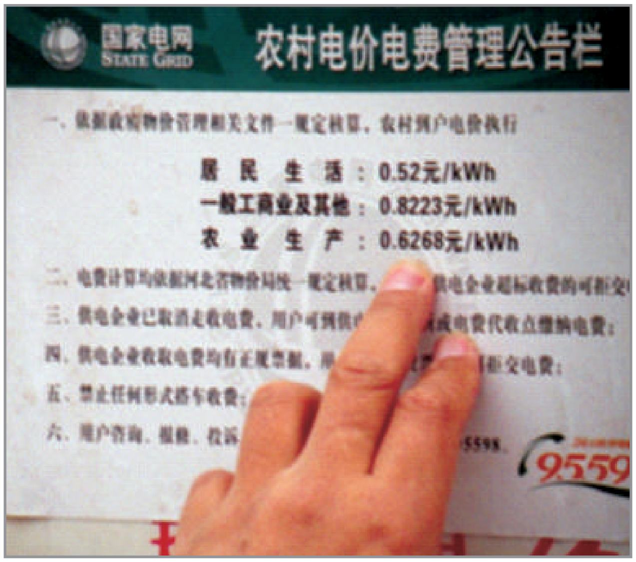
Figure 4 The swanky office of the Cui sun WUA

Each household has around 0.5 ha of land. The total area served by the WUA is 35000 *mu* (2330 ha). This area is served by 16 water courses. Also pressed in service are 167 irrigation wells with 16-20 kVA electric pumps, all privately owned and managed. Groundwater levels in this WUA area was 80 m deep and tube wells were 200-300 m deep.

Cui sun WUA was considered the best in the Shijin Irrigation System. Other WUAs were considered as good in water distribution and fee collection. However, Cui sun was known for its outstanding leadership. Proactive role of the Irrigation Management Bureau and Village Party Leaders ensure that water distribution is equitable and fee collection is vigorous; indeed, the Village Party Leader plays a key role in both. The authority of Village Party Leader then supplements the leadership capacity in WUAs; as a result, a high level of operating performance of WUAs is ensured even with ordinary leadership. Last year, Cui sun WUA collected a volumetric irrigation fee of Yuan 8.9 lakh (USD 1.4 lakh); this year, the collection was higher at Yuan 11.27 lakh (USD 1.8 lakh) for wheat which works out to USD 70/ha. The WUA measures water at the canal section where it is delivered and pays to the Irrigation Management Bureau for the measured volume. Then, it allocates this payment among users in proportion to the area irrigated in *mu* by different user-members. Village leader in every village takes the responsibility of [a]ensuring that every member receives water, and [b] collecting the ISF from them.[7] WUAs get 10 percent of the total water fee collected by them as a return grant. From the return grant, the WUA meets its maintenance costs, staff salary and even saves money to build its reserves. From accumulated savings, Cui sun WUA has built an impressive office.

Figure 5 Electricity meter on a tube well equipped with a smart card reader

Figure 6 Electricity tariffs charged to different consumer segments



The 10 percent return grant is also used to compensate the WUA managers. The five elected members of the WUA management team are all paid staff. Average salary is Yuan 16000/year mostly for 3 months' active work during the wheat irrigation season. During the irrigation season in winter, the WUA management team remains busy and meets very often; during the off-peak season, they have little work and meet on a need basis.

GROUNDWATER IRRIGATION

Tube wells are used for supplemental irrigation of fodder crops, cotton, corn, fruit and water melons. Farmers find canal water nearly as expensive as - or even more expensive than - well water despite the fact that farmers pay commercial tariff for power used to pump groundwater. We visited Nan Liang village, one of the Cui sun WUA villages. This had canals lined to water course level. The village had 45 tube wells, all equipped with electric pumps of 18-25 kVA. The groundwater depth was 65 m and tube wells were 200-250 m deep. All tube wells were installed and owned by the village committee. The electric meters on tube wells were equipped to read pre-

Figure 7 Solar powered groundwater meter transferring real-time water use data to Water Bureau

[7] The role of the Village Party Secretary as the final enforcement mechanism in collecting ISF or electricity charges or several other rules - is extremely important in explaining why some institutional interventions work in China but not in India (Shah et al. 2004).

paid smart cards. Farmers would insert these cards to start the tube well and keep pumping as long as the card remained charged. Each tube well was adjacent to a poll on which a solar panel powered transmitter was fixed at a height of about 15 ft. This read water withdrawals by each farmer and transmitted that record in real time to the Water Bureau office. The meter on the tube well mentioned the power prices charged to different classes of consumers: domestic consumers at Yuan 0.52/kWh; industrial consumers Yuan 0.8223/kWh; and agriculture, Yuan 0.6268/kWh.

Conclusion and lessons for India

Shijin irrigation system is very likely a show-case example of irrigation modernization in China and is unlikely to be representative of a majority of the irrigation systems. However, it does point to the direction in which canal irrigation is headed in China. Even in Shijin irrigation system, not everything we saw appeared worth emulation. There seemed excessive capitalization in lining whose net benefits are far from clear. Discouraging conjunctive use of ground and surface water too is of doubtful value. The financial and economic viability of canal-bed turbines would need careful scrutiny. The system appeared overstaffed, with high establishment costs off-loaded on farmers. A return grant of 10 percent of ISF collection to WUAs seemed too low, given the scale of responsibility shouldered by them. Finally, even if a country like India were to replicate Chinese style modernization, it is doubtful if results would be similar without a strong local authority system represented by the Village Party Secretary, a uniquely Chinese feature, so central to smooth working of WUAs.

Even so, the contrast between where canal irrigation is headed in India with that in China is striking. Irrigation bureaucracy is shrinking in India but growing in China. Planning and investment are focused on construction in India but on modernization in China. State governments are focused on minimizing irrigation budgets in India; provincial and local agencies are focused on improving service delivery and system performance in China. Farmers in India pay low or no ISF and receive poor or no irrigation service; farmers in China pay very high ISF and receive high level irrigation service. After 30 years of pushing WUAs, Participatory Irrigation Management (PIM) in India has made little progress. China began PIM in earnest recently; but it has strong WUAs that have taken over the management of all irrigation management responsibilities at the tertiary level. Thanks to a management vacuum, irrigation systems in India are increasingly becoming groundwater recharge systems with farmers recycling the seepage water using thousands of tube wells. In contrast, thanks to growing service orientation through intensive management, Chinese irrigation managers are able to provide tube well-quality canal irrigation service. With their insignificant revenue generation, funds-strapped Indian irrigation systems are hurtling towards a build-neglect-rebuilt syndrome. In contrast, by providing high level irrigation service, Chinese irrigation systems are able to generate high revenue to be able to invest in O&M and improve management capacity. If India wanted to take to the path of irrigation management reform, perhaps the first step would be to start working on the last contrast: shift from low ISF and low level of service to a rational ISF and improved, reliable irrigation service.

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About the IWMI-Tata Program and Water Policy Highlights

The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations. Through this program, IWMI collaborates with a range of partners across India to identify, analyze and document relevant water-management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

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