

Review

Chinese water policy for sustainable water resources: Options for the future

Zhang Xiuqin¹, Mu Xingmin^{1,2} and Shao Hongbo^{3,4*}

¹Northwest University of Agriculture and Forestry, YangLing 712100, China.

²Institute of Soil and Water Conservation, Chinese Academy of Sciences (CAS), Yangling 712100, China.

³The CAS/Shandong Provincial Key Laboratory of Coastal Environmental Processes, Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences (CAS), Yantai 264003, China.

⁴Institute for Life Sciences, Qingdao University of Science and Technology (QUST), Qingdao266042, China.

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China has no option but to press on with the implementation of the National Water Initiative as stated by its government in "Document No. 1". One might observe that it can be a bit heavy in political terms. Most hydrological means are pretty meaningless in reality. Though the nation is not sure if it can handle such a project effectively yet, it will certainly approach it with a degree of commitment. The paper aims to build an integrated understanding of these issues and to illustrate appropriate policy directions and management practices. These are ambitious goals, but they are essential and relevant in the milestone of the Chinese water resources management and policy.

Key words: Climate change, Chinese water vision, the national water initiative, national water resources management, integrated water resources management, policy implications.

INTRODUCTION

Water is an extremely complicated, complex and fascinating subject, which is exactly what people know it to be. They talk about national water challenge, and see water as their greatest environmental challenge. China prime minister thinks of it in those terms (Government Work Report delivered by Chinese Premier, Wen Jiabao to the National People's Congress in March 2008). The answers to this national challenge are almost infinite. The problem might be national but the solutions are very local. Always, people have to remind themselves about certain fundamental features of water.

One aspect which is very easy to forget, particularly by those who plan transcontinental aqueducts, is that a thousand litre of water is a cubic metre and weighs one tone (Berkoff, 2003), and that without the work of gravity, it costs an enormous amount to move it around, particularly over long distances. People usually say China has a great deal of water. It is true. But that is when you ignore

the arid centre of China, where there is virtually deep precipitation, much agriculture and large population.

As China's average annual rainfall is about 700 mm, you cannot say it is short of water overall; but the mean is meaningless (China Sustainable Development Strategy Study Group of the Chinese Academy of Sciences, 2007). This is true of most hydrological means, especially in a country like China where there is so much variability of precipitation and stream flow. Again, it is true because most water in China is in the tropical south. The Yellow (Huang) River and Hai and Huai (3-H) basins, China's most productive agriculture region with 75% of all its irrigated agriculture, survives with just 10% of its total run-off (China Agenda for Water Sector Strategy for North China: Vol.1; Summary Report, 2001).

CHINA'S WATER VISION AND CHALLENGES

In China, the five major physical problems confronting people in agriculture are: i) loss of land, ii) desertification, iii) soil erosion, iv) environmental pollution, and v) shortage of water. The main element of policy in China is

*Corresponding author. E-mail: shaohongbochu@126.com; xmmu@ms.iswc.ac.cn.

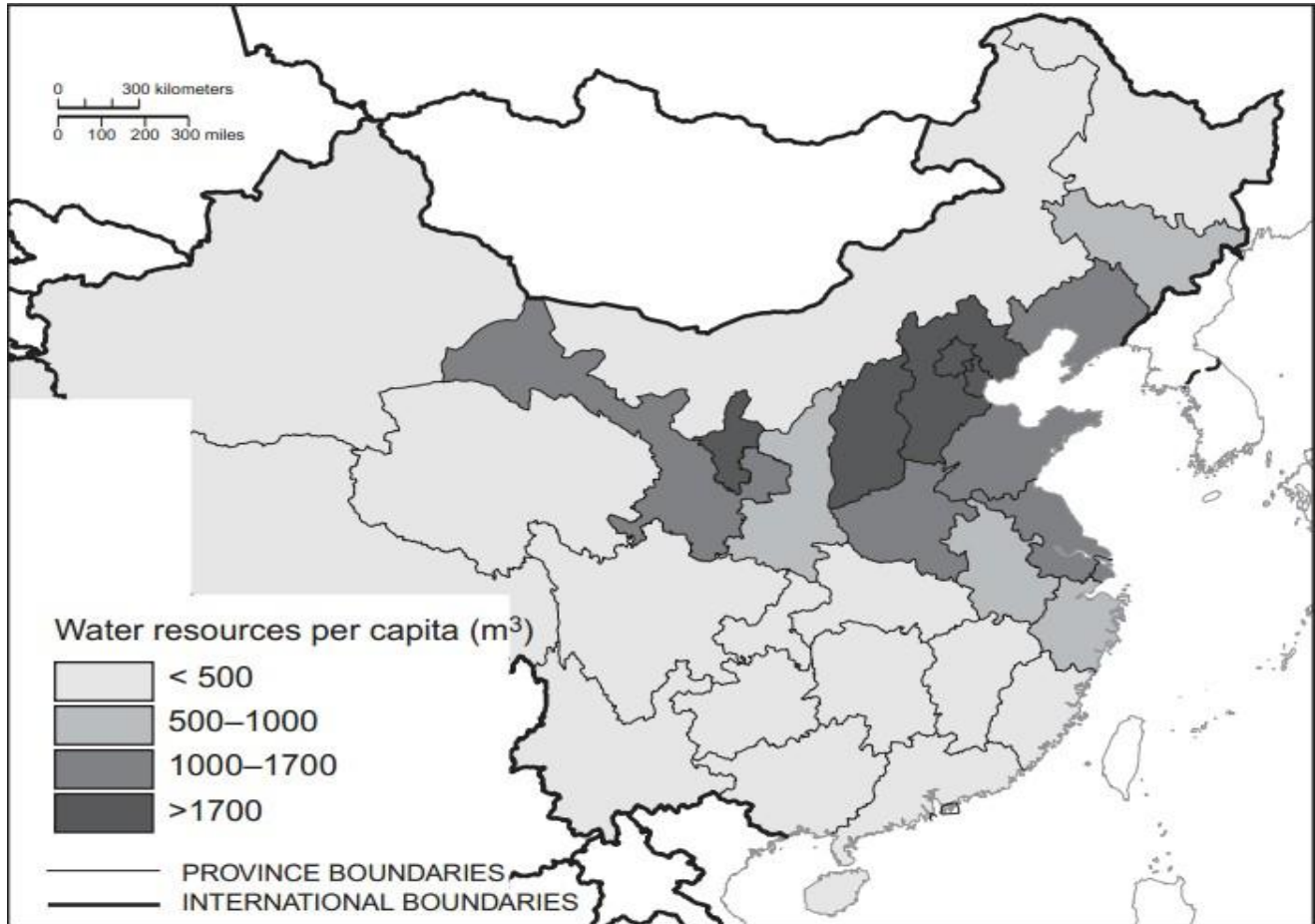


Figure 1. Spatial distribution of annual per capita water resources in China (Source: The World Bank (2007a)).

to achieve a combination of measures for resolving problems, so that measures covering environmental protection should be compatible with economic development. Practical measures to address China's pressing problems have been described within its Programme for Agenda 21 (1994).

China's total annual renewable water resources amount to about 2,812 km³, the sixth largest in the world. Its annual per capita freshwater resources, of about 2,156 m³ in 2007, was among the lowest in major countries (Data from AQUASTAT, a global information system on water and agriculture developed by FAO). In 2005, China's total consumption withdrawals were 563 km³. Surface water accounted for 81.2% of withdrawals, groundwater accounted for 18.4%, while 0.4% came from other sources (China Statistical Bureau, 2006). While China as a whole is a water-stressed country, the severity of the problem is worsened by the uneven distribution of the resource, both spatially and temporally (Figure 1).

The irrigation sector contributes an enormous amount to the Chinese economy, and indeed, irrigation feeds the world. Nevertheless, a lot of people are critical of irrigation, especially because of the inevitable or almost

inevitable build-up of salinity. All irrigation systems have within them the potential seeds of their own destruction. However, the users are aware of that risk and are better able to manage it.

The key focus of the National Water Initiative is Chinese water policy. As politicians, they would describe the purpose of the policy as '...to ensure that we have a secure and sustainable water for the future' (<http://www.mwr.gov.cn/>).

The National Water Initiative recognizes that people have been over-exploiting a scarce resource. In the view of many, the resource itself is diminishing because of climate change (Pittock, 2011). The key to the National Water Initiative is a shared vision. It seeks to ensure that the future of Chinese water is secure and sustainable. How does it do that? It seeks to balance allocation between consumptive use (water used in large measure for agriculture but also for industry, towns, mining and so forth) and the environment (Wang et al., 2011). Chinese should not so exhaust their rivers, their ground water and their wetlands that the environment continues to suffer, as they have done in some of our larger river systems, all in the name of providing for consumption.

Getting this balance right entails a reallocation of water; this is a very controversial issue in agriculture. Everyone has a proprietary feeling about their water; nobody likes their entitlements or allocations being reduced. There has been a very painful structural adjustment process recently, particularly relating to ground water. But it is something that has to be done. Chinese have to get the consumptive share right, and then, they have to share appropriately the risks: the risk of science concluding that the share needs to be shifted one way or the other, or of climate change reducing the overall amount of water that is available.

Chinese are trying to reallocate the cake while the cake is diminishing, which adds to the pain and stress within their rural communities. It is important to look beyond Chinese borders from time to time, as others face challenges similar to theirs. Of particular interest is the water challenge in Northern China and India, where the over-extraction of ground water is placing the agricultural production which feeds hundreds of millions of people, at a very grave risk. The over-extraction of ground water and the failure to recognize the interaction between ground water and surface water is one of the key issues that people have to grapple with all over the world (Shrestha et al., 2011). They are grappling with it now in Australia. Chinese have not fully recognized or accepted that surface water and ground water is really the same water in most cases; a mega litre taken out of the ground will almost certainly result in a mega litre not finding its way to a stream. More importantly, reduction in stream flow may be postponed for many decades (Viviroli et al., 2011). You may have seen photos, by Rick Evans, a hydrologist (http://www.skmconsulting.com/Markets/environmental/Staff+Profile_Rory+Nathan.htm), of the impact of over-extraction of ground water in parts of the United States where the streams of whole regions have dried up; even when it rains, they still do not flow because they have become losing streams rather than gaining streams. In other words, the water table has been depleted so much that even when water runs into the stream, it is then mobilized to top up the ground water.

Beyond that, people have to take account of climate change and the extent to which it may potentially reduce the total water yield. But equally well, they have to manage climate variability, whose breadth, as they saw in some charts (Yang et al., 2003), has been quite substantial between the national drought, the 1998 flood, and the drought they are currently having. That means they have two sets of 'noise' that they must accommodate, one being a short-term periodic one (natural variability) and the other being one with what they assume to be a longer evolutionary time-frame (climate change).

It has also been claimed that there is a lack of transparency in the decision-making process for quantity/quality management, insufficient public participation and information disclosure, poor communication, and lack of

involvement of stakeholders in basin or sub-basin organizations (Laghari et al., 2011). But, model river basin legislation has been developed for the Fen River in Shanxi Province, a major tributary of the Yellow River. The Shanxi Environmental Protection Bureau (EPB) is said to be considering issuing an Amendment of the Regulation on the Prevention and Control of Water Pollution in the Fen River Basin using the model legislation as a draft (Wang, 2004). This has identified several key problems in the existing national legislation such as the lack of cross referencing among a number of national laws and presumably offers remedies. It would seem worthy of wider circulation.

NATIONAL WATER RESOURCES MANAGEMENT

The right to water is also an integral part of other human rights, such as the right to life, which is contained in the International Covenant on Civil and Political Rights, 1996 (ICCPR), and the rights to health, food, housing and an adequate standard of living, which are included in the ICESCR. These rights are also provided for in a series of other international and regional treaties.

Declaration of Amsterdam (Second International Water Tribunal, 1992)

Article 1: All members of present and future generations have the fundamental right to a sustainable livelihood including the availability of water in sufficient quantity and quality.

An established goal of WHO and its Member States is that: all people, whatever their stage of development and their social and economic conditions have the right to have access to an adequate supply of safe drinking-water (Wang et al., 2005). In this context, 'safe' refers to a water supply which is of a quality which does not represent a significant health risk, is of sufficient quantity to meet all domestic needs, is available continuously, is available to all the population and is affordable. These conditions can be summarized as five key words: quality; quantity; continuity; coverage; and cost (Foster et al., 2004).

In Shen Dajun's account of water rights in China, it appears that at the level of individual farmers or groups of farmers, water rights per se do not exist (Shen and Speed, 2009). It has been suggested that eventual use rights, beneficiary rights and disposal rights might be exclusive, transferable and enforceable but without there being any ownership rights, which remain with the state. Currently, there are simply priorities to guide water use, once basic human needs have been satisfied, namely:

Water source area priority—host area first

Food security priority—important for maintaining social stability

Water use efficiency priority—used based on highest value

Investment capacity priority—allocation based on those with ability to fund projects

Current water use priority—consideration of current use
Basis for changing priority—expected to vary with social, economic and water resource development.

In 2002, China's Ministry of Water Resources initiated a pilot project in Zhangye City in Northwest China. The project was designed to establish a new water use rights system with tradable water quotas with the hope of reallocating water resources more efficiently through market-based instruments (Zhang and Zhang, 2008). However, the tradable water right system is not well enforced. AWM (Association of Water Management) practitioners face specific pitfalls when confronted with complexity. These relate to the inscrutable nature of complex systems, which tend to encourage opportunistic behaviour such as rent-seeking and corruption. These 'principal-agent problems' often result in the misallocation of scarce (water) resources and discriminate against poor rural people. A special attitude is required, namely awareness of the limits of professional expertise (Huppert, 2008). Based on both primary and secondary data, we find that mutual monitoring can improve the effectiveness of a water allocation and trading program (Chong and Sunding, 2006).

For both surface water and groundwater irrigation systems, the conditions needed to stimulate mutual monitoring include: (1) a hierarchical management system; (2) well defined water rights or quotas; (3) control of total water quotas and water sources by the upper hierarchy; and (4) an approximate balance between the water supply or pumping capacity and the water quota. We describe also the institutional requirements for stimulating mutual monitoring.

The first experimental site in creating a water saving society with transfer of water rights is being conducted now in Zhang Ye City. It is the first trial of water saving water by identifying water rights of farmers ("http://news.xinhuanet.com/newscenter/2004-03/22/content_1378785.htm."). This water rights system identifies farmers' water rights and this can prompt them to save water. In the Ning Xia and Inner Mongolian irrigation districts, they have developed a water rights system in which water rights can be transferred between different sectors. In this way, an agricultural saving water system can be sponsored by industry, such as by building high quality canals to reduce water seepage. This benefits the farmers and they can sell their water savings to factories. Then factories can use the water saved from agriculture to enlarge their own production. Before this, farmers used water without careful consideration and everyone wanted more water to irrigate, so more soils became salinized. In Ning Xia and Inner Mongolian irrigation districts, 90-96% of water is used for agriculture

and there is serious waste of water (Perry, 2007). On the other hand, industry needs more water to survive, so establishment of a water rights transfer system is urgent. Public participation evokes contradictory responses by the government. New regulations have recently been issued that seem to encourage public participation in some environmental reviews, while others restrict non-governmental and non-Chinese organizations from monitoring and reporting on water issues. The difficulty of obtaining independent information on water supply, use, and quality has recently been worsened by increased government control over the hydrologic activities of nongovernmental actors, and non-Chinese scientists and organizations, ostensibly to protect "national security" (Gleick, 2008). New regulations took effect in mid-2007 requiring official governmental approval of any hydrological monitoring and reporting. The regulations also state that water data must only be released to the public by "relevant government department or authorized hydrological organizations," which permits total control over the release of independent assessments and monitoring.

On 22 March 2004, the State Council issued the "Guidelines for Full Implementation of the Law", which requires the disclosure of government information. According to the Guidelines, "Apart from national secrets, business secrets and private matters, the administrative institutions should disclose and allow the public to review governmental information." When discussing how to build a complete, science-based and democratic decision-making mechanism, the guidelines requires the government "to clearly define the administrative decision-making power of all levels of governments and government departments, and improve the regulations for internal decision-making. Establish an administrative decision-making process which combines public participation, expert review and government decisions. Practice law-based, science-based and democratic decision-making."

Meanwhile, the Guidelines require that "the procedure of administrative decision-making should be improved. Besides state secrets, the items of decision-making, the arguments and the results should be disclosed and accessible to the public. The information should be disclosed to the general public through seminars, hearings and evaluation meetings to collect opinions for the projects that involve the wider public and are closely related to the people's interests. Legality assessment should be conducted for the major administrative decisions during the decision-making process." In 2005, people are informed that the Nujiang's hydropower planning has been reviewed by the planning and environmental departments. However, so far the EIA and related documents concerning the Nujiang project still have not been disclosed (Li, 2005). There is still no way for the public to learn how the developers and local government plan to avoid environmental damage, or to arrange proper relocation, or to assure the safety and economic feasibility of the dams. We believe that it does not fulfill the legal requirements for such a major plan if it

Table 1. The intrinsic value in China.

| Intrinsic value | |
|------------------------------------|--|
| Adjustment for societal objectives | |
| Net benefits from indirect uses | |
| Net benefits from return flows | |
| Value to users of water | |

bypasses the public participation requirements in Chinese law. The decision-making under such circumstances lacks the public support and cannot tolerate history scrutiny.

Both these examples highlight the shortcomings of administrative reallocation decisions and the problems associated with inadequate water property right and institutional structures. Given that water reallocation mechanisms based on direct administrative intervention rarely lead to economically efficient outcomes, it is likely there are economic benefits to more-formal market structures. Further, by their nature, more formal market structures will provide the mechanism to transparently reallocate water and resolve disputes using legal institutions. If farmers in water-exporting regions had the property rights to transfer water, income from water sales would more than offset the forgone income from reduced agricultural production. The income from water sales is estimated to be around 500 million Yuan per year (Michelsen, 1994). In the absence of property rights, the lost value of agricultural production lowers farm household incomes substantially. Conversely, with revenue from the sale of water, farm household incomes in the exporting regions would rise substantially. Importantly, without compensation, the regions with the lowest incomes are likely to be affected the most by water transfers.

Water can be reallocated by using a number of means, two of which have been considered here—administrative reallocation and free water trade (Zheng et al., 2011). While it may be theoretically possible to reach an economically efficient outcome by administering water reallocation, there are number of barriers that prevent this from happening in practice. For example, the information requirements are demanding. Information asymmetry between the administrative body and irrigators on the marginal value and opportunity costs of water means that allocation decisions would be made based on imperfect information about where the greatest benefits can be generated.

Water markets, on the other hand, coordinate price signals and disperse information and preferences. Water markets would provide a mechanism to transfer water to higher-value uses on a large scale and to the other productive uses, such as industry, and the environment. For formal water markets to work efficiently, property rights to water must be private exclusive and transferable.

Secure ownership provides the incentive to invest in human or physical capital to improve the productivity of the resource. Transferability provides the flexibility to reallocate the rights according to the changing demand and other conditions. The role of the state is to protect these property rights by enforcing contracts and reducing transactions costs and other barriers to exchange (Heaney et al., 2006). However, legislation, institutions and the necessary regulatory framework to support water reallocation do not currently exist in the Yellow River Basin (Briscoe, 1997).

The value of water in alternative uses is important for the rational allocation of water as a scarce resource (using the “opportunity cost” concept), whether by regulatory or economic means. Charging for water is applying an economic instrument to affect behaviour towards conservation and efficient water usage, to provide incentives for demand management, ensure cost recovery and to signal consumers’ willingness to pay for additional investments in water services (He and Chen, 2005). The full value of water consists of its use value—or economic value—and the intrinsic value. The economic value which depends on the user and the way it is used, include: value to (direct) user of water, net benefits from water that is lost through evapotranspiration or other sinks (e.g. return flows), and the contribution of water towards the attainment of social objectives. The intrinsic value includes non-use values such as bequest or existence values (Table 1).

The full cost of providing water includes the full economic cost and the environmental externalities associated with public health and ecosystem maintenance. The full economic cost consists of: the full supply cost due to resource management, operating and maintenance expenditures and capital charges, the opportunity costs from alternative water uses, and the economic externalities arising from changes in economic activities of indirectly affected sectors (Table 2).

China is the only country that has legislated a ‘resources’ charge for certain classes of water diversions (Wouters et al., 2003). This charge earmarked for improved resources management purposes is independent of any costs of providing the services. However, at the time examined (1998), records were unreliable/unavailable regarding the application and actual recovery rate. But it appears that any funds that were collected were deposited in the provincial general

Table 2. The economic externalities in China.

| | | | | |
|--------------------------------|-------------|--|--|------|
| Environmental externalities | | | | Full |
| Economic externalities | | | | Cost |
| Opportunity cost | | | | |
| Capital charges | Full supply | | | |
| Operation and maintenance cost | Cost | | | |

revenues account. The current status of this policy and its application is unknown (Fredrickson, personal communication). This charge presumably partially reflects a need for contributions to the cost of reservoir construction on major rivers. Since many reservoirs have hydropower, irrigation, flood control as well as water supply benefits, apportioning these separately would appear difficult.

‘There has been “strong public reaction” to the price increases in some cities’, the National Development and Reform Commission said in a notice in early July 2009.

Some local news reports have suggested the price increases are being driven more by corporate greed than a real need to conserve water. The agency, which supervises the prices of regulated goods like water, said local governments need to take public concerns into account as they plan for necessary price increases. The eastern city of Nanjing raised residential water prices by 12% in April but also rolled out subsidies to reduce the impact on low-income households (“Water Tariff Raise in Xi’an http://www.xawb.com/gb/news/2007-03/02/content_1126532.htm.”).

The rise in water bills has upset consumers even in cities where rates have not been rising before. Zheng Hong, a lawyer in Beijing who lives with seven family members, says his household spends 60 to 70 Yuan (\$ 8.78 to 10.25) a month for tap water. He is against any price increases. “The lower, the better,” he says. “Compared to my hometown in Henan province, the water prices in Beijing are already pretty high” (Batson, 2009).

Chinese laws are arranged in a hierarchical ordering, in which laws of a higher level always supersede the laws of a lower level when there is a conflict. Lower level laws must be as or more stringent than higher level laws, but may not be less stringent. Legislation ranges from the Constitution of the People’s Republic of China at the top, to local methods and technical standards, at the bottom... Beneath laws are regulations. These are issued by the State Council and its ministries, and tend to be more technical and specific than laws. Local laws and regulations are often based on national laws and seek to implement national laws.

Rules, resolutions, standards and methods rank lower than regulations. Ministries and agencies under the State Council may formulate these. Rules tend to be more administrative and methods more technical, while standards provide numerical bases for compliance that

methods. As of 1998, over 100 environmental rules and methods, and 350 standards have been issued, primarily by local government (Sheng, 2005).

Hierarchical ordering of Chinese legislation

The classification according to legal status and force from highest to lowest is as follows (Figure 2):

- 1) The Constitution of the PRC
- 2) Basic laws (jiben fa) enacted by NPC
- 3) Other laws (falv) from NPC Standing Committee
- 4) Interpretations of the Constitution and basic laws (lifa jieshi) issued by the Standing Committees
- 5) National administrative regulations and other documents having the force of law issued by SC (xingzheng fagui) made by the State Council
- 6) Ministerial regulations, national standards (guojia biao zhun) and rules(bumen guizhang) issued by national ministries and commissions
- 7) Regulations (difang fagui) issued by People’s Congresses (and their standing committees) at the sub-national level, consistent with national legal enactments
- 8) Resolutions released by Provincial Governments and their different departments
- 9) Regulations and other legal orders known as difang zhengfu guizhang issued by the executive branch of people’s governments at the sub-national level
- 10) The resolutions and determinations made by local power body and administrative body at different levels below the provincial level
- 11) Technicality regulations and standards with legal force

Some problems with Chinese laws include:

- 1) Overly general laws: Many laws are written without detailed explanation of the agencies responsible for certain activities. Lack of reference to implementation means that, in many cases no actor is appropriately assigned to oversee regulations. Additionally, a lack of clear definition of legal terms also allows agencies to avoid performing their duties.
- 2) Overlapping laws: Laws overlap when new regulations fail to replace old regulations, creating confusion and conflict. For example, the introduction in 1993 of a volume-based charge on industrial wastewater... did not replace the existing non-compliance charge.

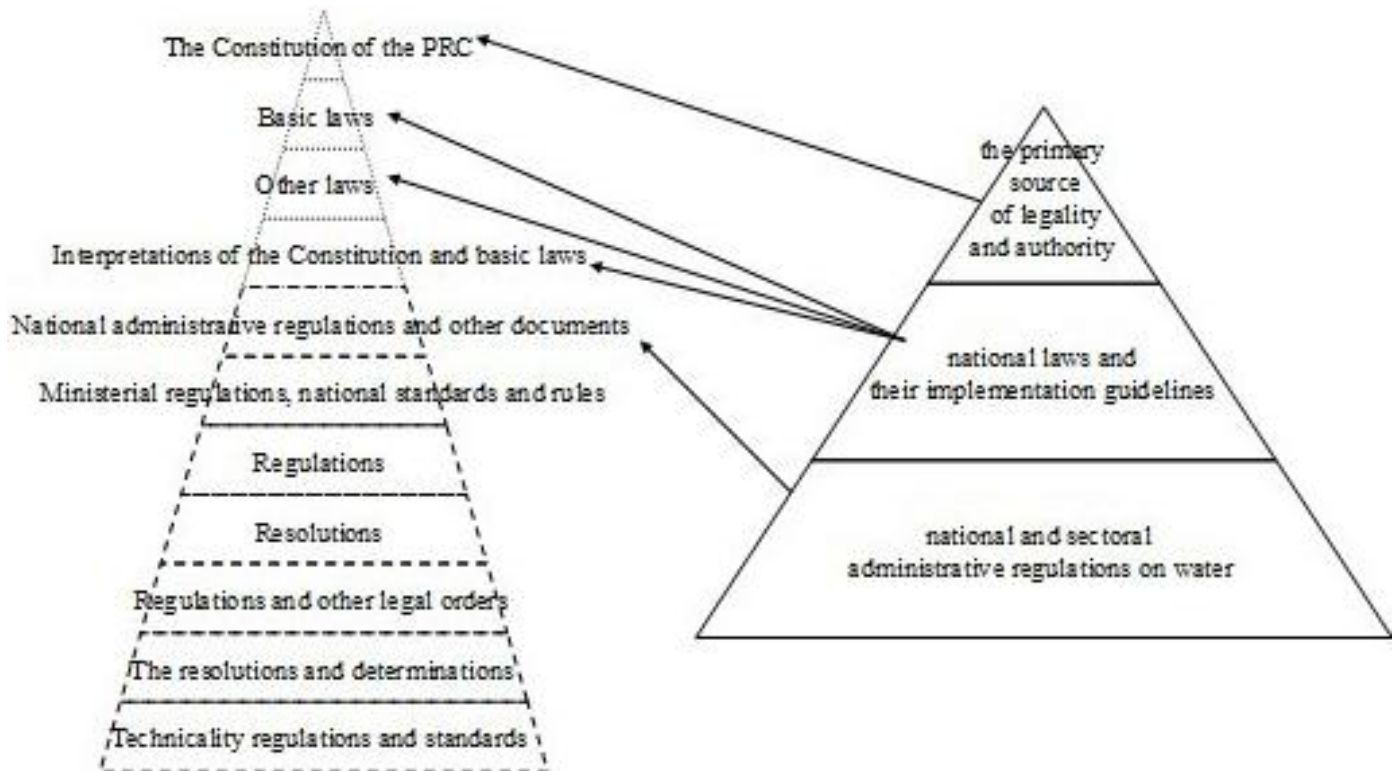


Figure 2. Technicality regulations and standards in China.

3) **Conflicting laws:** Laws conflict when they are established by different organizations without consulting with each other. For example, some contents and articles in the Procedure for Water Use License System and Regulations of Water Quality Management for Water Use System promulgated by the MOWR directly conflict with Regulations for Urban Water Demand Management and Regulations for Urban Groundwater Exploitation Management promulgated by the MOC.

4) **Poor promulgation:** Poor promulgation and announcement of laws and legislation often means that responsible agencies are not made aware of them. Often these laws are not even known to the legal profession and are even less well known to officials throughout the county who are responsible for administering them" (Hou, 2001).

Conflicting interests of the Ministry of Construction and Ministry of Water resources have been resolved by the creation of Water Affairs Authorities in the major cities of Shenzhen and Shanghai. Altogether four governmental executive bodies were entangled in water-related affairs management. Consequently, functions of the water administration body were weakened. In July, 1993, the innovative Shenzhen Water Affairs Authority was created, which had been based on a full-scale and in-depth investigation by taking reference to Hong Kong's experience. A three level administration system was established. The urbanised and rural areas were integrated, all related sectors were coordinated to form a unified

water affairs management pattern, realizing unified management of surface water, groundwater, rain-fall and tap water. It was realised during the innovation of water management system that a legal system should be built accompanying the establishment of the new system (Lin, 2000). These include: Shenzhen SEZ Water Re-sources Management Regulation, Shenzhen SEZ Water Supply Regulation, Shenzhen Water and Soil Conservation Regulation, Shenzhen SEZ Drinking Water source protection regulation, Shenzhen S EZ River Channel sand dredging regulation, Shenzhen SEZ regulation of secondary supply of drinking water, Shenzhen SEZ Flood Control and wind prevention regulation, Shenzhen SEZ Regulation for turnover of Customers' Water Supply facilities, Shenzhen Water Charge collection regulation, Shenzhen Water Resources fund management regulation and more. Unified management of water affairs by the sole administration body has been clearly defined in the local laws and regulations.

China's central government has embraced the "scientific concept to development," which emphasizes the balance between economic development and environmental sustainability. But some local officials still prioritize gross domestic product (GDP) growth over environmental protection, partly due to the current evaluation system of political performance. The evaluation system is being restructured by introducing the new concept of green GDP, which would calculate the

environmental and ecological cost along with the economic growth. Achievements may be offset if the cost is too dear.

The State Environmental Protection Administration (SEPA) and the Organization Department of the Central Committee of the Communist Party of China, which is in charge of Party officials' promotion, are studying how to incorporate environmental parameters into evaluating an official's performance, such as overall environmental quality based on public survey, quality of air and drinking water, forest coverage and so on. While the "economy-goes-first" mentality lingers on the minds of many local officials, environmental departments are expected to be watchdogs to form some counter-balance. But this is not easy to realize in reality, as local environmental protection bureaus remain part of the local government, which controls their budget and staff, instead of reporting directly to SEPA.

To change this situation, reforms in power structure have been started on a trial basis. For two years the provincial environmental protection administration of Shaanxi in northwestern China has required the local environmental bureaus at city and county levels to directly report to the provincial administration instead of local governments, so as to guarantee their independence to enforce environmental laws and regulations despite local administrative interventions. Similar experiments have been carried out for the past ten years in dozens of large and medium-sized cities nationwide, such as Dalian, Ningbo and Xiamen. Further steps are being considered for SEPA, the theoretically highest body to enforce environmental laws and regulations, to set up monitoring mechanism directly at major sites of significant ecological or geographical values, lest local bureaus fail to function as they should.

The department of water administration under the State Council shall be in charge of the unified administration and supervision of water resources at the national level (Li, 2011). The river basin authorities, set up by the department of water administration under the State Council, for the important rivers and lakes (determined by the state) shall, within their jurisdictions, exercise the water resource administration and supervision provided by laws and regulations and authorized by the department of water administration under the State Council. The departments of water administration in the local governments at and above the county level shall, within the limit of their authorities, be in charge of the unified management and supervision of water resources.

The relevant departments under the State Council (Ministry of Water Resources, the other Ministries and Commissions under the State Council, such as National Development and Reform Commission, Ministry of Agriculture, Ministry of Land and Resources, Ministry of Environmental Protection etc) shall, in conformity with the division of their duties, be responsible for work relating to the development, utilization, conservation and protection

of water resources.

The relevant departments under the local governments (Department of Water Resources, the other Ministries and Commissions under the local governments, such as Local Development and Reform Commission, Department of Agriculture, Department of Land and Resources, Department of Environmental Protection etc) at or above the country level shall, in conformity with the division of their duties, be responsible for the development, utilization, conservation and protection of water resources within their administrative regions.

IMPROVING INTEGRATED WATER RESOURCES MANAGEMENT (IWRM): HOW FAR CAN WE GO?

Despite the fact that some aspects of water resource management need improvement, only a small portion of the Water User Associations (WUAs) provides incentives to improve water management (Wang et al., 2012). There is little participation by farmers in any of the management activities, even in villages with WUAs, and many WUAs have close ties with the village leadership. Policy makers seeking to deepen reform efforts in China should focus on providing incentives and increasing farmer's participation (Table 3).

We have also endeavored to explain why some villages have chosen to retain collective management, while others have decided to form WUAs or engage in contracting. At least three implications are evident. First, locality matters: regression results show that villages are more likely to reform when water is relatively abundant and when the village canal network is relatively large. Hence, in China's future design of water management reforms, policy makers should consider the local conditions of villages and be aware that not one reform path fits all villages. Second, local governments play important roles. When the county level or the township level governments promoted either WUA or contracting, most villages reformed. Thus, policy makers should continue to rely on local governments to move the reform in a direction that can address China's water problems faster and better. Third and probably most significantly, water management reform alone is not adequate to address China's water scarcity problems.

Institutional reform has not occurred in the most water scarce parts of China (Huang et al., 2009). If the main policy goal is to save water, policy makers must look beyond water management reform. A more comprehensive strategy, which combines water management reform with other complementary policies (such as water pricing), may be more effective.

For irrigation to prosper in the long term, there needs to be continuing access to sufficient water of adequate quality, with low salt content, being the primary quality concern. There is thus a coincidence of irrigator and river environment concerns with respect to managing salinity

Table 3. Potential key interests of stakeholders.

| Direct stakeholder | Potential key interest |
|-----------------------------|---|
| Infrastructure owner | Preserve and increase value of infrastructure |
| Water user | Right to define service and ensure performance standards |
| Payer | Low cost, cost efficiency, commensurate benefits |
| Service provider | Protect work opportunity, profit, minimize complaints |
| Indirect stakeholder | |
| Regulator | Policy compliance, containment of conflicts, prevention of resource depletion and environmental degradation |
| Agribusiness | Business opportunities, income, capture markets |
| Consumer | Low crop prices, availability of produce |
| Competing user of resources | Protect water, land, forests; preserve quantity and quality of resources. |

in the rivers. Beyond this, irrigators do not have primary vested interest in the condition of the river or the dependant riverine ecosystems. Their engagement in the public discussion on the state of the rivers is to ensure that their interest in water supply is maintained through access and allocation policy. The public discussion is largely centred on the perceptions of the net benefits of using water to maintain river and near-river ecosystems relative to irrigated production. Apart from tourism and recreational activities, the attributes being promoted are aesthetic and cultural – values that can be held equally by irrigators and non-irrigators alike. To assure continuity of supply, irrigators need to win the hearts and minds of the voting public so that there is a shared sense of fair and equitable balance of water access and benefit opportunity. To this end, irrigators will need to become more involved as managers of the rivers, where management is more than ensuring the supply of water for irrigation.

Another issue is irrigation efficiency. The Chinese Government Water Fund will be supporting some innovative demonstration projects in that regard, and people will have to watch for those. Water lost upstream is potential water for people to use downstream. The key to irrigation efficiency, however, is the market: and that is why trading is so important. The more water is valued, the more it will tend to be used efficiently, because things that are cheap or undervalued are used less prudently than those that are highly valued.

The Chinese Vice-Minister of Water said in northern China that they had virtually outlawed flood irrigation and were moving to dripper techniques, and in this change they were working with the Israelis (Zhai, 2005). Why has Israel been a leader in irrigation efficiency? It is because it has so little water. Water is used most efficiently where there is least of it.

The cleaner production technology training workshop was co-hosted by the EU-China River Basin Management Programme (RBMP) and the Shaanxi Provincial Bureau of Environmental Protection (EPB) in Xi'an from November

12 to 13, 2008. The participants are the government officials and experts from EU, the Chinese Ministry of Environmental Planning, Yellow River Basin Water Resources Protection Bureau and the Shaanxi Provincial Bureau of Environmental Protection. They discussed with the representatives from the local industries along the Wei River on how to use the clean production technology and recover the Wei River's water quality. Being the largest branch to the Yellow River, the Wei River in Shaanxi suffers from severe pollution and ecological deterioration as a result of discharges of wastewater from Industry, cities and agriculture in the catchment. Thus, it has become the pollution source to the Yellow River (Ghadouani and Coggins, 2011). The poor water quality represents a hazard to the health of people reliant on this watercourse for their life and livelihood. The uses for which the water is suitable have become limited and the costs of treating it to become useable have risen, limiting and constraining development in the region.

A particularly egregious (very bad) example of poorly coordinated water pricing is found in Xi'an City and its surrounding area in Shaanxi Province, where water shortages are severe and worsened by water pollution. Drinking water and sewage tariffs in Xi'an City were 1.95 and 0.36 yuan/m³ respectively in 2005 (Xie, 2009). In the same period, the drinking water price in Jiaokou, which is downstream from Xi'an, was reported to be as high as 15 Yuan/m³ because the Wei River was heavily polluted and local residents had to transport drinking water from the city. Yet for a nearby papermaking mill just across the Wei River, which relied on groundwater, its cost was only 0.08 Yuan/m³ (ADB, 2005)".

The Central Government and Provincial Government have stated their clear intention that the improvement of water quality is an important priority under the scientific concept of development and for the establishment of a Harmonious Society. Binding targets have been set for the reduction in pollution in the province. The regulations relating to discharges have been revised and the attention to enforcement increased. However, meeting the

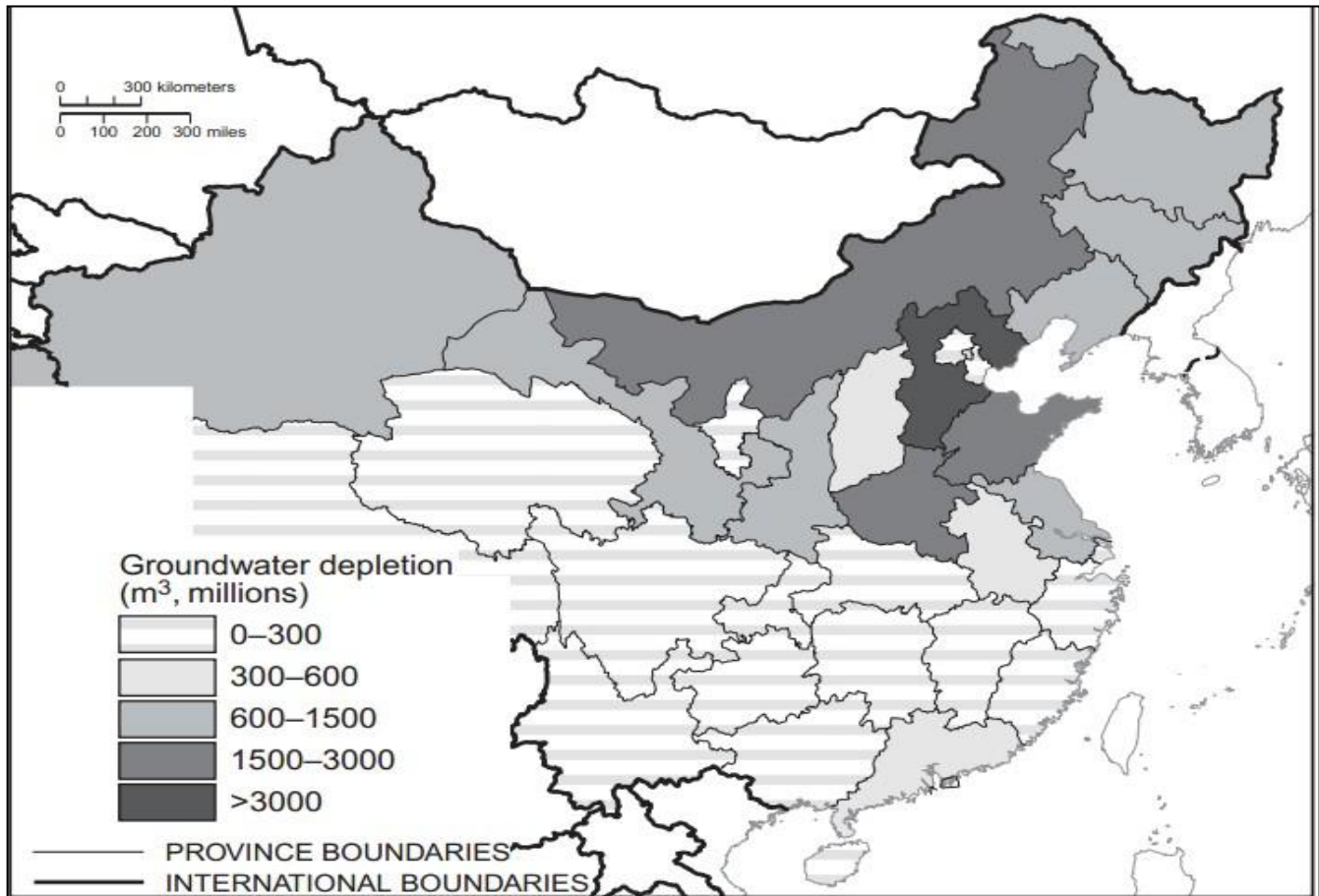


Figure 3. Groundwater depletion by province (million m³). Source: Adapted from World Bank (2007a), which was originally from Ministry of Water Resources.

objectives for reduced pollution will require investment in new technology, processes and infrastructure. It is now necessary for Chinese enterprises to take the next steps towards taking responsibility for their environment and building sustainable operations. This event focused on helping some of the key industries which are engaged in economically productive activity to gain a better understanding of the requirements they are facing from the EPB in Xi'an and the technological options for meeting those requirements. Chinese will draw from EU experience to describe how industry in the EU has successfully made the transition to better environmental performance.

The success of any of these agricultural water-saving measures in reducing the decline in aquifer water levels depends directly on the efficacy with which the reductions in irrigation demands can be translated into corresponding permanent reductions in water-well abstractions (Shah et al., 2003). It is essential that agricultural water savings in some fields are not simply transferred to expand the overall area under irrigation, or to increased water use in other sectors (Figure 3). For this purpose,

there are various institutional (socio-political and organizational) issues which must be addressed:

- 1) farmers need to be well informed on the benefits of adopting more-efficient irrigation methods and need to grasp fully the 'real water saving' concept;
- 2) local groundwater resource managers need to appreciate the need to set targets for WUAs on reducing abstraction;
- 3) closer linkages must be established between the agricultural extension service promoting water-saving measures and the process of issuing groundwater abstraction permits;
- 4) groundwater abstraction needs to be put on a sound legal footing, by comprehensive implementation of the existing law on water-well abstraction permits;
- 5) implementation of local water-well abstraction measurement and groundwater-level monitoring, and the dissemination of the information generated to water users;
- 6) provision of economic incentives (such as part financing and/or easy-access low-cost loan capital) for the installation of more-efficient irrigation technology;

7) a realistic 'groundwater resource fee' needs to be imposed, generating finance for aquifer management monitoring needs and serving as an incentive for reducing groundwater abstraction;

8) more emphasis on the 'new roles' required of the WRBs, in terms of support to WUAs for managing and monitoring the status and use of groundwater resources, and in public and political education and awareness.

The effluents from secondary municipal wastewater treatment plants and those from the lightly polluted domestic wastewater or grey water treatment facilities serving a building, a group of buildings or residential sub-districts, are being discharged into the dual water systems for multi-purpose uses, such as watering of gardens, parks and green belts, floor and car washing, and toilet flushing. At present, Shenzhen City, in the Guangdong Province, Qingdao City, in the Shandong Province, Dalian City, in the Liaoning Province, Beijing, the capital of China, and some other cities where water is scarce, have built some kind of wastewater reclamation and reuse plants and put them into operation. This reuse has produced water savings ranging from three to five percent in the respective cities (Xu, 2001).

Filtered and disinfected secondary effluent from some municipal wastewater treatment plants is applied to industries for various uses, such as cooling water, process water, hydraulic transportation of slag and ash, and injection to the oil fields for oil exploitation.

Some municipal treatment plant effluents are discharged into artificial lakes or creeks to be used for recreational purposes, such as fishing or boating.

These days, many cities of Northern China suffer from water shortages and the groundwater table below them has dropped sharply because of over-exploitation. For example, in Shijiazhuang City, where the groundwater is the main water source, the water table has dropped from 3 to 5 m in the 1950's to 35 to 45 m in the 1990's because of over-pumping (Bai, 2000). In 1996, this city had to change its main water source, from groundwater to surface water from two big reservoirs.

The irrigation of farmland using reclaimed municipal wastewater has proven to be an effective measure to raise the water table levels through slow infiltration of the effluent.

With many communities approaching the limits of their available water supplies, water reclamation and reuse have become an attractive option for conserving and extending available water supply by potentially (1) substituting reclaimed water for applications that do not require high-quality drinking water, (2) augmenting water sources and providing an alternative source of supply to assist in meeting both present and future water needs, (3) protecting aquatic ecosystems by decreasing the diversion of freshwater, reducing the quantity of nutrients and other toxic contaminants entering waterways, (4) reducing the need for water control structures such as dams and reservoirs, and (5) complying with environmental

regulations by better managing water consumption and wastewater discharges. Water reuse is particularly attractive in the situation where available water supply is already overcommitted and cannot meet expanding water demands in a growing community. Increasingly, society no longer has the luxury of using water only once (Khan and Mager, 2005).

Producing reclaimed water of a specified quality to fulfill multiple water use objectives is now a reality due to the progressive evolution of water reclamation technologies, regulations, and environmental and health risk protection. However, the ultimate decision to promote water reclamation and reuse is dependent on economic, regulatory, public policy, and more importantly, public acceptance factors reflecting the water demand, safety, and need for reliable water supply in local conditions.

The incentives for a water reuse program make perfect sense to technical experts—a new water source, water conservation, economic advantages, environmental benefits, government support, and the fact that the cost of wastewater treatment makes the product too valuable to "throw away" or dispose.

So, why has not the concept been embraced and supported wholeheartedly by the community? There is much to be learned about human side of politics, public policy, and decision-making associated with technological advances. As technology continues to advance and the reliability of water reuse systems is widely demonstrated, water reclamation and reuse must continue to expand as an essential element in sustainable water resources management.

POLICY IMPLICATIONS: EMERGING ISSUES

Increasing water scarcity and declining water quality must be addressed through water management reform, along with economic incentives for water-use efficiency, increased water investments, and a focus on increasing crop productivity through agricultural research and technology.

We address holistic synergies in water resources management. It will examine complex connections between such areas as governance, organizational responsibilities, knowledge and management of health hazards, technical choices, regulatory frameworks and criteria, and public responses and stakeholder consultation processes.

CONCLUSION

Finally, the paper highlighted the importance of differing technical, environmental and social drivers, whether for the need for survival and to minimize starvation, or whether to maximize profit in an enterprise, or even to ensuring the continuity of a government. There were many different drivers. Chinese need to understand how they can be best integrated to ensure that they do manage

their water resources successfully for the benefit of future generations.

All people now know that there are ways of managing Chinese water without damaging the environment and making poor people poorer.

China can benefit from developed countries sharing its technology and its hard-learned lessons. Future research needs to steadily build the case for change while equipping farmers, irrigation system operators and other water resource managers with the means to respond.

Chinese considerable expertise in integrated river basin management allows them to help China avoid the same problems in other countries. And their scientists' and farmers' pioneering efforts to reduce water use—whilst maintaining crop production and incomes—is paying dividends by freeing up water to maintain river health.

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