CHAPTER 5

China and Water

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The remarkable growth in China's population and economy over the past several decades has come at a tremendous cost to the country's environment. China has experienced an economic growth rate averaging 10 percent per year for more than 20 years. But sustained growth and the health of the country are increasingly threatened by environmental deterioration and constraints, particularly around water. Water is critical for economic growth and well-being; conversely, economic activities have an impact on water availability and quality. When water resources are limited or contaminated, or where economic activity is unconstrained and inadequately regulated, serious social problems can arise. And in China, these factors have come together in a way that is leading to more severe and complex water challenges than in almost any other place on the planet.

China's water resources are overallocated, inefficiently used, and grossly polluted by human and industrial wastes, to the point that vast stretches of rivers are dead and dying, lakes are cesspools of waste, groundwater aquifers are over-pumped and unsustainably consumed, uncounted species of aquatic life have been driven to extinction, and direct adverse impacts on both human and ecosystem health are widespread and growing. Figure 5.1 shows the major rivers of China. Of the 20 most seriously polluted cities in the world, 16 are in China. The major watersheds of the country all suffer severe pollution. Three hundred million people lack access to safe drinking water. Desertification, worsened by excessive withdrawals of surface and groundwater, is growing in northern China (Feng 2007).

These problems are threatening to slow economic expansion and weaken political stability in a variety of ways. Significant outbreaks of illness, including cancers, are being reported in heavily polluted regions, driving up health care costs and public concern. Companies are canceling business ventures because of water concerns. There is growing internal dissent and conflict over both water allocation and water quality, raising new political pressures on the central and regional governments to come to grips with water problems. In 2005, the Chinese government acknowledged that 50,000 environmentally related protests occurred that year, many of which were related to water degradation (Turner 2006). Even the official Chinese media has reported that "The pursuit of economic growth has been the priority overshadowing the vital issues of water resources and ecological balance" (China Daily 2007a). It is not yet clear how quickly the Chinese will get their severe water challenges under control, or at what ultimate cost to human and ecological conditions.

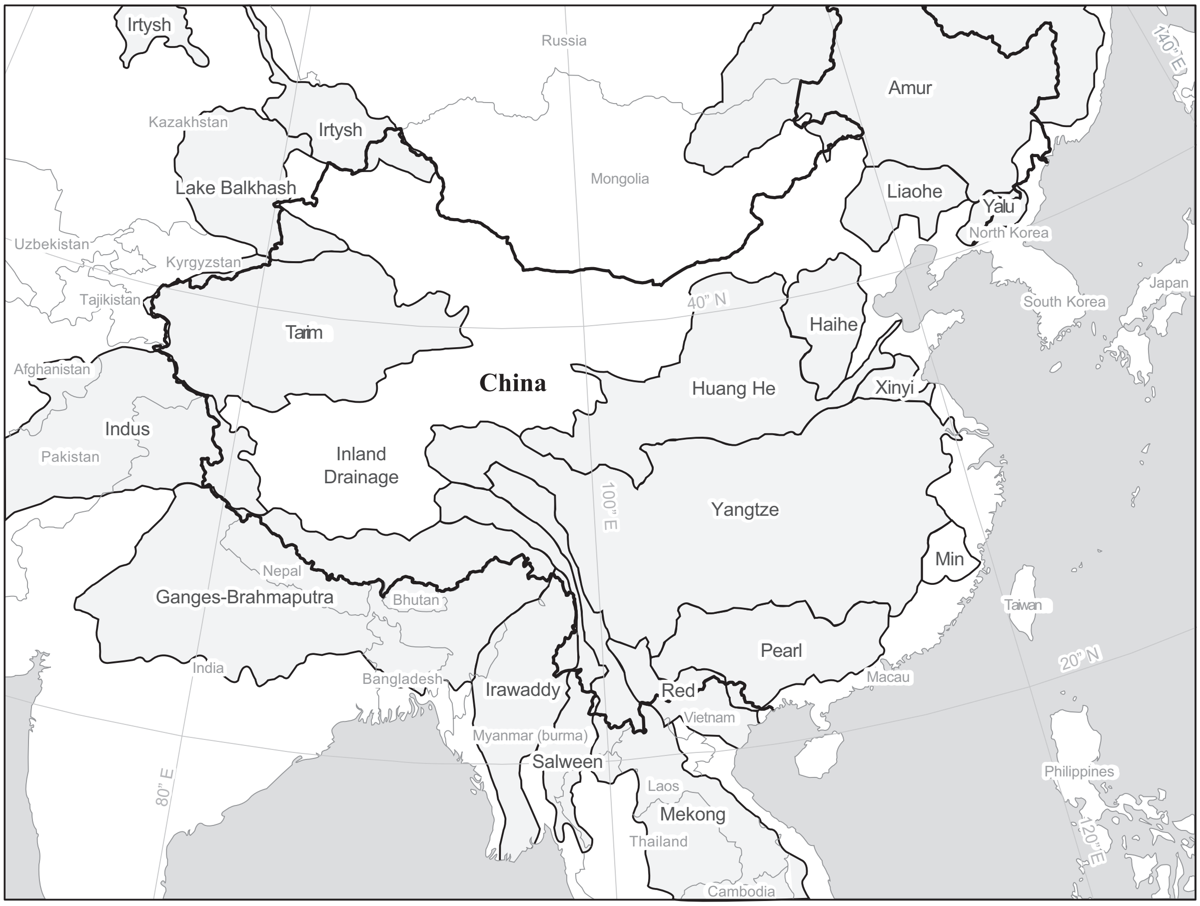

FIGURE 5.1 MAJOR RIVER BASINS IN CHINA.
Source: ESRI, USGS/WWF. Lambert conformal conic projection. Courtesy of Matthew Heberger.

Addressing China's crippling water problems is hampered by the efforts of local governments to protect local industries and jobs, government corruption, the desire to sustain rapid economic growth, and what has been described as the "crippling weakness" of the leading national environmental regulatory body, the State Environmental Protection Administration (SEPA) (Turner 2006). At the same time, these problems have encouraged public concern and efforts. Grassroots environmental efforts have grown in China and have had some success at raising awareness and spurring action, although nongovernmental organizations are still harassed and viewed with suspicion by officials. This chapter reviews the state of water problems in China and offers insights into new trends and efforts to address those problems.

The Problems

Water Quality

Comprehensive data on water quality in China are hard to find, either in English or Chinese, but there are growing indications of China's severe water contamination. The State Environmental Protection Agency (SEPA) publishes quarterly reports, but the consistency and accuracy of the data in those reports are uncertain. The World Health Organization (WHO) and the Organization for Economic Cooperation and Development (OECD) in Paris also publish data on water quality in China.

These data offer some snapshots: Chinese statistics estimate that 40% of the water in the country's surface waters was fit only for industrial or agricultural use, and even then only after some treatment. An estimated 20,000 chemical factories, half of which are along the Yangtze River, are dumping uncontrolled or only marginally controlled pollutants into China's rivers. In 2006, nearly half of China's major cities did not meet state drinking-water quality standards (OECD 2007), and a third of surface-water samples taken were considered severely polluted (Xinhua 2007f). The Tenth Five-Year Plan (2001–2006) mandated the construction of thousands of new wastewater treatment plants, yet a 2006 survey by SEPA revealed that half of new plants actually built were operating improperly or not at all (Boyle 2007). Groundwater quality is degraded by the routine and massive dumping of untreated or partially treated wastewater.

According to SEPA statistics, China experienced over 1,400 environmental pollution accidents in 2005, around half of which involved water pollution (Xinhua 2007j), and many incidents are never reported. In May 2007, the SEPA released its first quarter 2007 report indicating little improvement over time in China's seven main rivers, and it noted significant deterioration in water quality in the Songhua, Hai He, and Huai He rivers, and in Taihu, Chaohu, and Dianchi lakes, despite efforts to clean them up. According to this report, only 69 percent of key cities met national potable water standards (China Daily 2007s, Xinhua 2007p), an improvement from previous years but still problematic. Officially, Beijing tap water has been declared safe to drink under China's new national drinking water standards for 106 contaminants, but complaints in parts of the city indicate that local sources of contamination still affect quality, particularly the old distribution system that was put in place 50 to 60 years ago (China Daily 2007p).

As a consequence of these problems, the OECD estimates that hundreds of millions of Chinese are drinking water contaminated with inorganic pollutants such as arsenic and excessive fluoride, as well as toxins from untreated factory wastewater, inorganic agricultural chemicals, and leeching landfill waste (OECD 2007). In an extreme indication of the growing concern over water quality, local farmers in contaminated regions grow grain with poor quality water, sell that grain, and purchase grain from other parts of China they believe has safer water (Guo 2007). In the Huai He basin, widely acknowledged to be extremely badly polluted, there are numerous villages where no young men have been able to pass the physical examination for entering the Army, which some analysts ascribe to water-related illnesses and contamination (Economy 2004).

Poor water quality is having an impact on Chinese cancer rates. The Ministry of Health acknowledged in 2007 that air and water pollution (together with food additives and pesticides) helped make cancer the most lethal disease for urban residents in China. "The main reason behind the rising number of cancer cases is that pollution of the environment, water and air is getting worse day by day," said Chen Zhizhou, a health expert with the cancer research institute affiliated to the Chinese Academy of Medical Sciences. Reports on "cancer villages" have appeared more frequently in recent years, with clusters of cancers being linked to the use of heavily polluted water (China Daily 2007t).

These problems are increasingly well known in China, but despite rhetoric from officials, little progress has been made in reducing discharge of pollutants, according to Zhou Shengxian. Zhou is the director of the State Environmental Protection Administration (Xinhua 2007f). Efforts to clean up China's grossly polluted rivers have been

FIGURE 5.2 PROVINCES IN CHINA.
Source: ESRI, USGS. Lambert conformal conic projection. Courtesy of Matthew Heberger.

underway for more than a decade, with limited results. The Huai He remains heavily polluted despite major government investments and efforts of local and national authorities for more than a decade. Untreated wastewater volumes still exceed national standards; chemical oxygen demand remains high – 30 percent above targets, even by official statistics. Official data show that more than 4.4 billion tons of untreated or partially treated wastewater are dumped into the river annually (China Daily 2007k). Part of the problem is China's very large population. The Huai He, for example, runs through four major provinces, including Henan, China's most populous province, with more than 100 million people. Another part of the problem, however, rests with weak, incompetent, or corrupt public environmental agencies (see Fig. 5.2 for a map of China's provinces).

Water-Related Environmental Disasters in China

In the United States, much of the existing environmental legislation had its origins in environmental disasters, such as the burning of the Cuyahoga River, the Love Canal toxics catastrophe, and severe air-quality contamination events. Such disasters are now beginning to occur with disturbing regularity in China. As in the United States in the 1970s, these disasters are spurring social concern and political activism.

In 2005, a severe environmental disaster occurred on the Songhua River, when a chemical plant explosion in the city of Jilin contaminated the river with 100 tons of benzene-related pollutants. The contamination flowed downstream and forced the temporary suspension of water supply to nearly 4 million people in Harbin, the capital of Heilongjiang Province. It also led to contamination problems in the Russian city of Khabarovsk along the Heilongjiang River shared by China and Russia. This incident was covered extensively in worldwide media and led to new efforts on the part of the Chinese government to tackle water-quality problems (China Daily 2007o).

After the Songhua disaster, the government prepared plans to build over 200 "pollution control projects" along the Songhua River at a cost of nearly $2 billion. In Heilongjiang Province, the local government inspected 4,000 commercial and industrial enterprises and shut down a small number of them in an effort to cut the worst pollution. The city of Jilin in Jilin Province built a new sewage treatment plant to process a substantial amount of previously untreated waste. And new monitoring systems have been installed in the Songhua and Heilong rivers (Xinhua 2007h).

The benzene contamination incident in Jilin is not the only water disaster in recent years. Several incidents have caused the shutdown of local or municipal water systems (Eng and Ma 2006). A mere three months after this accident, a plant in Sichuan Province spilled toxins into the upper reaches of the Yuexi River, disrupting the water supply of 20,000 people in the city of Yibin (Turner 2006). According to statistics provided by the SEPA, another 130 water pollution incidents occurred after the Songhua River spill by September 2006.

In 2007, local reservoirs around Changchun City in Jilin Province suffered a blue-green algal outbreak attributed to pollutants from both industrial and agricultural sources, including both fish and pearl farms, which rely on heavy use of fertilizer and pesticides. Such outbreaks lead to the suffocation of native fisheries as the algae consume all of the oxygen in the water. The outbreak also threatened the quality of water, and led to a reduction in drinking water supply to the city of more than seven million. Similar blue-green algae outbreaks were reported in Taihu Lake, Chaohu Lake, and Dianchi Lake, threatening local domestic water systems, leading the director of SEPA order all fish farms to be removed from the three lake areas by the end of 2008 (Xinhua 2007m, China Daily 2007q).

In mid-2007, a series of water contamination incidents in Jiangsu Province in eastern China led to the cutoff of water supplies to millions of people. A severe blue-green algae outbreak affected tap water in the city of Wuxi. A subsequent surface water incident led to severe contamination by ammonia, lead, and nitrogen. That water apparently originated from industrial sources upstream in Shandong Province (China Daily 2007o, China Ministry of Water Resources 2007, Xinhua 2007m). Also in 2007, the city of Yan'an in northwestern Shaanxi Province was forced to shift water supply after the major reservoir for the city was polluted by crude oil from a broken pipeline that contaminated the Xingzihe River. Yan'an has a population of 2.15 million (Xinhua 2007k).

Water Availability and Quantity

China faces serious water challenges from constraints on water supply as well as deteriorating quality. China's per-capita annual renewable water availability is around 2,140 cubic meters compared to 1,720 m^3/p/yr in India and over 10,000 for the United

TABLE 5.1 Per-Capita Water Availability (Total Renewable Water Resources) (m^3/person/yr): 2003–2007 Average

China	2,138
India	1,719
United States of America	10,231

Source: 2008 FAO of the UN: Aquastat database, www.fao.org.

TABLE 5.2 Major Rivers in China With Their Average Annual Runoff

River	Length (km)	Drainage Area (km^2)	Average annual runoff (km^3)
Changjiang (Yangtze)	6,300	1,808,500	951.3
Huang He (Yellow)	5,464	752,443	66.1
Heilongjiang (Amur)	3,420	896,756 *	117.0
Songhua (Sungari)	2,308	557,180	76.2
Xijiang (Pearl)	2,210	442,100	333.8
Yarlung Zangbo	2,057	240,480	165.0
Tarim	2,046	194,210	35.0
Lancangjiang	1,826	167,486	74.0
Nujiang	1,659	137,818	69.0
Liao He	1,390	228,960	14.8
Hai He	1,090	263,631	28.8 **
Huai He	1,000	269,283	62.2
Irtysh	633	57,290	10.0
Luan He	877	44,100	6.0
Minjiang	541	60,992	58.6
Total		5,224,473	2,039.0

Notes:
* Including the Songhua River Basin
** Including the Luan He River Basin
Source: http://www.eoearth.org/article/Water_profile_of_China

States (Table 5.1). The distribution of water in China, as in other countries, is highly variable in both space and time. While parts of China have abundant natural water resources, other regions are naturally arid and water scarce; for example, northern China is far drier than southern China. China has several of the world's largest rivers, bringing water from the Tibetan Plateau and western China to coastal cities. Table 5.2 shows the major rivers in China along with their average annual runoff.[1] These rivers are unevenly distributed, with large rivers and flows in the south.

China has also long suffered from extremes of floods and droughts. Some of the worst floods on record, in terms of loss of human life, have occurred in China,

1. Westerners know China's rivers by different names than often used by the Chinese, such as the Yellow (Huang He) or the Yangtze (Changjiang). While this chapter tries to consistently use the Chinese names, some of the more familiar western names are used for some of the major rivers. Table 5.2 lists both the Chinese transliterations and the most common English names.

including a flood in 1930 that claimed 3.7 million lives. Half a million more people died in floods in 1939 and another 2 million died in floods in 1959 (Cooley 2006). And periodic droughts are worsening China's water-supply challenges, as described.

This uneven distribution, combined with China's extensive population, inadequate urban infrastructure, and poor management, have caused more than two-thirds of the country's more than 600 cities to suffer from water shortages. Over 100 of them are seriously affected.

Guangdong Province is located in China's southern subtropical zone and is relatively water rich compared to other parts of China. Yet even here water-quantity problems are developing as a result of inefficient and wasteful use combined with growing demand and drought. Quotas on water use for industry, agriculture, and residences are being imposed in the province for a 2-year trial period (China Daily 2007a).

These concerns over supply, along with growing overdraft of groundwater, are an increasing problem for Chinese officials and water managers and are driving investments in new infrastructure and demand management efforts. To make matters worse, large numbers of Chinese do not have access to safe water and adequate sanitation – a consequence of both water quantity and quality problems. In 2004, 88.8 percent of China's urban population reportedly had access to clean drinking water and 70 percent had access to adequate sanitation, but availability of both is significantly lower in rural areas and the data are self-reported (Ministry of Foreign Affairs 2005). Government officials acknowledged in 2007 that 300 million rural Chinese had no access to safe drinking water (Xinhua 2007i, Lee 2007).

The failure to meet basic human needs for water in China, as elsewhere, leads to water-related diseases and preventable deaths, especially among children. Long-term data on water-related diseases are hard to find for China, but official statistics from the mid- to late-1990s suggested that intestinal worms, associated with the lack of safe water and adequate sanitation, are a severe problem in rural China. In 1992, for example, the Chinese Ministry of Health reported that roundworm infected nearly 200 million children under the age of 14, with additional infections from hookworm and whipworm (NPHCCO 1999). Between 1995 and 1999, typhoid incidence rates in rural Guangxi Province ranged from 27 to 153 per 100,000 (Yang et al. 2001, Yang et al. 2005). Typhoid continues to be endemic in southern China despite recent progress in meeting basic water needs (Boyle 2007). The OECD Environmental Indicators in China report issued in July 2007 estimated 30,000 rural children die each year from diarrhea caused by polluted water (OECD 2007). The World Health Organization reported an incidence of 108.4 mortalities per 100,000 persons from diarrhea-related illness in China in 2002 (WHO 2003). In comparison, Vietnam's diarrheal disease mortality rate in 2002 was under 11 per 100,000 people; Thailand's was under 5 (WHO 2004).

Groundwater Overdraft

One critical consequence of China's maldistribution of water is excessive, and ultimately unsustainable, withdrawals of water in more arid regions. As China has grown, its policy of food self-sufficiency has led to extensive agricultural production in the North China Plain, a region with relatively limited natural endowment of water. The North China Plain produces around half of all of China's wheat. Throughout this area, especially where populations have soared in recent years, groundwater is being pumped out far faster than it is naturally recharged and levels are falling fast. Some groundwater levels are now hundreds of meters below ground (Griffiths 2006). These levels of pumping cannot be sustained. "There will be no sustainable development in the future if there is no groundwater supply," acknowledged hydrologist Liu Changming of the Chinese Academy of Sciences (Griffiths 2006).

Overpumping and contamination of groundwater is forcing cities and business to dig deeper to find clean, adequate supplies. In northern Hebei province, villages are digging 120 to 200 meters to find clean drinking water; a decade ago wells were only 20 to 30 meters deep. Deep wells cost thousands of yuans – as much as half the annual income of farmers (Guo 2007).

Among the consequences of groundwater and surface water overdraft is the loss of wetlands. One survey estimated that over 80 percent of the wetlands in the North China Plain have been lost, and natural streams and creeks have dried up. Major river levels have dropped significantly due to human consumption. Northern China's largest natural freshwater lake, Lake Baiyangdian, is both disappearing and grossly polluted (Griffiths 2006). Until groundwater withdrawals are limited to sustainable levels, China's economic productivity will be threatened by rising water costs and scarcity.

Overuse of groundwater is even affecting China's most well-known cultural monument, the Great Wall. A 220-kilometer long section of the wall runs through the Minqin region of China in the Shiyang river basin. Withdrawals of water from the basin have reduced both surface and groundwater levels and led to desertification in the Minqin oasis region. Groundwater levels, for example, have dropped by 14 meters in the past half century. This in turn has led to the burial of large sections of the Great Wall by sand. Li Bingcheng, an expert on the Great Wall, said the sections of the wall in Minquin will be gone in 10 to 20 years if action is not taken to reduce the threat (China Daily 2007j).

Recent Floods and Droughts

China has experienced consecutive droughts over recent years with significant economic consequences. According to Zhang Jiatuan of China's State Flood Control and Drought Relief agency, "Since the 1990s, losses from drought have been equivalent to 1.1 percent of China's average annual gross domestic product, or about 300 billion yuan ($41 billion)" (China Daily 2007c).

Even the more relatively water-rich regions of the country appear to be experiencing increasing natural shortages. In 2007, a severe drought left well over a million people short of drinking water in southern China (Xinhua 2007a,b) and was spreading throughout the country (China Daily 2007c). The drought, which decreased rainfall between 20 and 35 percent from normal in the region, dried up hundreds of water-supply reservoirs, and thousands of wells, according to the Guangdong Provincial Hydraulics Bureau, and even the major rivers of the Yangtze (Changjiang), Yellow (Huang He), and Zhujiang are low. 2007 also saw a decrease in the water level of China's largest freshwater lake, Poyang Lake, to its lowest level in recorded history because of a combination of low rainfall and excessive human withdrawals of water (Xinhua 2007d). The low lake level led to shortages of drinking water for local residents and to cutbacks in industrial production.

China is also prone to severe flooding because of a combination of large rivers, variable climate, and vast populations living in floodplains. In 2005 more than 1,000 people were killed in China's annual flood season, while in 1998, 4,185 people lost their lives in the deadliest rainy season of the past decade (China Daily 2007l). In just a few weeks of heavy rainstorms in central China in 2007, almost 200 people died from flooding. By the end of 2007, floods nationwide had affected 180 million people, with over 1,200 deaths. The 2007 floods also ruined 12 million hectares of crops and destroyed more than one million houses, leading to a direct economic loss of over 100 billion yuan (Xinhua 2007c, l).

The economic impact of floods on China's economy is greater than that felt by most industrialized countries, and the Chinese Minister of Water Resources, Chen Lei, said in 2007 that China's annual direct economic losses from floods since the 1990s averaged 110 billion yuan (Xinhua 2007c) or nearly 2 percent of national GDP. These figures, if correct, are substantially higher than flood losses in the United States, which have been pegged at an average of less than 0.25 percent of GDP annually (Xinhua 2007c).

Part of the problem is that so many people live in areas prone to flooding, and these numbers are growing. Minister Chen projected that by 2020, forty-one percent of China's population will be exposed to flood risks (Xinhua 2007c). Almost 67 percent of the country's gross domestic product (GDP) also comes from these vulnerable regions.

Climate Change and Water in China

Climate changes will have direct and significant impacts on water availability and quality by altering precipitation patterns, increasing the intensity of extreme events, raising water temperatures, and accelerating the melting of snow and glaciers. Some Chinese experts have begun to publicly attribute increasing severity of drought to man-made climate change (Xinhua 2007n). Minister of Water Resources Chen Lei said in 2007 that China is already suffering a shortfall of water supply of around 40 billion cubic meters annually because of climate change and that there has been both increased flooding and drought (China Daily 2007b). In particular, data from the ministry suggests that rainfall in northern China is decreasing, and resources in the watersheds surrounding the Yellow River, Huai He River, Hai He River and Liao He River had dropped by 12 percent over the past decade (China Daily 2007b). "The lack of rain is mainly due to global warming," Chinese climate experts are reported to have said (China Daily 2007c). Precipitation seems to have increased in western China at the headwaters of some major rivers, but this is not translating into increased flows because evaporation rates (and unmonitored human withdrawals) are also rising rapidly (Xinhua 2007n).

One of the most significant risks to water resources from climate change is expected to be dramatic changes in snowfall and snowmelt dynamics (IPCC 2007, National Assessment 2000). In some countries, this will mean more rapid glacier melt and retreat, with impacts on long-term water availability to downstream communities. Such glacier melt is already being seen in most regions, including China, which gets as much water annually from glaciers as from the entire flow of the Yellow River. China ranks fourth in the world in terms of both area and ice volume of glaciers, after Canada, the United States, and Russia. China's glaciers cover approximately

60,000 square kilometers and have a total volume of 5,590 cubic kilometers (China Daily 2007e).

Scientists are reporting that the overall area occupied by glaciers has shrunk by about a third over the past century (China Daily 2007i). They further stated that global warming will make the trend of retreating glaciers "irreversible" (China Daily 2007e).

The shrinking of China's rivers at their mouths has long been observed and attributed to overuse and excessive withdrawal of water along those rivers. Recently, however, drying of China's major rivers has also been observed at the source and headwaters of those rivers, leading the Chinese Academy of Sciences (CAS) to conclude that climate change is already having an effect (Coonan 2006). The water resources of the Sanjiangyuan region - the headwaters of the Yangtze, Yellow, and Lancang rivers – depend on glacier melt and appear to be diminishing. This region, also known as the Qinghai-Tibetan Plateau, provides 25 percent of the water flowing down the Yangtze River, 49 percent of the flow of the Yellow River, and 15 percent of the flow of the Lancang River (China Daily 2007i). The Qinghai-Tibetan Plateau used to host 36,000 glaciers covering an area of 50,000 sq km, but their area has shrunk by 30 percent over the past century (Xinhua 2007n). In 2007, Chinese scientists warned that major glaciers in China, including the most well-known "Glacier No. 1" at the headwaters of the Urumqi River in the Tianshan mountains had decreased by over 10 percent in the past four decades and that the rate of retreat is accelerating. The loss of river flows from the dwindling Glacier No. 1 is threatening oases in the Xinjiang Uygur Autonomous Region (China Daily 2007e).

In July 2007, the CAS issued a report concluding that climate changes are also shrinking wetlands on the Qinghai-Tibetan plateau (Associated Press 2007). Aerial photos and remote sensing from satellites show that the wetlands have shrunk more than 10 percent in the past 40 years, with losses of nearly 30 percent occurring at the headwaters of the Yangtze. Even though rainfall has increased in the region, the increase in evaporation from warmer temperatures has more than compensated. Other observed changes include melting permafrost and dying vegetation.

Water and Chinese Politics

Water problems have begun to affect local and regional politics in China. President Hu Jintao in his 2007 report to the 17th National Congress of the Communist Party of China (CPC) called for a more efficient and environmentally friendly approach to development, growth, and consumption. Hu called for more "scientific development" that focused on major water issues including "securing more clean drinking water, improving water conservation, water pollution prevention, restricting excessive water resources exploitation and cutting water waste" (China Daily 2007b). Ma Jun, a water expert and the author of the book *China's Water Crisis*, publicly warns that current levels of water consumption and contamination are unsustainable (Ma 1999).

China's water problems are exacerbated by water laws that remain outdated, weak, and inadequately enforced. Because China is a heavily centralized country, governments at both the national and regional levels play a critical role in water policy and management, with traditionally little input from non-governmental organizations or individual participation in review and decision making. But there has been little comprehensive water policy development and few consistent national laws. Most water-quality laws were put in place several decades ago and lack enforcement mechanisms, with minimal fines and "vague civil liabilities" for polluters (China Daily 2007n). These laws have also traditionally limited the power of national environmental agencies in favor of local control, leading to widely differing levels of enforcement, incentives for local corruption, and confusing standards for industries.

There is growing perception that the nation's water woes result from insufficient centralized regulation – an odd problem in a country often perceived to be dominated by a strong centralized government. In fact, China – like the United States – manages water resources with a complex set of agencies at all levels of government, from the local to the central. Responsibilities for water resources, data and information, construction of infrastructure, environmental protection, agricultural development, transportation, and other water-related activities are split among competing and conflicting institutions.

China has also devolved substantial management responsibility to provincial and sub-provincial governments, undermining watershed-based management efforts (Eng and Ma 2006). Some advocates of centralized water management tools call for increasing the power of Beijing at the expense of provinces. They point to the success of centralized management in helping to restore at least some perennial flows in the Yellow River delta, which drew international attention in the late 1990s, when flows in the delta disappeared for over 200 days per year because of excessive withdrawals upstream. At that time, Beijing imposed limits to water allocations to the provinces.

Like similar historical trends in the United States and Eastern Europe, some of the first effective citizen organizations are developing around environmental issues, specifically water. While there continue to be only a small number of NGOs addressing water quality and quantity problems in China, their numbers and influence are expanding. In the past 5 years, a growing number of Chinese NGOs have begun to track water issues and to challenge projects they deem damaging. In the few cases in which public participation has been permitted, several large infrastructure projects have been successfully delayed, which some observers think is sending a signal encouraging more public participation (Eng and Ma 2006). This is leading to a struggle between existing powerful interests and environmental groups in China. Eng and Ma (2006) and Yardley (2007b) have offered examples that these efforts are having an effect:

- Local organizations and individuals worked to inform the public and media about the impacts of Yangliuhu Dam on an ancient and still functioning irrigation system that had been declared a World Cultural Heritage Site. Extensive media coverage and public dissent forced the developer to abandon the project in 2003.
- In 2004, Chinese NGOs opposed development projects on the Nujiang, one of the last two free-flowing rivers in China. Their efforts drew national attention and led Premier Wen Jiabao to halt the project pending a more comprehensive EIA.
- Environmentalists have been working to preserve the Tiger Leaping Gorge in a campaign to reduce the impact of a massive dam project on ecological and cultural diversity.
- A dam in Sichuan Province that would have inundated an ancient Qin Dynasty cultural site was canceled after local opponents called it an attack on China's heritage.

Among the obstacles NGOs have to overcome are restrictive regulations on their actions and limited internal capacity and funding. This may be changing (see Improving Public Participation).

Growing Regional Conflicts Over Water

As noted earlier, China's water resources are unevenly distributed. Because much of China's water policy revolves around massive transfers of water from one region to another, or large infrastructure projects that affect multiple political jurisdictions, there are growing regional conflicts over water-management decisions.

In one of the most serious examples of regional water conflict, there is a long history of violence over allocations of water from the Zhang River, a tributary of the Hai He that originates in Shanxi Province and flows through both Henan and Hebei provinces (see Figure 5.2 Map of Provinces). Conflicts over excessive water withdrawals and the subsequent water shortages have been worsening for over three decades between villages in Shenxian and Linzhou counties. In the 1970s, militias from competing villages fought over withdrawals. In 1976, a local militia chief was shot to death in a clash between Shexian's Hezhang village and Linzhou's Gucheng village over the damming of Zhang River. The violence escalated significantly in the 1990s: in December 1991, Huanglongkou village of Shenxian county and Qianyu village of Linzhou city actually exchanged mortar fire over the construction of new water diversion facilities. In August 1992, bombs were set off along a distribution canal collapsing part of the canal and causing flooding and economic losses (China Water Resources Daily 2002, Eng and Ma 2006). Despite efforts to mediate the dispute, violence continued in the late 1990s with confrontations, mortar attacks, and bombings, leading up to a clash on Chinese New Year in 1999 that reportedly killed nearly a hundred villagers and caused millions of dollars of damages to homes and water facilities. Some progress has been made to negotiate a settlement to this dispute, but new projects in the region may fuel new disputes (Eng and Ma 2006).

The North China Plains are also seeing growing tensions over water. As the population of Beijing has soared over the past several decades, the city has taken control of almost all of the major rivers flowing through surrounding Hebei Province. Until recently, one exception was the Juma River, a tributary of the Hai He, which flows 30 kilometers from the capital. Both Beijing and Hebei provincial officials have built major water diversions on the Juma leading to a conflict between the two governments. Withdrawals from the Juma now divert almost all of its flow, forcing downstream residents in Hebei to rely on groundwater resources. In the last few years, Beijing moved forward with new plans to tap groundwater connected to the Juma River, to raise its dam on the Juma to capture more water, and to transfer that water to Beijing's Yanshan Petrochemical Plant, the largest industrial water user in the city. Hebei officials fear that this series of new developments will cut off water to nine cities and counties downstream, affecting water supply to nearly three million people, worsen desertification in the region, and threaten the ecology of Lake Baiyangdian in north China (Eng and Ma 2006). Despite protests from top officials in Hebei Province to the Beijing water authority, no effective agreement or collaboration has occurred, and local tensions are rising.

All countries face old and new water challenges and have a variety of economic, institutional, and technological tools available for solving those challenges. But the priorities of the Chinese water management authorities have focused on a limited set of solutions and it is not yet apparent whether officials will move quickly enough to address quality and quantity problems in order to avoid more serious catastrophes in the near future.

Moving Toward Solutions

Expanding Water Supply

The standard response of the global hydrologic community to water scarcity has been, for over a century, to try to find more traditional sources of "supply" by looking farther and farther afield. China is no different. In fact, China today represents the epitome of the hard path approach to water,[2] with its intense reliance on large infrastructure projects to tap into dwindling supplies and sources and to divert water from one region to another. Many of the top leaders in China today were trained as engineers, including Hu Jintao, China's president and party chief (Griffiths 2006). It is thus no surprise that Beijing and central water agencies have typically responded to issues of scarcity with proposals for massive new infrastructure rather than new approaches to management.

This hard-path philosophy has driven work on a wide range of ambitious projects to build hydroelectric plants, dam rivers, and transfer water from one region to another. Almost half of the world's large dams (defined as dams higher than 15 meters) built since 1950 are in China (Fuggle and Smith 2000). On the Yangtze alone, there are an estimated 50,000 dams including the largest in the world, the Three Gorges Dam project (see the Water Brief, in this volume). The Chinese are now building the South-to-North Water Transfer Project, to funnel 45 billion cubic meters a year to the northern part of the country from the Yangtze River basin. That project was approved in 2002 to address water shortages in the north. Even if fully built, it will not be completed until in the middle of this century, and while several phases are already under construction, there is growing concern about both environmental and social problems.

This massive diversion consists of three major pieces: 1) an eastern route that will move water from the lower Yangtze to the north through a 1,200 kilometer long canal; 2) a middle route that will tap the Hanjiang, a major tributary of the Yangtze, and 3) a western route that will move water from the upper reaches of the Yangtze, Tongtian, Yalong, and Dadu rivers to augment water in the Yellow River Basin. As part of this project, in late 2007 China began digging a tunnel nearly 8 kilometers long under the Yellow River in Shandong Province – just one of the major rivers and physical objects the water-transfer project will have to overcome. Upon completion, water from the project will reportedly benefit about a dozen provinces, municipalities, and autonomous regions in north China including, especially, the regions around Beijing. Those areas produced one-third of the country's grain output and GDP with about 20 percent of the country's average per-capita water resource (Yardley 2007a). The Chinese government claims that as many as 300 million people could benefit from the project but it will also inevitably lead to adverse impacts in the regions where the water originates or would otherwise have flowed.

2. See Gleick (2003) for a discussion of the hard versus soft paths for water.

China is also looking to increase its reliance on hydroelectricity to satisfy the rapidly growing energy needs of its rapidly growing economy. Dirty coal presently accounts for two-thirds of all electricity projection, killing miners, polluting air and water, and emitting vast quantities of greenhouse gases. To ease these problems, China wants to greatly expand non-coal energy sources, including hydroelectricity, which presently provides around six percent of total electricity. Chen Deming, a governmental economic planner, stated in 2007, "We believe that large-scale hydropower plants contribute a lot to reduce [fossil] energy consumption, air and environmental pollution" (Yardley 2007b). Similarly, regional shortages lead to calls for more development of rivers and aquifers.

In late 2007, workers began damming the Jinsha River to build the Xiluodu hydropower station, which will be the second largest facility in China, and the third largest in the world when it is completed around 2015 (Xinhua 2007e). This dam had been halted previously because of the lack of a proper environmental impact assessment, but work has resumed. Moreover, the dam is being built in a national protection zone for several species of endangered fish (Yardley 2007b). Upon completion, the dam will be 278 meters high and have an installed capacity of 12.6 gigawatts. The Jinsha River is a major tributary of the upper Yangtze River and flows between Yushu in Qinghai Province and Yibin in Sichuan Province. This project is one of only dozens planned for this region along the Jinsha, Yalong, and Dadu rivers.

More traditional water-supply and treatment infrastructure is also being built rapidly, including water and wastewater treatment plants. Officials announced plans to build ten sewage disposal plants in northwest China's Shaanxi province, along the Weihe River, the largest tributary of the Yellow River. Another 30 plants are to be built by 2010. Statistics from Shaanxi province show that more than 800 million tons of uncontrolled sewage and wastewater are currently discharged into water of the Weihe basin each year, which is around 20 percent of total sewage loading in the Yellow River basin (Xinhua 2007g).

China recently announced that total investments in the water sector during the ongoing "11th Five-Year Plan" (from 2006 to 2011) could be as large as a trillion yuan (Xinhua 2007o, China Daily 2007u), with a focus on investment in water-distribution systems and the construction of a thousand water and wastewater treatment plants. Among the challenges that have hindered China's efforts to upgrade its water systems are a lack of technical expertise, a shortage of capital, and competition for resources from other sectors of the society equally in need of modernization.

As a result, China has begun to explore working with private corporations and funders. Water officials have explicitly encouraged foreign participation in China's water markets. Deputy Director of the Ministry of Construction, Qin Hong, called for foreign investment at a meeting of water business leaders from many developed countries. "Foreign investment will be encouraged especially in wastewater treatment projects," Qin said (China Daily 2007u).

In 2007, a large wastewater treatment plant developed as a "public-private partnership" opened in Guangzhou. This plant was built by the Guangzhou Wastewater Treatment Co. Ltd, a partnership of the state government and Earth Tech, a subsidiary of Tyco International. The plant was built as part of a broad effort to reduce the flow of untreated sewage into the Xijiang (Pearl) and is a build-operate-transfer (BOT) agreement in which the plant is to be transferred to the government in 17 years (China Daily 2007d). Even with the operation of this plant, total daily wastewater treatment capacity in the Pearl River Delta is only around 30% of total wastewater discharge volumes.

Another leading international water company, Veolia has been aggressively seeking joint ventures in China and now has more than 20. They have announced that their Asian business, which currently accounts for less than two percent of its global activities, could grow to as much as 20 percent in coming years. Veolia projects are being developed in Beijing, Shanghai, Tianjin, and Shenzhen. One project, a renovated water supply plant in Tianjin, now supplies drinking water to 1.8 million people (Xinhua 2007o). In another agreement, Veolia set up a joint French-Chinese venture to build a series of water projects, including urban and industrial wastewater treatment plants, desalination facilities, water-treatment equipment, and water-management services in the northern city of Teda. The joint venture, called the Tianjin Teda Veolia Water Company Limited, was sought to help the Chinese with management expertise and the provision of financial capital. Total expenditures may grow to nearly 2 billion yuan (Xinhua 2007o).

China is also beginning to explore desalination as a source of coastal water supply. Large facilities have been proposed for the county of Xiangshan in eastern Zhejiang Province, and the in northern China city of Tianjin. Xiangshan suffers severe water shortages. The plant proposed for Xiangshan is to be the largest in China, with a production capacity of 100,000 cubic meters per day. Unlike most desalination plants currently in development, which use reverse osmosis membranes, the Xiangshan facility will use multi-stage flash distillation, using heat from an existing power plant. Initial estimates are that the plant will cost 1.1 billion yuan. The cost of water will be around 6 yuan per cubic meter and will be blended with local supplies and sold for 2.5 yuan, with the government bearing the cost of the subsidy (China Daily 2007r).

Improving Efficiency

As is true elsewhere, part of China's problems with water quantity is caused by wasteful use. Absolute scarcity of water is seriously aggravated by grossly inefficient use in some sectors. There are vast opportunities to improve the efficiency of water use, and Chinese hydrologists and water managers are working to tap into this potential. In north China, projects are under way to try to learn how to reduce the water demands of winter wheat. Cities are beginning to raise the price of water as an economic signal to use it more efficiently, though many economic subsidies that encourage inefficient use remain.

Water use per unit of GDP or economic productivity is higher in China compared to many other countries, according to government statistics. In 2003, 465 cubic meters of water were used to produce 10,000 yuan worth of GDP, four times the world average and nearly 20 times that of Japan and Europe at that time (Economic Daily August 8, 2005). Similarly, to produce 10,000 yuan of "industrial added value, 216 cubic meters of water were used, 10 times more than in developed countries" (China Daily 2007a). In the relatively water-rich southern province of Guangdong, per-capita water use in the city of Guangzhou is more than double the use in Beijing, and triple the use in Paris (Zheng Caixiong 2007).

More draconian actions to curb inefficient uses or to cut demand may be required in the coming years. Some Chinese scientists have suggested that growing urban and industrial water demands may eventually lead to the elimination of winter wheat in northern China as agricultural uses give way to higher-valued uses that produce more jobs and income per unit water. This would be a dramatic change from their policy to continue to satisfy food needs as much as possible from internal production rather than international markets. The international consequences of massive Chinese purchases of grain are not well understood, but there are already serious pressures on global food markets and new imbalances could worsen the risk of shortages and famines.

Improving Environmental Protection and Enforcement

Improvements in water quality will require both new technology and new laws with two key components: clear standards and adequate enforcement. While debates about the adequacy of China's environmental standards continue, there is little dispute that enforcement of existing water-quality and monitoring laws has been grossly inadequate.

A 2007 opinion piece in the English language *China Daily* noted "We need more severe rules and penalties to change business as usual including stopping discharged waste water from further polluting our rivers, oceans and underground water supplies" (China Daily 2007a).

In 2007, Zhou Shengxian of SEPA acknowledged the country's serious and unresolved water-quality problems and called for tighter controls on pollutant discharges and better enforcement. "To contain water pollution, we should, firstly, continue to strictly control the discharge of various pollutants." He also said that tougher emission standards would be adopted by 2010 for drinking water and indicated that beginning in 2009, all new "enterprises which discharge pollutants" will have to obtain permits in order to operate or to be listed on the stock exchange (Xinhua 2007f). The use of agricultural fertilizers was also acknowledged to be a problem for water quality and SEPA called for gradual reductions in fertilizer use together with improved oversight over poultry farms. There was, however, less clarity on when existing facilities would be more tightly regulated.

In July 2007, SEPA asked local authorities in areas along the country's four major rivers to change the priority from economic development to environmental protection. Local authorities in six cities, two counties and five industrial zones—all in the Yellow, Yangtze, Huai He and Hai He river basins—were given 3 months to rectify their "environmental problems" (Xinhua 2007f). According to official sources, the campaign has led to the closure, suspension, or renovation of 700 enterprises (Xinhua 2007f), although these kinds of closures have often been lifted or ignored when the attention of the central government turns elsewhere.

The SEPA has also announced new efforts to raise drinking-water quality standards and to rehabilitate rivers and lakes. "Serious water pollution has been an obstacle to the healthy development of society," said Zhou. "We should be more determined and devoted to the rehabilitation of rivers and lakes" (Xinhua 2007i). The new standards are the first major amendment to the older one, enacted in 1985 and set drinking water limits for 106 parameters, with a deadline of full implementation by 2012. Provincial governments are able to set secondary standards (China Daily 2007q). The SEPA also announced that projects over the next decade that discharged heavy metal or organic pollutants into lakes and rivers being rehabilitated would be rejected and that new limits would be imposed on nitrogen and phosphorous discharges into closed water bodies.

Also in 2007, the government of Jiangsu Province promulgated new water-quality regulations to clean up Taihu Lake, where pollution has led to the almost complete eutrophication of the lake, severe blooms of blue-green algae, and the contamination of major drinking water supplies for the region around Shanghai. The lake is located in a densely populated area northwest of Shanghai and is home to numerous factories from six major polluting industries, including dye, chemicals, paper production, steel manufacturing, and food processing (China Daily 2007g). Clean-up plans may cost as much as $14 billion over a 5-to-10-year period. Algal blooms in June 2007 led to the shutdown of water supply in the industrial city of Wuxi and forced as many as 5 million people to rely on bottled water (China Daily 2007f). As a temporary measure, regulators ordered the mass closure of chemical plants on the margins of the lake. The new regulations will tighten standards for emissions of COD (chemical oxygen demand), ammonia, nitrogen, and phosphorus in industrial wastewater and sewage.

While these kinds of periodic campaigns have been launched by environmental agencies, consistent enforcement is still rare. The failure of the state regulatory agencies to successfully regulate, monitor, and enforce Chinese water-quality laws will ultimately require a change in approach. Standard methods, such as improving enforcement and monitoring, are being tried, but new methods are also being explored. In mid-2007, for instance, the SEPA sent a list of 30 major polluters to leading national financial institutions, including the People's Bank of China and the China Banking Regulatory Commission, in an effort to reduce their access to credit and loans for operations. The listed industries were mostly in water-intensive sectors like paper-making, coking, pharmaceuticals, iron and steel, and brewing. Most of the plants on the list are small and medium-sized facilities, which face more challenges getting bank loans, but some criticism from the Chinese Academy for Environmental Planning suggests that this approach would be more influential if larger companies and facilities were also listed. Other financial methods to promote enforcement being explored include policies on taxation, insurance, and the listing of securities (China Daily 2007m).

The Use of Smart Economics

Water policymakers are increasingly looking to economic tools, such as proper pricing and the elimination or modification of subsidies, to help in the sustainable management of limited water. In China, where water prices have long been heavily subsidized by the government, new efforts are underway to update pricing structures to encourage both improvements in efficiency and wastewater treatment. In Beijing, for example, prices for domestic water use have more than doubled to around 4 yuan per cubic meter. Water prices for certain commercial uses such as car-washing, are far higher – as much as 45 yuan per cubic meter (China Daily 2007h). In the city of Shenzhen, local government officials have been pushing for a new pricing structure to encourage the use of recycled water, rainwater, and other resources. Jiang Zhunhu, director of the Shenzhen water resources bureau said, "Increasing the price of water is an effective solution to easing the shortage."

In southern China, some regions are also imposing price-driven quotas on residential use. For urban homes, the quota means that homes that use more than 210 liters a day will have to pay a surcharge above the basic rate. This amount of water is just enough to satisfy the most basic human needs of around 50 liters per person per day (Gleick 1996) for a household of four. Use above the quota will lead to additional charges in the form of a three-tier rate structure, similar to those increasingly being used to encourage efficient use in the United States (for a discussion of the use of rate structures to encourage urban conservation and efficiency, see Chapter 6). Families who use less than 22 cubic meters a month will pay a basic rate of 1.32 yuan a cubic meter, still well below the average cost of water in most industrialized countries. Those who use between 23–30 cubic meters per month will pay a higher rate of 1.98 yuan a cubic meter; use above 30 cubic meters a month will cost 2.64 yuan a cubic meter, double the base rate (Zheng Caixiong 2007). Separate quotas are being imposed on the industrial, agricultural, and commercial sectors. China has a long way to go, however, to rationalize the use of pricing and economics as a tool to sustainable water management.

Improving Public Participation

Water problems, including recent environmental disasters, are spurring the public to action. Open debate and public participation in Chinese environmental policy have been limited and unusual, but there are signs that growing concern over water pollution and contamination is leading to efforts by citizens to change water policies and laws. A major environmental law passed in China in 2003 for the first time ostensibly encouraged public participation in environmental decision making. This law, the Environmental Impact Assessment (EIA) Law requires all major construction projects to undertake an impact assessment. Further, it states "The nation encourages relevant units, experts and the public to participate in the EIA process in appropriate ways" (Eng and Ma 2006). In addition, the law states that "the institutions should seriously consider the opinions of the relevant units, experts and the public" and "should attach explanations for adopting or not adopting the opinions." Eng and Ma (2006) note that like many other laws in China, "the EIA Law is merely a guideline and the requirement for public participation is very briefly stated. Still, it has provided an initial legal cornerstone for encouraging public participation in governmental decision making processes." In an astounding admission in 2005, the Chinese government acknowledged that 50,000 environmentally related public protests occurred that year (Turner 2006).

In fall 2007, China's National People's Congress publicized a draft of a new law on water pollution to solicit public opinion (Xinhua 2007j). The law proposes heavier punishment on both polluters and "irresponsible" officials, including fines for industrial offenders and administrative punishments or criminal charges for officials who delay reporting or hide water pollution incidents.

Associated with this growing public participation in environmental issues, central government officials have had to permit the creation and operation of nongovernmental organizations concerned about the environment. Many of these NGOs are focusing on water pollution and threats to aquatic ecosystems, and are learning how to use existing environmental laws to force change. Yu Xiaogang directs the Green Watershed initiative in Yunnan, and won the prestigious Goldman Environmental Prize in 2006. Yu has worked with local villagers to help them understand the impacts of dam construction. Other citizens have sued chemical plants to force compensation for health and environmental damages or to make more environmental information accessible to the public (Turner 2006).

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 non-governmental actors, and non-Chinese scientists and organizations, ostensibly to protect "national security" (Xinhua 2007q). In 2006, a dam protester was executed for what government officials claimed was his role in the death of a policeman at a protest of 100,000 people opposed to Pubugou dam (BBC 2006, Haggart 2006). 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 (Xinhua 2007q). An additional constraint on foreign efforts to report or monitor on China water issues is the requirement that local authorities must supervise all such efforts. Only time will tell whether China develops a healthy level of public participation in addressing the country's water problems.

Conclusion

Sustainable water management has long taken a backseat to the Chinese drive for economic growth. As a result, China has developed a set of water quality and quantity problems as severe as any on the planet. Water problems are so severe now that they are having a direct impact on humans, including growing constraints on economic activities and growing adverse effects on public and ecosystem health. China's SEPA minister has acknowledged these problems: "Serious water pollution has affected people's health and social stability and become the bottleneck thwarting China's sound and rapid economic and social development" (Xinhua 2007f).

The failure of the state regulatory agencies to successfully regulate, monitor, and enforce Chinese water-quality laws will ultimately require a change in approach. Unless China moves rapidly to develop the legal, technological, and institutional tools to clean up water pollution, reduce wasteful and inefficient uses of water, restore natural ecosystems, and develop sustainable sources of supply, then environmental and human catastrophes will worsen.

In addition, growing constraints on total supply are imposing limits to the size and type of economic activities the Chinese can pursue, raising the specter of reductions in agricultural production or industrial output in coming years. New tools, approaches, and technologies will all have to be tried as China attempts to move toward long-term sustainable use of its scarce and valuable freshwater resources.

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