Challenges and Conservation Measures: Water Resources of the North China Plain

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The North China Plain, including plains of the Yellow (Huaig He) River, Huai He River and Hai He River, has a very important political, economic and cultural position in China. Its population is 35%, its GDP 32% and its irrigated area 42% of the figures for the whole of China.

The region is now facing a severe shortage of water: a big challenge for sustainable social, economic and environmental development. Taking the Hai He River plain as an example, the average available volume of water per person per year is equal to 1/7 of that in China overall, and less than 1/24 of that in the world. The consumption of water of the Yellow River, the Huai He River and Hai He River is 67%, 59% and 90% of the flow, respectively. Groundwater has been overused: the deficit is nearly 90 billion m^3, affecting about 90 000 km^2 — 70% of the area of the plain.

In recent years the scarcity of water has seriously increased. The main reasons are that the climate is becoming dryer, runoff from upper reaches of the rivers has declined following regional revegetation activity and other conservation work, industry and cities are developing quickly, and irrigation for agriculture has increased. The regional development plan anticipates that in 2010, 2030 and 2050 the water deficit will be 10–23, 16–30 and 16–31 billion m^3 per year respectively.

In order to resolve the water shortage of North China, a very large engineering project to carry water from the south is now in progress. This project is only one part of a comprehensive program which combines water transfer ('water carrying'), water saving, water quality protection, use of runoff water and groundwater, and unified management of all water in the region, which we hope will alleviate the water crisis of North China.

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Regional physical and socio-economic background

The North China Plain (NCP) is located in the central eastern part of China (Fig. 1); it includes the plains of the Yellow (Huaig He) River, Huai He River and Hai He River. The eastern boundary is formed by the Yellow and Bo Seas. On the western, northern and southern sides respectively lie the Taihang Mountains, Yanshan Mountains and Dabie Mountains. The region — the biggest plain in China — includes Beijing, Tianjing, Hebei, Shandong and Henan, and part of Anhui and Jiangsu provinces; the total area is about 320 000 km^2. Although this area is only 3.3% of the total of China, it is the most important region in terms of politics, economics and culture: its population is 35%, GDP is 32% and irrigated area is 42% of national totals.

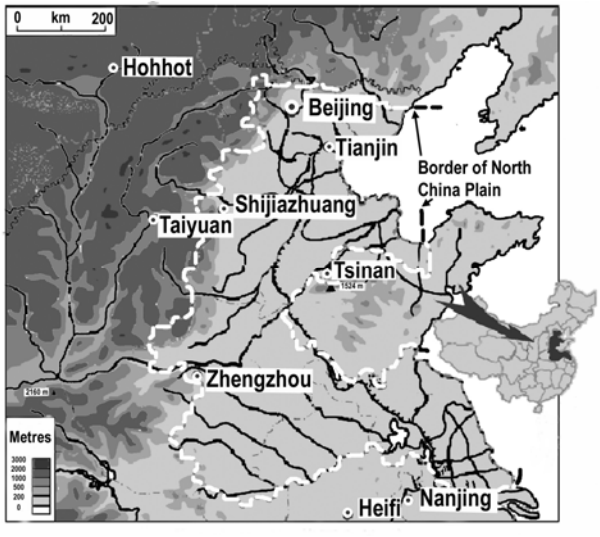

Figure 1. The location of the North China Plain

The North China Plain is the main agricultural area of China. There are 180 000 km^2 of cropland, 56% of them irrigated, and the 'index of cultivation' (reflecting the extent of multiple cropping in a single year) is 160%. The agricultural yield is 40%, wheat yield 50%, cotton yield 60% and maize yield 30% of national totals (see Table1).

Table 1. Land uses of the North China Plain

Land use	Area ('000 km^2)	Fraction of total (%)
1. Agricultural cropping	**192.9**	**59.3**
1.1 Cropland	182.5	56.1
1.2 Suitable for crops	10.4	3.2
2. Forest land	**40.9**	**12.6**
2.1 Forestry	13.8	14.2
2.2 Suitable for trees	27.1	8.3
3. Grassland	**26.1**	**8.0**
3.1 Grassland	20.6	6.3
3.2 Suitable for grass	5.5	1.7
4. Other	**65.3**	**20.1**
4.1 Salt land	1.6	0.5
4.2 Water	6.8	2.1
4.3 Roads and residential areas	57.0	17.5
Total	**325.2**	**100.0**

Problems and challenges of water resources in the North China Plain

Scarcity of water

The total water resource of the NCP is 96 billion m^3 per year. The amount per capita is estimated to be 732 m^3 y^{-1}, or 1/9 of the world average — but this average figure conceals greater deficits. Along the Hai He River, for example, the average water volume per person per year is equal to 1/7 of that in all China, and less than 1/24 of that of the world. Projected water deficits are shown in Table 2.

The rates of water use of the Yellow River, the Huai He River and Hai He River are 67%, 59% and 90% respectively of the total flows. Groundwater has been overused to the extent of nearly 90 billion m^3, affecting an area of about 90 000 km^2 — 70% of the area of the plain.

Climate change has also affected regional water resources. In 1980–1989, precipitation was 10–15% less than the long-term average and temperatures were up by 0.1–0.6°C.

Table 2. Predicted water deficits in the North China Plain (Wang and Yang 1998)

Water	Basin	Year		
		2000	2010	2030
Water demand (10^9 m^3)	NCP	1593	1816	2051
	Hai He (P = 50%)	447	512	584
	Huai He (P=75%)	687	791	890
	Yellow (P = 50%)	459	514	578
Water supply capability (10^9 m^3)	NCP	1402	1394	1375
	Hai He (P = 50%)	368	365	358
	Huai He (P = 75%)	620	620	620
	Yellow (P = 50%)	414	409	396
Water deficit (10^9m^3)	NCP	190	422	677
	Hai He	79	147	225
	Huai He	66	170	270
	Yellow	44	105	182

P = probability

In the same period, runoff in the Hai He Basin decreased by 46% (Fig. 2). On the other hand, total water consumption is increasing greatly: the amount of water used annually in China has risen by a factor of 4.5 in the last 50 years.

Over-exploitation of groundwater

Groundwater is the main source of water in the NCP. About 60% of water for domestic use, 68% of that for industry and 45% of that for agriculture comes from groundwater. In North China, about 87% of the water supply has been drawn from groundwater, an over-exploitation to the extent of about 30 billion m³ of water annually. Because of over-exploitation of groundwater, a rapid fall in the level of the water table has become a critical ecological issue in many parts of China (Figs 3, 4). The total area affected by falling levels of groundwater in North China is >23 000 km^2. Groundwater resources in some regions are essentially exhausted. The consequences of the lowering of the water table include seawater intrusion and land subsidence in 75% of coastal cities and their surrounding areas.

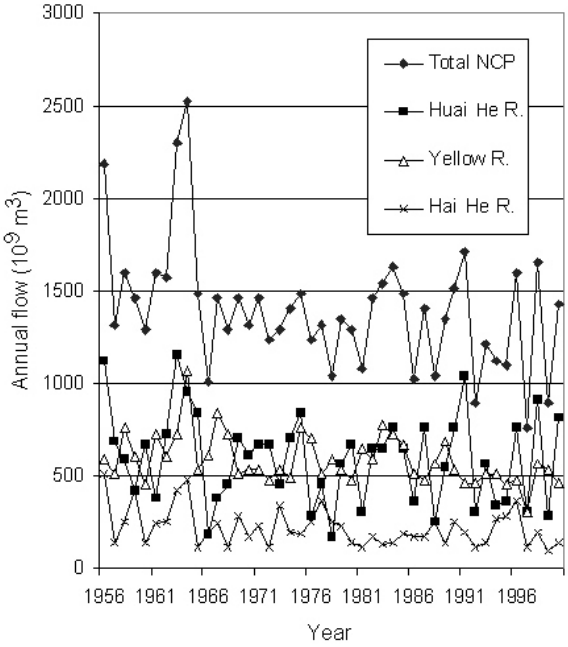

Figure 2. Runoff of rivers in the North China Plain

Figure 3. Ground cracking resulting from over-exploitation of groundwater, Hengshui region, Hebei Province (Xinhua Network)

Figure 4. The bed of a dried-up lake

Severe water pollution aggravates water shortages

The main sources of water pollution are industrial and municipal wastewater, chemical fertilisers, pesticides, animal manure and solid wastes. At present, only 14% of urban domestic sewage is treated. The figure for industrial sewage is 85%, but only 5% of sewage is reused. Moreover, increasing use of chemical fertilisers and pesticides,

the raising of livestock and heavily-polluting rural industries are accelerating water pollution and ecosystem deterioration. Non-point-source pollution accounts for 70% of the total pollution load in China's waterways. An evaluation of the water quality of rivers indicates that only 24% could meet the EPA standard of grade 1 and 2, with 17% in grade 3, and 32% in grades 4 and 5 (Table 3). (EPA grades are explained at http://www.epa.gov/owow/tmdl/2006IRG/report/2006irg-sec5.pdf)

Low water use efficiency (WUE)

Agriculture accounts for about 70% of the total water used. The average agricultural WUE in China is about 0.4–0.5. In North China, for example, the irrigation quota is 7500–12 000 m^3ha^{-1}, some 2–5 times the actual amount required by crops.

Remedies for problems of water resources

The Chinese Government has pursued a policy of water conservation 'combining benefit generation with disaster mitigation, equally stressing saving water and the development of new water sources, and simultaneously seeking flood control and drought prevention'. Improved water conservation and ecosystem management are being sought throughout the whole country.

Integrated measures to save agricultural water

Saving water is now the first priority in China. The agricultural sector is the biggest water user, taking 87% of all fresh water. Reducing water use by agriculture is urgent. In the coming 10 years, urban water demand will increase by 60% and industrial demand by 62%.

Table 3. Water quality grades of seven Chinese rivers, 2005

River	Fraction in each EPA grade (%)				
	1 and 2	3	4	5	Worse than 5
Yangtze	56	20	11	2	11
Yellow	7	27	34	7	25
Zhujiang	55	21	18	0	6
Songhuajiang	5	19	45	12	19
Huai He	3	14	38	13	32
Hai He	17	5	18	6	54
Liao He	14	16	22	8	40
Total	24	17	25	7	27

In the North China Plain, these growing demands can be satisfied mainly by taking irrigation water from agriculture. The efficiency coefficient for utilisation of agricultural irrigation water in China is now only 0.4. Water-saving irrigation technology must be adopted: within 30 years, the efficiency coefficient should be upgraded to >0.6 in an area of 10 million ha. The increased future industrial and domestic water use will be due mainly to new users, who will greatly increase water consumption.

The Chinese Government has paid great attention to the treatment of water pollution: construction of municipal sewage plants has been speeded up in several regions. The rate of reuse of treated wastewater should be improved, and wastewater should be regarded as a resource.

Improving ecosystem management in the middle and upper reaches

Fragile and degraded ecosystems in the middle and upper reaches of rivers of the NCP have obviously aggravated the water resources crisis. The Chinese Government has developed a comprehensive plan for ecosystem restoration: to harness and rehabilitate the key water, soil erosion and desertification areas in the middle and upper reaches of the Yellow and Yangtze Rivers by the year of 2010; to make every effort to improve rural ecosystems by the year of 2030; and to establish sound ecosystems appropriate to sustainable development by 2050. Hillside fields in small watersheds have been terraced in order to control soil erosion. By integrating ground surface reservoirs, soil water reservoirs and underground reservoirs, it is possible to manage water resources more effectively.

Improving management of water resources

The Chinese Government has given close attention to legislation relating to the management of water resources and allied construction work. The goal is to manage water resources in an integrated manner, using river basins as the management unit. A system of water licences will be adopted to administer water utilisation and enhance supervision of resource use.

Encouraging the application of advanced technology in water use and protection

It will be necessary to make extensive use of new technologies and equipment in harnessing rivers and water conservation. Critical issues should be identified through scientific studies. We are willing to make full use of international exchanges and cooperation in watershed management and in the promotion of water-saving irrigation technologies, as well as in more general ecosystem management, to solve our water resource problems.

Transferring water from south to north

To address water shortages in North China, a large engineering project is now in progress to transfer water from the south to the north. The program of which the engineering works are part combines basic principles of water saving, water transfer and water quality protection with comprehensive utilisation of runoff water and groundwater to effect unified management of all water in and out of the key basins to alleviate the water crisis of North China.

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