Water in China: Shortages, Surpluses, and Solutions

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Looking at Water Issues Interdisciplinarily

- Geology and hydrology Where is there water and how long will it stay?
- Atmospheric sciences How much water will enter the system?
- Ecosystem sciences How much water is required for ecosystem services at what level?
- Agricultural science How much water is required for farming?
- Economics How should water be allocated among competing uses?
- Public Health How much water do people need for hygiene; how can water supplies be made "safe"?
- History What is the past of water use in an area?
- Political science/policy studies How can governments affect water use and allocation?
- Philosophy 天下莫柔弱於水。而攻堅強者莫之能勝以其無以易之。

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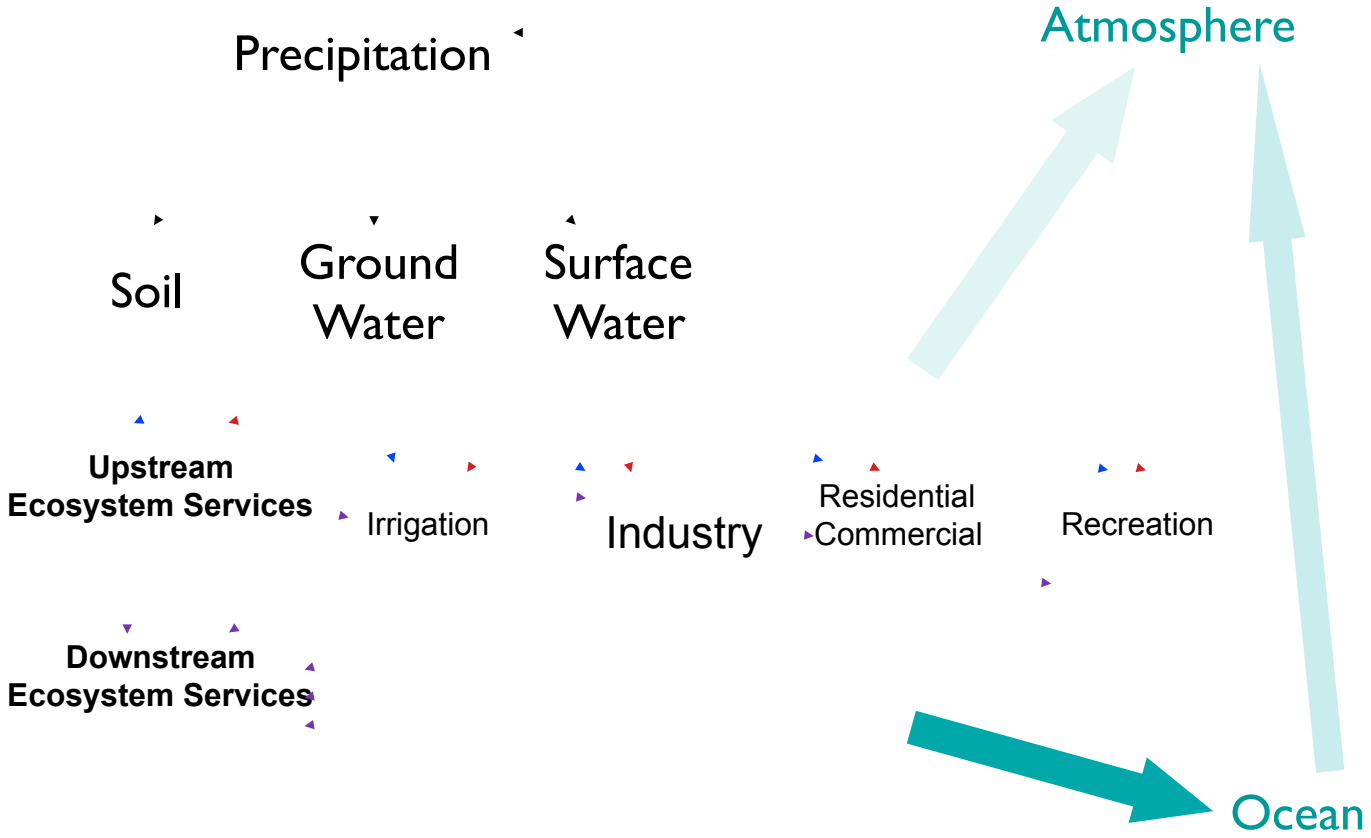
Under Heaven, there is nothing as soft and weak as water. And in attacking the sturdy and strong, there is nothing that can overcome its ability to use its absence to change things.

天下莫柔弱於水。而攻堅強者莫之能勝以其無以易之。

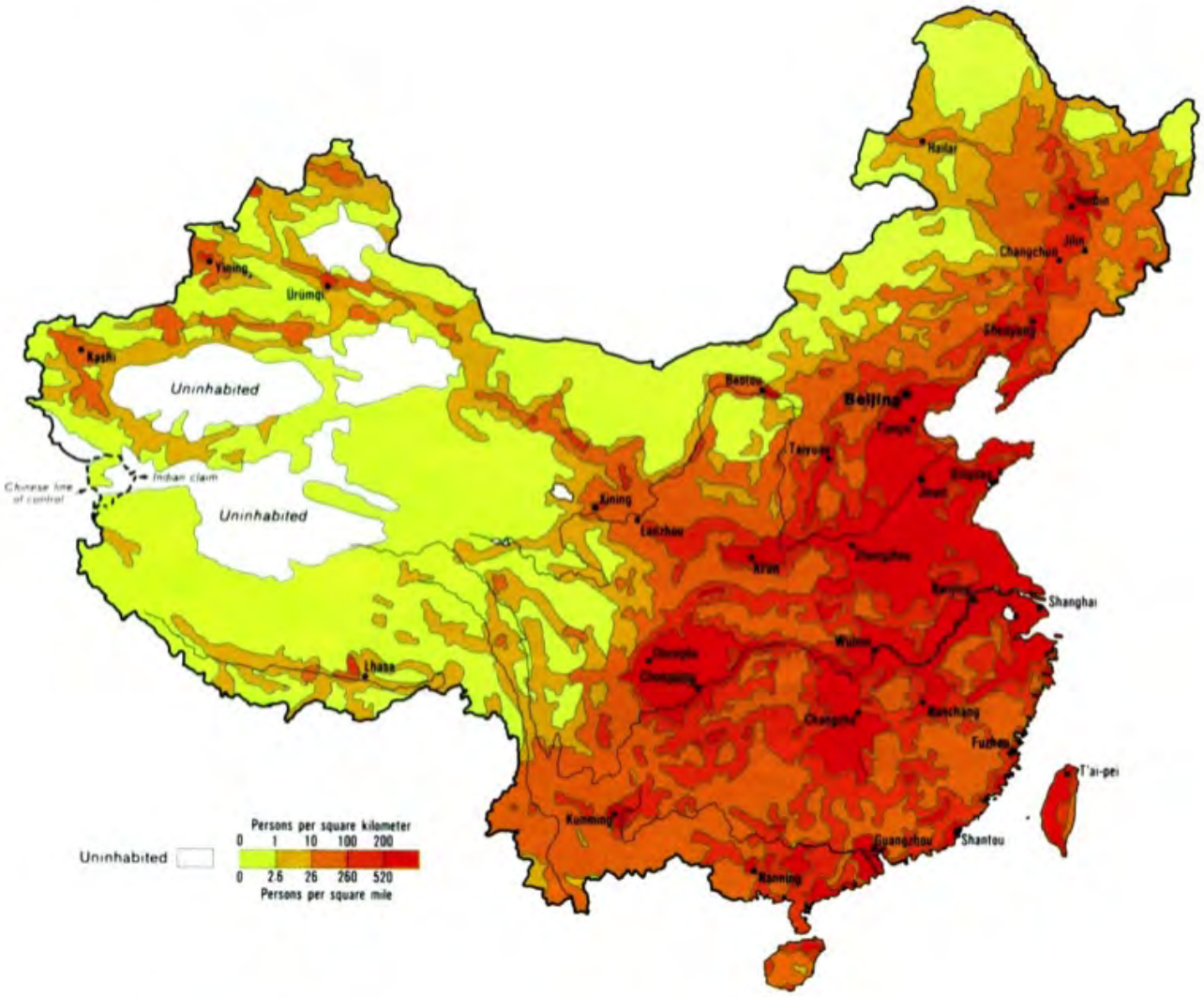
Looking at Water Issues Interdisciplinarily

It's all about allocation

- Geology and hydrology
- Atmospheric sciences
- Ecosystem sciences
- Agricultural science
- Economics
- Public Health
- History
- Political science
- Policy studies
- Philosophy

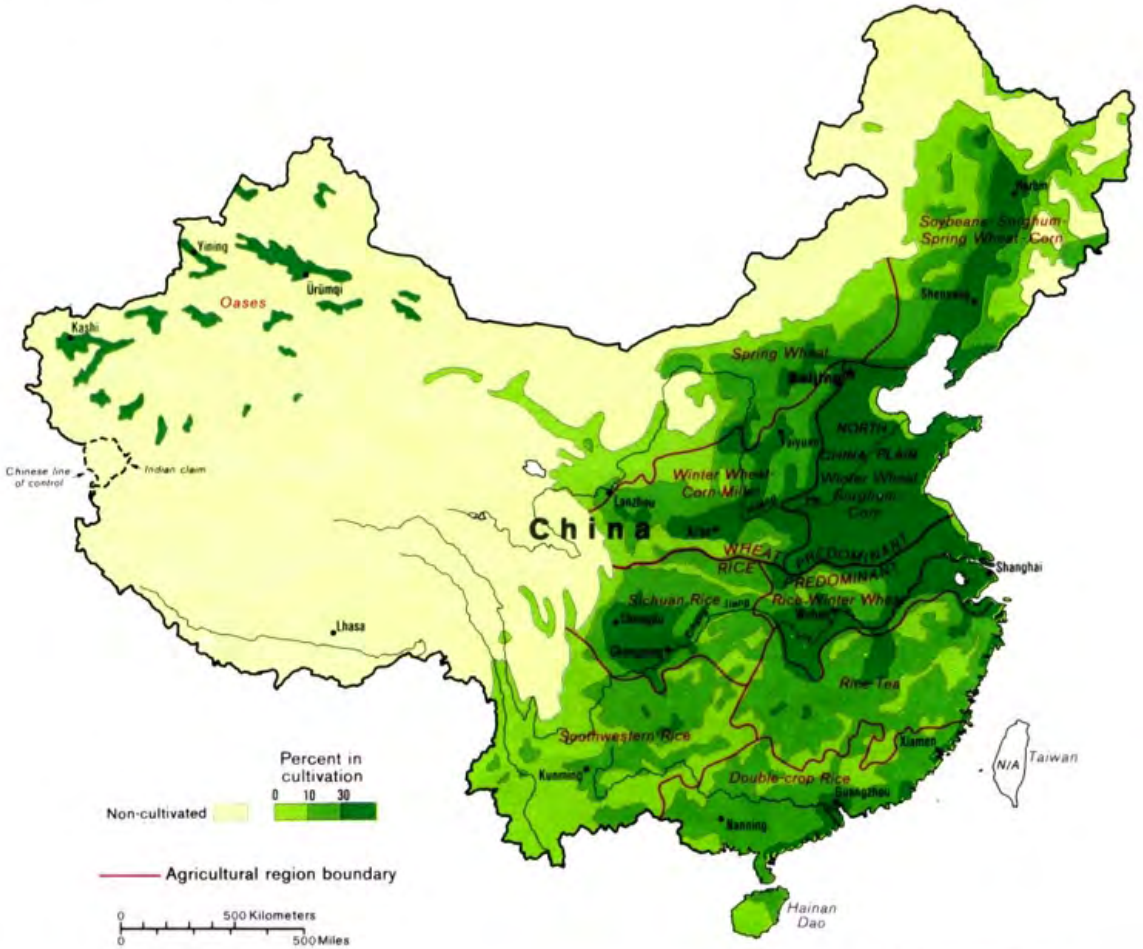


China: Population Density



Boundary representation is not necessarily authoritative.

Agricultural Regions



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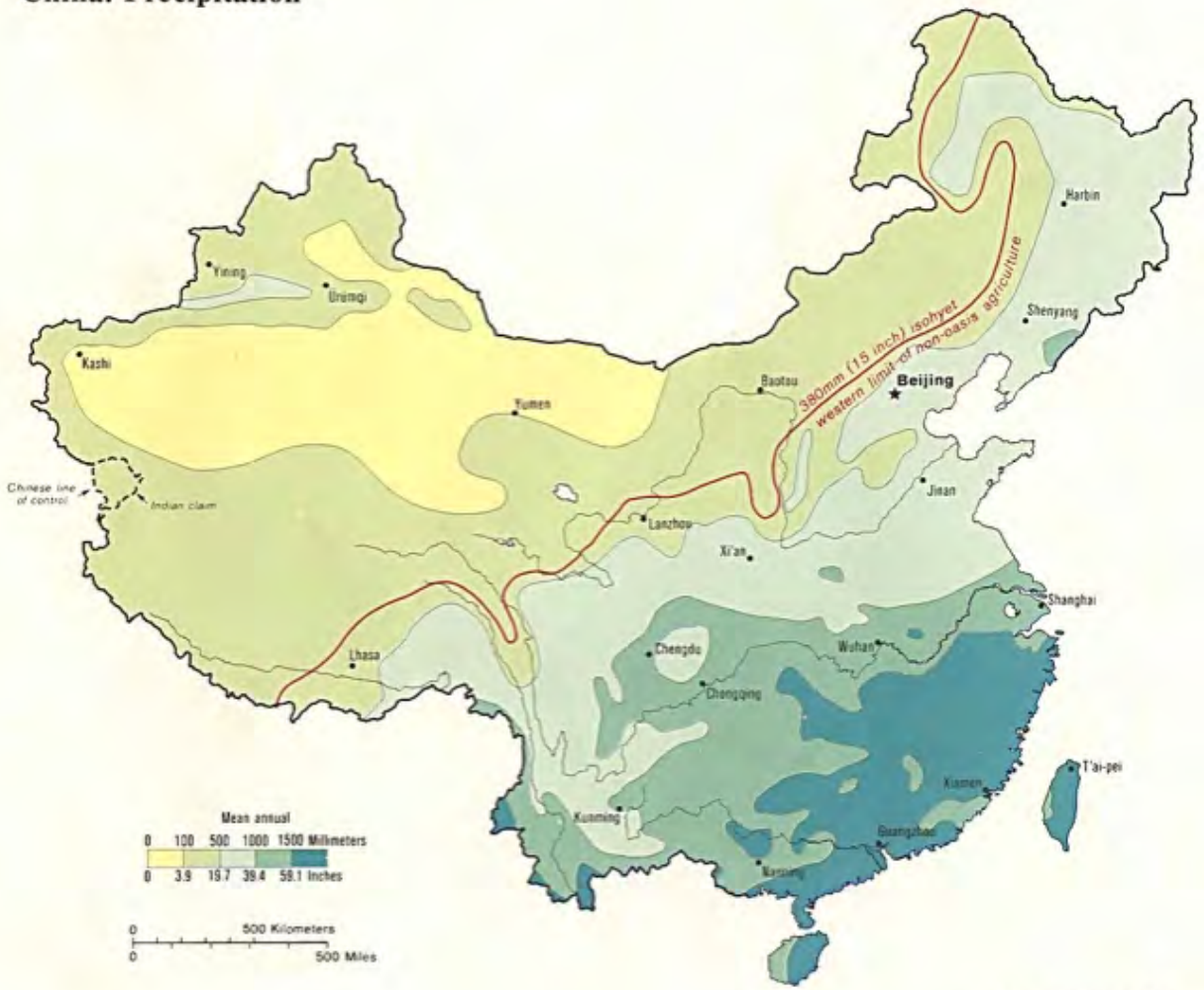
China: Precipitation



Summer Monsoons

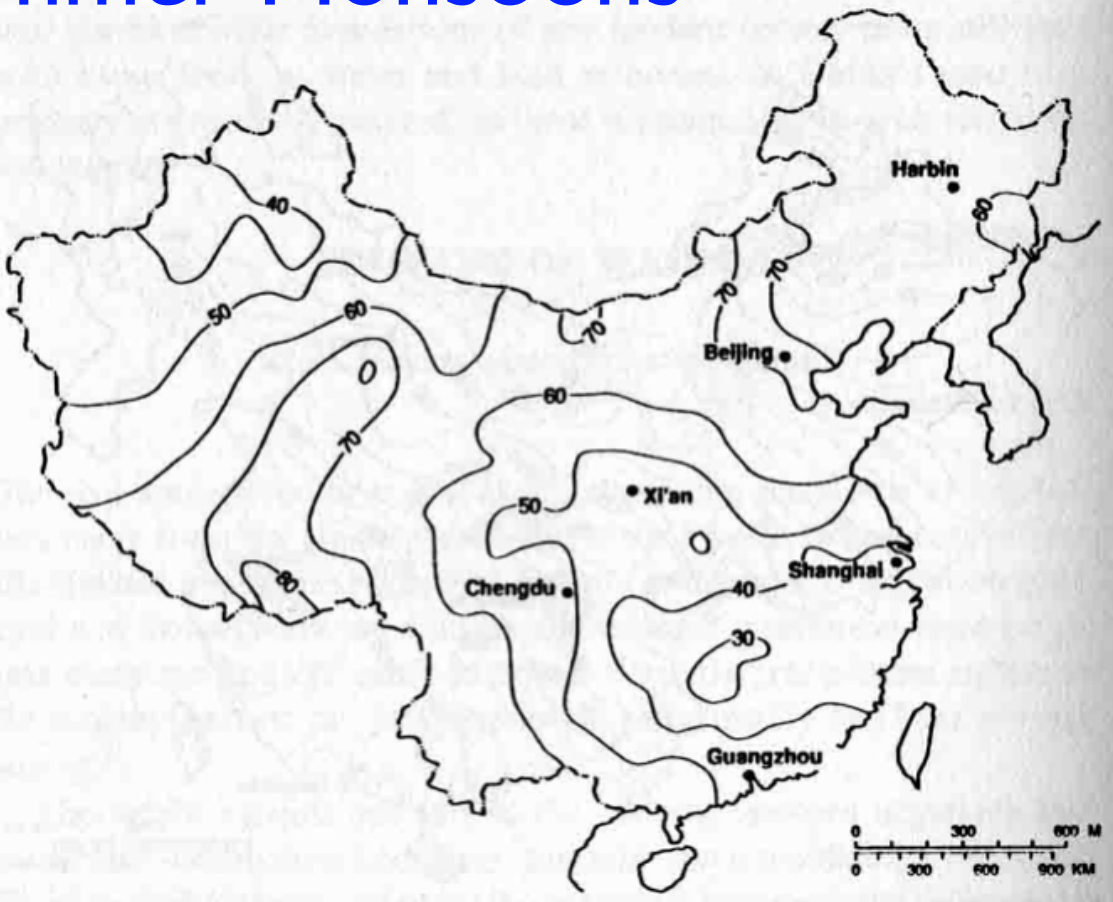


Figure 2.2. Distribution of the annual share of summer (June to August) rains shows their dominance throughout northern China. Redrawn from Domrös and Peng, *The Climate of China*, 6, 169.

Floods and Droughts

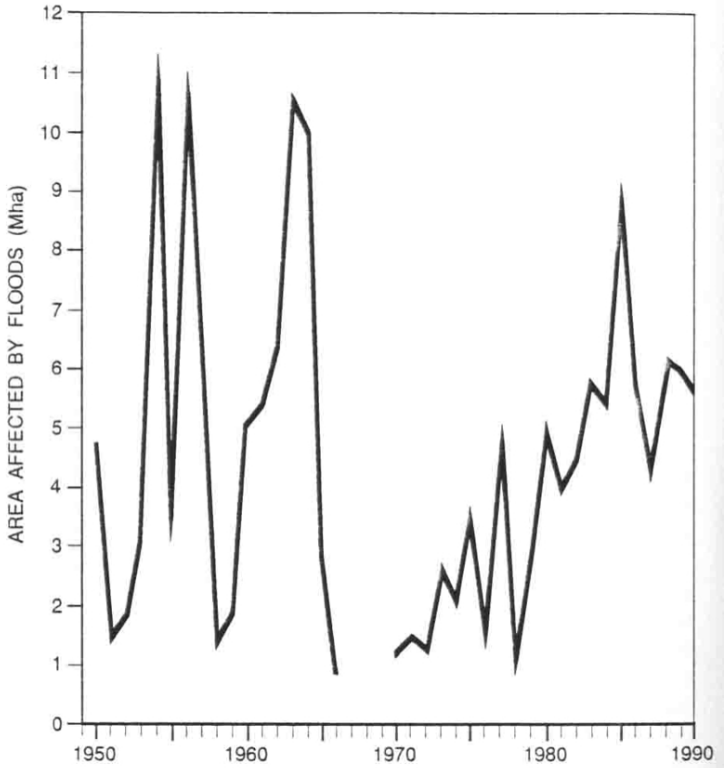


Figure 2.5. Areas affected by floods, 1950–1990. While the 1950s and 1960s show no consistent direction, an upward trend is apparent since 1970. Based on the same sources as fig. 2.3.

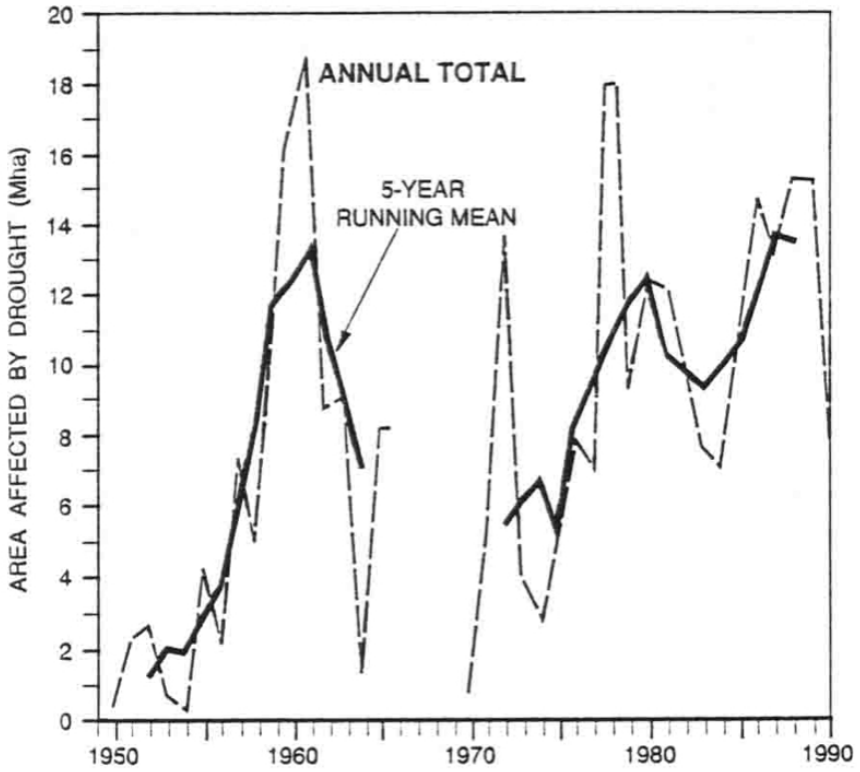
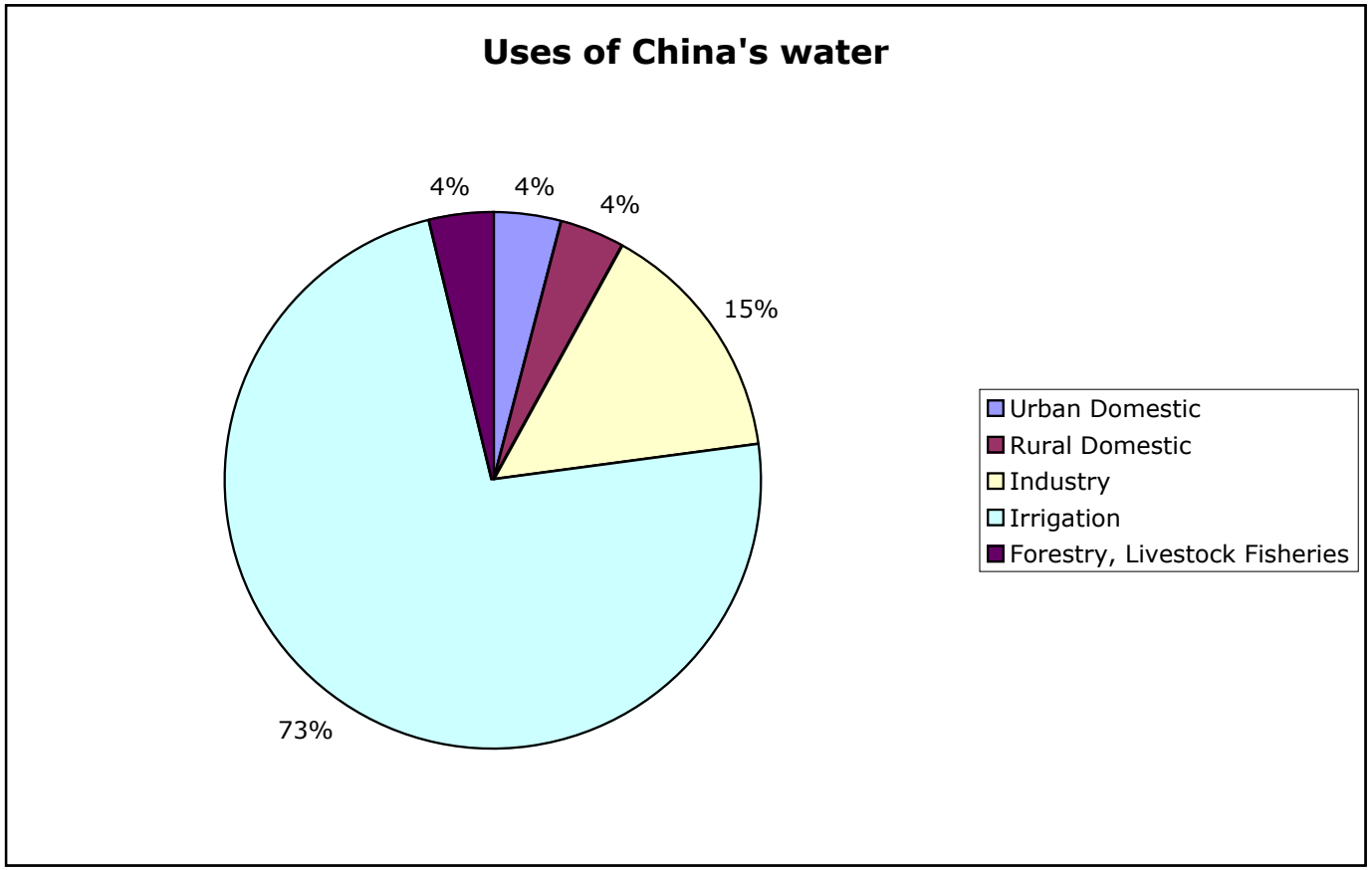


Figure 2.3. Areas affected by drought, 1950–1990. Based on the series in *Statistical Yearbook of China 1984*, 190, and the subsequent annual updates. Five-year running means indicate remarkably similar rates of deterioration during the 1950s and the 1970s.


Uses of China's water
4%
4%
4%
15%
73%
Urban Domestic
Rural Domestic
Industry
Irrigation
Forestry, Livestock Fisheries

More and More Irrigation

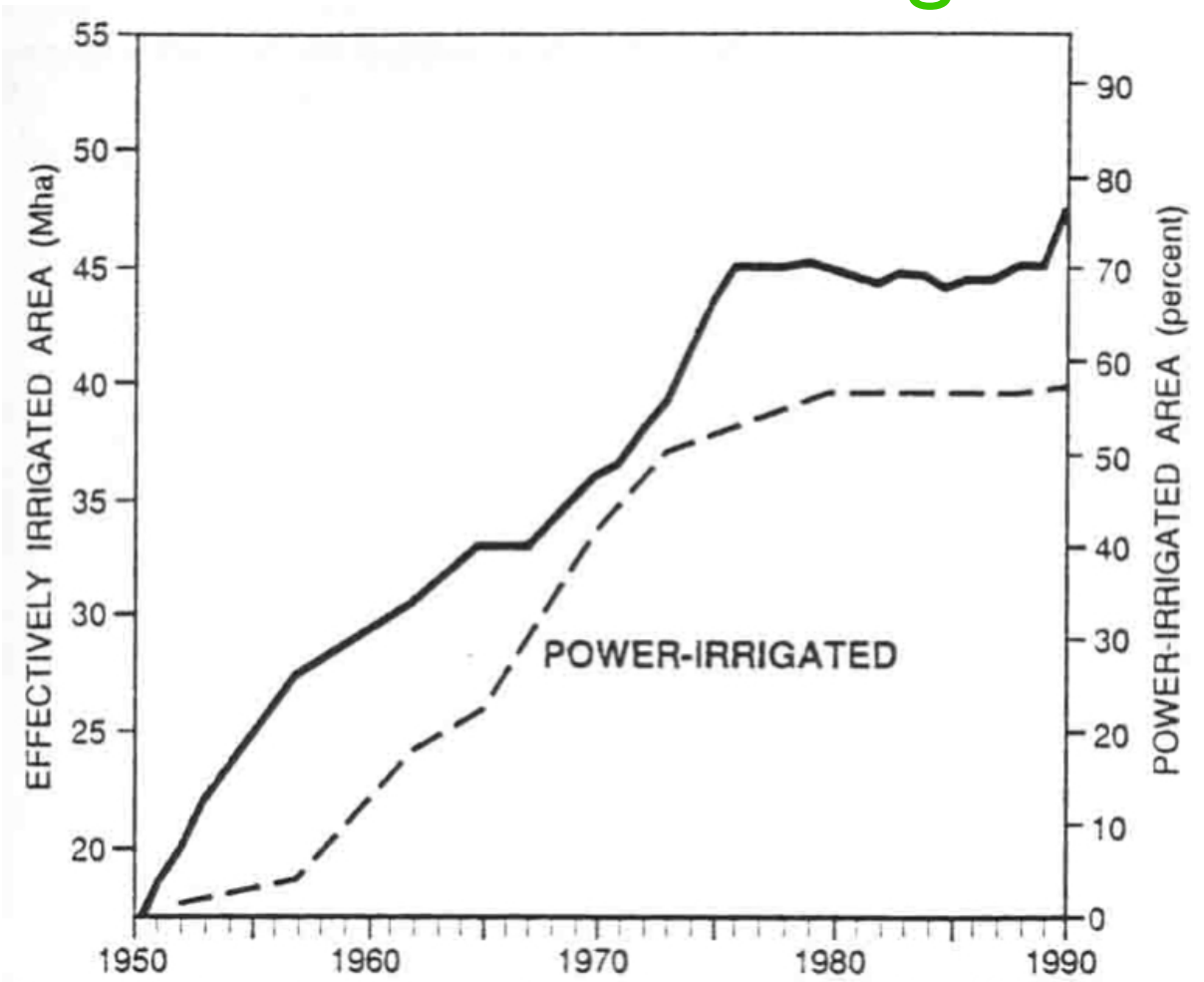
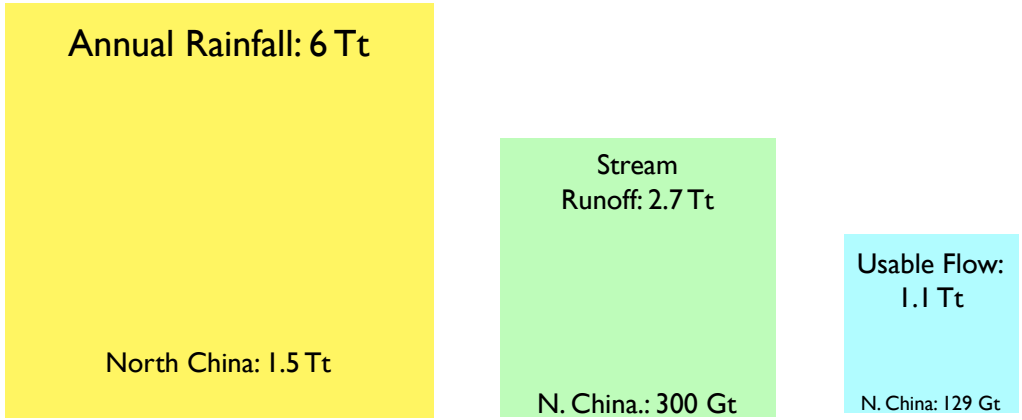


Figure 2.4. Expansion of China's irrigated land, 1949–1990. Plotted from the State Statistical Bureau (SSB) data.

Table 1. LAND, WATER AND POPULATION IN NORTH AND SOUTH CHINA

	Water Resources	Population	Cultivated Land	Water/ Person
North China	13.8	45	60	650 m^3
South China	82.0	53	35	2,385 m^3

From Gavan McCormack,"Water Margins: Competing Paradgims in China," 2001



North China (3H Basins)'s Share of China's Water

North China's Shortages

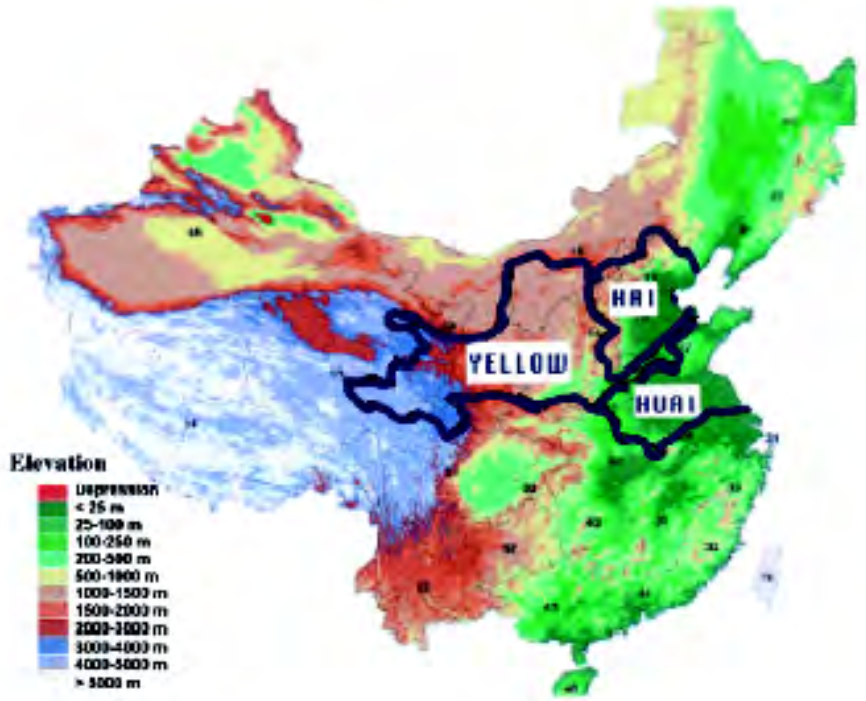


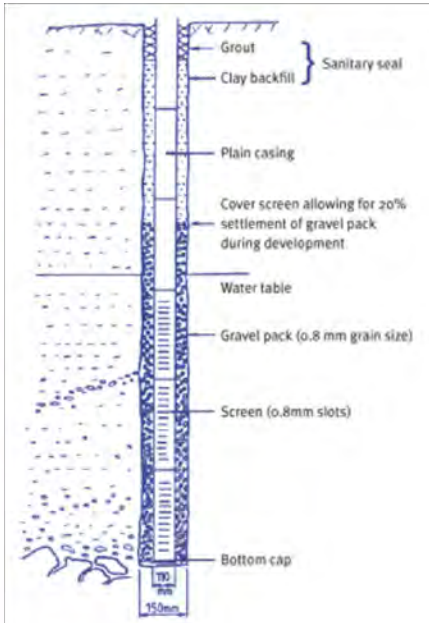
Fig. 1 Relief map of China showing the 3-H basins.

Table 2. WB estimates: supply and demand for 50% year, 1997 and 2050 (projected): km^3.

	1997				2050[a]			
	Hai	Yellow	Huai	Total	Hai	Yellow	Huai	Total
Supply[a]								
Surface water[b]	15.1	21.9	34.7	71.7	17.3	24.6	33.2	75.1
Groundwater	15.9	13.0	16.5	45.3	19.4	15.2	25.7	60.3
Transfers[c] from Yellow River	3.7	(−10.0)	6.3	10.0	0.0	0.0	0.0	0.0
Transfers[c] from Yangtse	0.0	0.0	2.9	2.9	6.8	0.0	12.8	19.6
Total	*34.7*	*34.9*	*60.4*	*129.9*	*43.5*	*39.8*	*71.7*	*155.0*
Demand[a,d]								
Urban domestic	2.6	1.5	2.4	6.5	6.7	3.7	6.1	16.5
Rural domestic	1.7	1.2	3.0	5.9	1.8	1.4	2.5	5.7
Industry	6.6	5.9	9.4	21.9	9.2	11.8	17.4	38.4
Irrigation	34.7	33.3	44.3	112.3	32.5	30.2	39.2	101.9
Forestry, livestock and fisheries	0.5	1.7	4.6	6.8	0.5	4.0	6.5	11.0
Total	*46.2*	*43.6*	*63.6*	*153.4*	*50.7*	*51.2*	*71.8*	*173.6*
Shortage[d]								
Priority (non-irrigation)	2.1	1.6	2.1	5.8	0.3	0.3	. . .	0.6
Irrigation	9.4	7.1	1.1	17.6	7.0	11.1	0.1	18.2
Total	*11.5*	*8.7*	*3.2*	*23.4*	*7.2*	*11.4*	*0.1*	*18.8*

Irrigation in North China

- Before 1950: Less than 10% irrigated
- 1950s and 60's Expansion of Surface Water Capture
- Late 1960s to 1990: Tapping the North China Aquifer with Tubewells
- Late 1990s Privatization of Tubewells
- Late 1990s Replacement of Surface Water with Tubewells

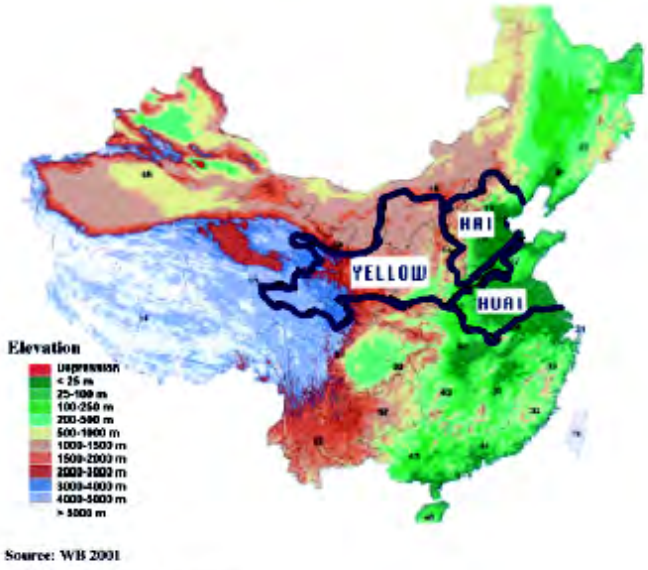


Irrigation in North China:
Irrigated Land (1000ha)/Grain Output 10,000t)

Year	Hebei	Henan	Shandong
1949	749 / 469	431 / 713	247 / 870
1970	2678/1272	2520/1555	2502/1465
1990	3758/2276	3550/3303	4463/3570
2008	4579/2905	4955/5365	4866/4260

Problems Caused by Water Shortages in North China

- Yellow River did not reach the sea in 1990s
- Huai and other rivers severely polluted
- Water table on the North China Plain falls
- Urban shortages and loss of pressure
- Decline in water quality
  - Nitrate pollution from agriculture
  - Heavy metal and other pollution from industry
- Seawater incursion in coastal areas



f map of China showing the 3-H basins.

Problems Caused by Water Shortages in North China:
Yellow River Runs Dry

- 18 of 26 years, 1974-1999
- 1998, 250 days
- Increasingly drawn off for various uses, primarily agricultural
- Management system uncoordinated
- Little incentive to conserve

Problems Caused by Water Shortages in North China:
Huai and Other Rivers Severely Polluted

- Mao's Plan: construct 175 dams on the Huai
- 1975: Two dams collapse, 230,000 people die
- 1993: Chemical release turns the river black
- 1994-2000: Major campaign to clean up the river
- 1996: Hundreds of polluting factories shut down
- 1998: River turns black again
- 1999: 10 people collapse from fumes on river bank
- 2000: Huai runs dry

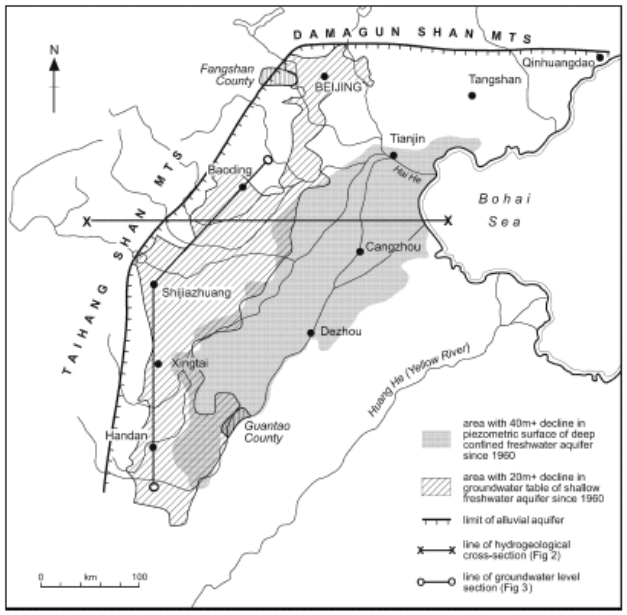
A fisherman examines his net for fish after casting it in the polluted waters of a river in Shenqiu County. After an hour's work, he was able to catch ten small bait fish with blisters on their bodies.

http://www.stephenvoss.com/stories/ChinaRiverPollution/index.html

Problems Caused by Water Shortages in North China:

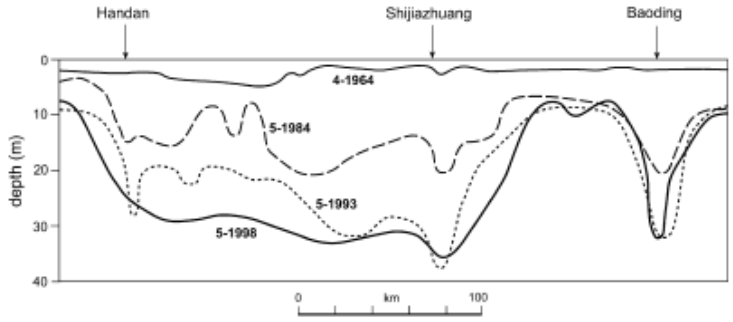
Falling Water Table of NCP Aquifer

Fig. 1 Sketch map of the North China Plain showing the distribution of areas exhibiting marked aquifer depletion (based on data provided by the Ministry of Geology and Mineral Resources/Ministry of Land Resources, MGMR/MLR)



More energy required for wells
Urban shortages more common
Cones of subsidence
Salinization
Eventually, it will run out

Fig. 3 Historical evolution of the water-table of the shallow aquifer along a north–south transect of the North China Plain (based on data provided by the MWR)

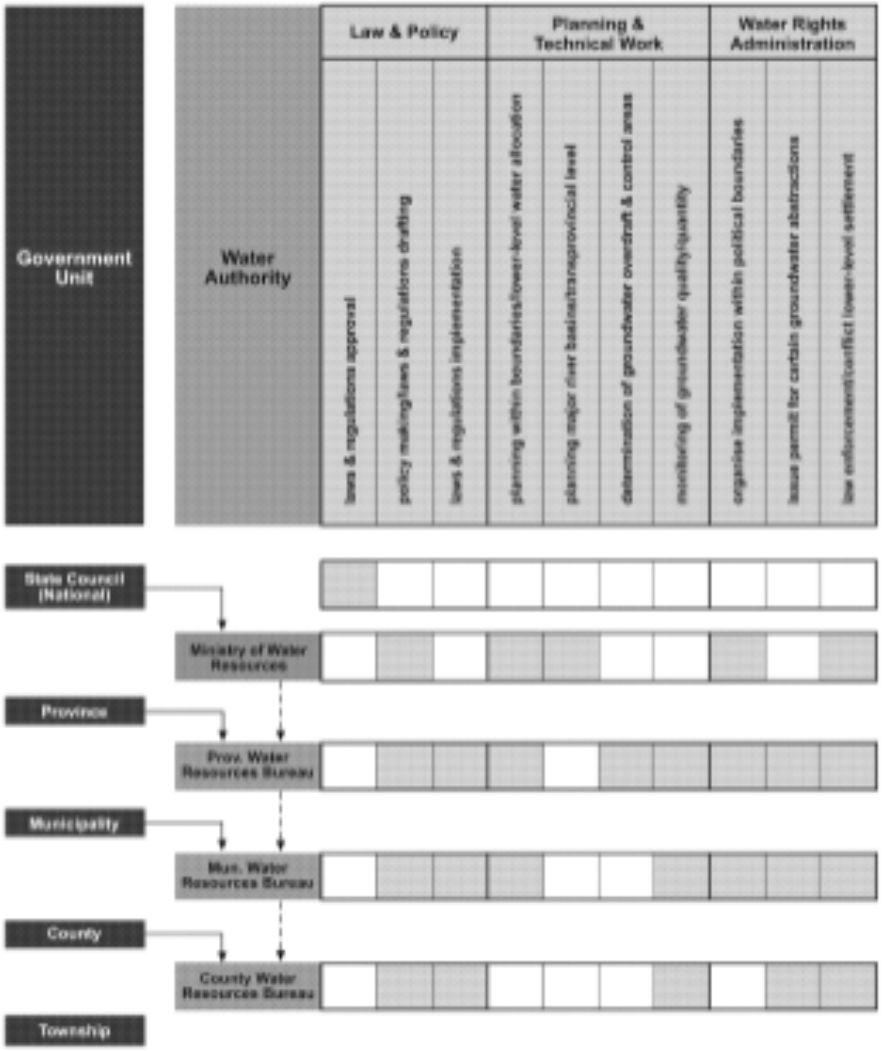


What is at risk?

- Approximately 7mt of grain, about 2% of China's total output
- Fresh water supply for consumers in areas with salinization
- Healthy water free from nitrate pollution
- Stability of ground in areas with land subsidence

Management Issues

- Ownership of Water Rights
- Commons stakeholder coordination
- Regulatory Agency Coordination
- Permitting Process
- Quotas, Targets, and Cadre Promotion



天下莫柔弱於水。而攻堅強者莫之能勝以其無以易之。

Water, Sustainability, and Resilience

- 50 years of increased agricultural production
- 70 years of food security
- Agricultural production is now locked in to a system of wells, waterworks, and high-yield crops
- Environmental problems have ensued
- What is going to happen when the aquifer is drained? Some parts may run out as early as 2025.

Local Case: Cangzhou, Hebei

Local Case: Cangzhou, Hebei

1930s Agriculture:
3 crops in two years
Wheat and Misc. Grains

Rainwater

Manure

1980s Agriculture:
2 crops/year
Wheat and Corn
High Yields

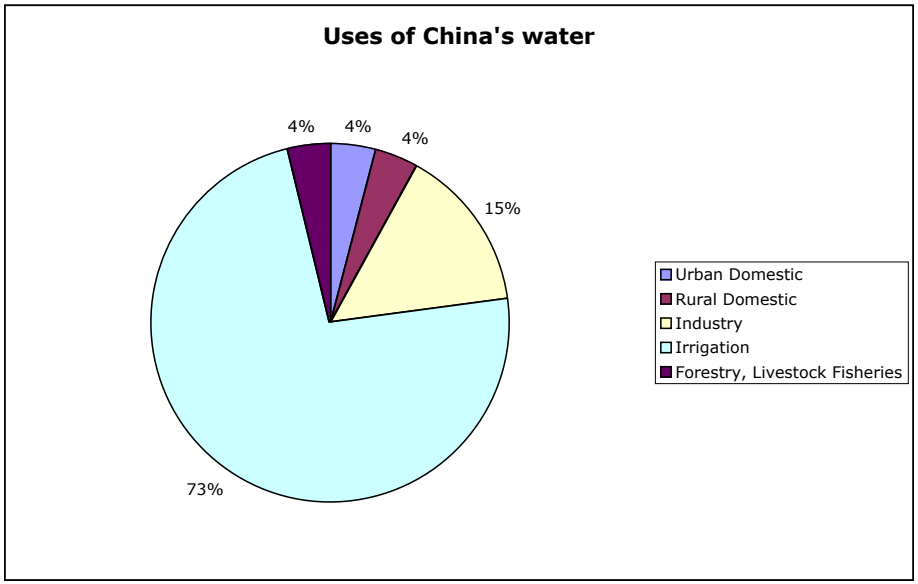
Irrigation Water

Chemical Fertilizer

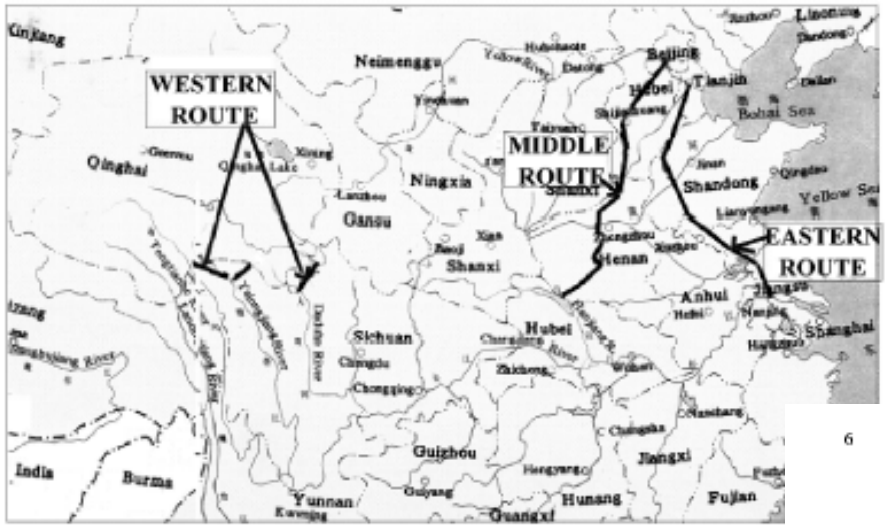
Conservation Options: the Demand Side

- Charge farmers real prices for water
- Implement effective stakeholder organization
- Provide more efficient means of irrigation
- Convert marginal land away from agriculture
- Build a few more reservoirs
- Meter urban water
- Use gray water for some uses, especially after primary treatment
  - Irrigation
  - Aquifer recharge
- Use pollution control as conservation

It's all about allocation



South-to North water transfer: the Supply Side



Source: MWR 1995

Fig. 2 Sketch map of the South–North Water Transfer Project.

南水北调

It's all about allocation across space

Estimated dates of conclusion

Eastern Route	2013
Central Route	2014
Western Route	2050??

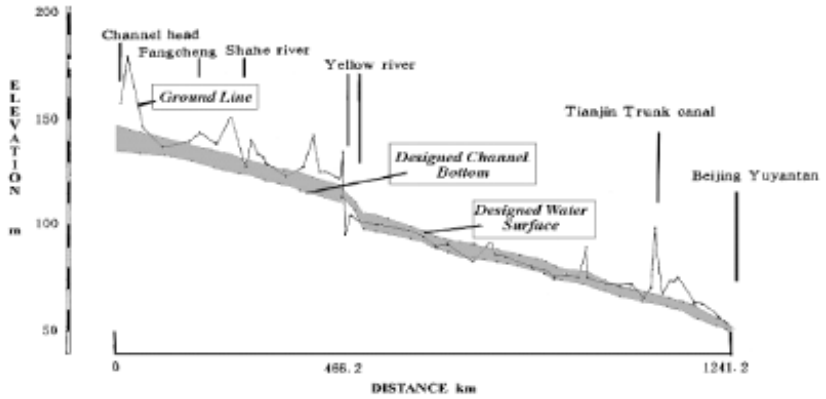


Fig. 3 Profile of Middle Route of the South–North Transfer Project. Source: MWR 1995.

Fig. 4 Profile of Eastern Route of the South–North Transfer Project. Source: MWR 1995.

How Big is this One?

Proposed size of Central and Eastern Routes: 40Gt ($km^{2)}$

Table 1: **Main Water Transfer Works Built in China Since 1949**

Project name	*Length of main canal (km)*	*Energy source*	*Annual diversion (billion m^3)*	*Province or municipality*	*Exporting region*	*Importing region*	*Objective*	*Year of Completion*
Luan River diversion	286	Gravity	19.50	North China	Luan River	Beijing-Tianjin-Tangshan	Urban water supply	1984
Huang-Qingdao diversion	262	Pump	6.85	Shandong	lower reaches of Huang River	Qingdao	Urban water supply	1990
Qinglong-Qinhuangdao diversion	63	Gravity	1.67	Hebei	Qinglong River	Qinhuangdao	Urban water supply	1991
Biliu-Dalian diversion	150	Pump	1.30	Liaoning	Biliu River	Dalian	Urban water supply	1995
Datong-Qinwangchuan diverson	70	Gravity	4.43	Gansu	Datong River	Qinwangchuan	Industry	1994
South-North transfer	400	Pump	41.00	Jiangsu	lower reaches of the Chang River	Northern Jiangsu	Industry and agriculture	1962
Dong-Shenzhen	83	Pump	6.20	Guangdong	Dong River	Shenzhen, Hong Kong	Urban water supply	1965

Source:
Liu Changming and He Xiwu (eds.), *Zhongguo 21 shiji shui wenti fanglüe* (*Strategies for China's Water Problems in the 21st Century*) (Beijing: Kexue chubanshe, 1996), p. 171.

The famous Red Flag Canal: 600Mt

What are the Environmental Costs of S-N Transfer?

Central Route:

Relocation

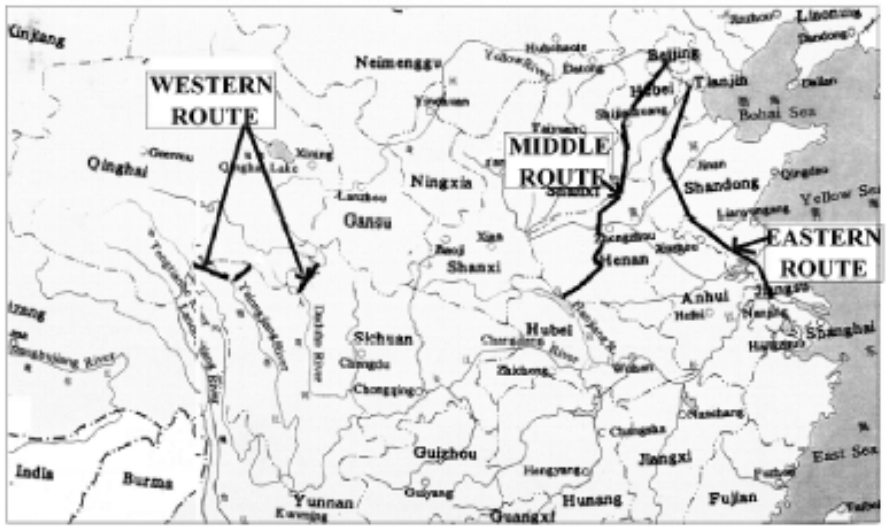
Shortages in Sending Area?

Eastern Route:

Fuel burnt to run pumps

Seawater incursion

Water polluted at source and en route



Source: MWR 1995

Fig. 2 Sketch map of the South–North Water Transfer Project.

Burning (flooding?) Questions

How much water can be conserved?

Are Transfer and Conservation
Mutually Exclusive?

Will transfer make people less likely to conserve?

What are the environmental costs of transfer?

You be the judge:

Problems Caused by Water Shortages in North China

Yellow River often does not reach the sea
Huai and other rivers severely polluted
Water table on the North China Plain falls
Urban shortages and loss of pressure
Decline in water quality
Seawater incursion in coastal areas

Vs.

What are the Environmental Costs of S-N Transfer?

Central Route:
- Relocation
- Shortages in Sending Area?

Eastern Route:
- Fuel burnt to run pumps
- Seawater incursion
- Water polluted at source and en route

天下莫柔弱於水。而攻堅強者莫之能勝以其無以易之。

Looking at Water Issues as issues of system dynamics, sustainability, and resiliency

It's all about Allocation:
across time as well as users

- Let's think about what happens when we
- Draw down the NCP aquifer
- Build the Sanxia Dam
- Pollute the Huai River
- Build the South-to-North water transfer project