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“To fight for every drop of water or die”

## WATER IN CHINA

Norman Gall

“The power of water” • “With Many People, Strength Is Great”  
More Great Walls • Dry roots • Cities of the plain  
Big projects • “Unsustainable”?



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“To fight for every drop of water or die”

# Water in China

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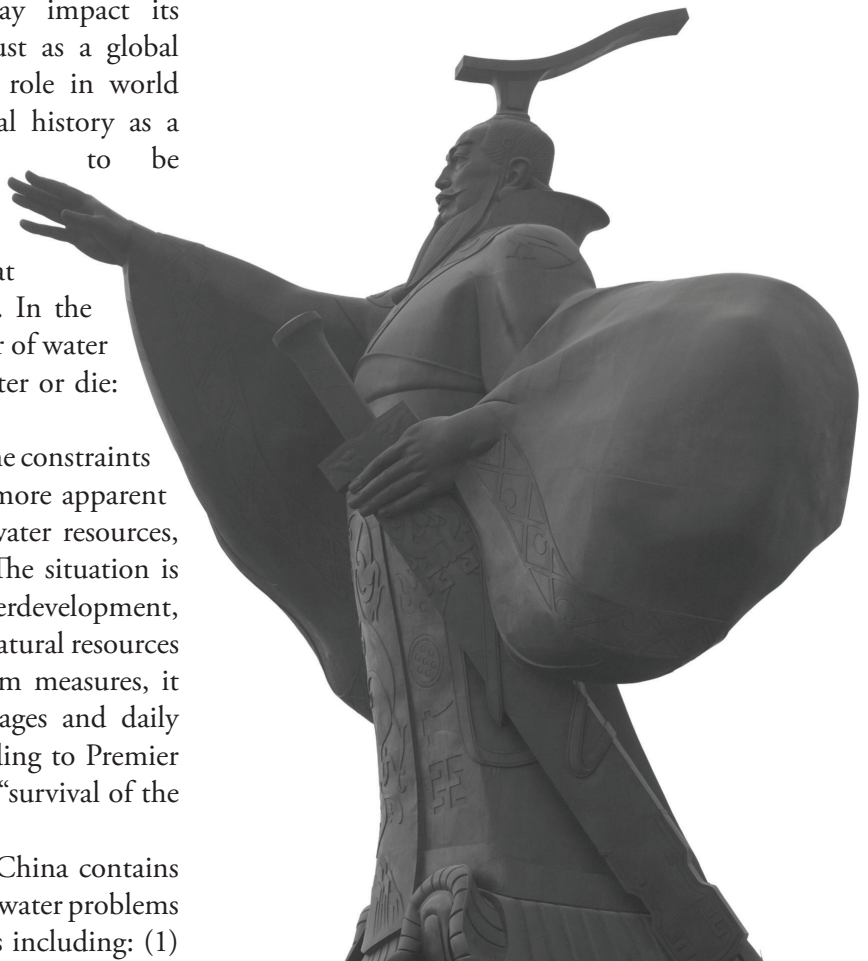
Norman Gall

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China’s growing water shortages may impact its growth and stability, weakening its thrust as a global power as it embarks upon an assertive role in world affairs for the first time in its millennial history as a unified state. Water shortages may prove to be far more important for China’s future than the scandals and power struggles inside the Communist Party leadership that recently captured international attention. In the words of Wang Shucheng, former minister of water resources: “To fight for every drop of water or die: that is the challenge facing China.”

These concerns are gaining urgency. “The constraints of our available water resources become more apparent day by day,” Hui Siyi, vice minister of water resources, told a press conference early this year. “The situation is extremely serious in many areas. With overdevelopment, water use already has surpassed what our natural resources can bear. If we don’t take strong and firm measures, it will be hard to reverse the severe shortages and daily worsening of the water situation.” According to Premier Wen Jiabao, water shortages threaten the “survival of the Chinese nation.”

With 19% of the world’s population, China contains only 6% of the planet’s fresh water. China’s water problems are deep and complex, with several causes including: (1) underpricing, waste and overuse; (2) rapid depletion of vast underground reservoirs that accumulated over thousands of years; (3) deforestation, erosion and silting of rivers; (4) decay of irrigation infrastructure; (5) pollution of rivers and groundwater by agricultural, industrial and household waste. Chinese specialists say that pollution is as great a problem as the physical availability of water. One-third of the water flowing in China’s rivers is so polluted that it is unfit for any use, neither for households, industries nor agriculture. The World Bank warned of “catastrophic consequences for future generations” if a balance between use and supply is not achieved.



*Qin Shi Huan – First August Emperor*

## Global scarcity

Water scarcity is now global, but it may be more critical in China than in any other big country. With 97% of the world’s water contained in saline oceans, freshwater is mostly locked in polar and mountain glaciers. Less than one-third of all freshwater is potentially accessible in aquifers, lakes, rivers and wetlands. A new study by

the McKinsey Global Institute (MGI) projects a near-doubling of world water demand in the half-century that began in 1980, from 3.2 trillion m<sup>3</sup> in 1980 to 6.3 trillion m<sup>3</sup> by 2030, with 65% of this growth driven by agriculture, 25% by industry and 10% by urban use. However, barring radical adaptation and innovation, MGI seems skeptical that this projected level of use will be reached, while half of the world's population in 2030 could be living in regions suffering from water scarcity. Water scarcity, land loss and a shrinking and rapidly aging rural workforce have led many to question official doctrines of food self-sufficiency. China lost 6% of its farmland since 1997 to erosion, urbanization and industrial and infrastructure projects.

Water scarcity in China is becoming a driver of the mutual dependence with Brazil, which has reached a scale never contemplated a decade ago. China's diminishing capacity to feed its population tends to increase dependence on Brazil as a source of "virtual water" in the form of food supplies, while Brazil has become dependent on exports to China to sustain economic activity and balance its international accounts. In 2004 China's total net "virtual water" imports were 78 billion cubic meters, equivalent to 11% of the water needs for its domestic agriculture, reaching 108 billion cubic meters in 2008. In 1995 China produced and consumed 14 million tons of soybeans. By 2010 China still was producing 14 million tons but consuming 69 million tons, or one-fourth of the world's supply. Brazil exports a large share of the soybeans needed to sustain China's pork consumption, half of the world total, and a beef market that became the world's third-largest within a generation. Exports to China changed the structure of agricultural production in the Americas, especially in the United States, Brazil, Argentina and Bolivia. Trade between Brazil and China grew by 50% annually since 2006, multiplying 10-fold since 2002 to reach roughly \$80 billion in 2011. Half of the capitalization of São Paulo's Bovespa stock market consists of companies heavily committed to China. In the first quarter of 2012, China overtook the United States as the leading source of imports to Brazil, after increasing its market share from 5% in 2003 to 14.5% in 2011. China became the biggest foreign investor in Brazil, as its stock of investments, only \$290 million as recently as 2009, surged suddenly by \$13 billion in 2010 and by another \$10 billion in 2011.

China's opening to the world economy, launched by the great Communist reformer Deng Xiaoping (1904-

1997), brought enormous benefits to the Chinese people as the economy grew by nearly 10% yearly over the past two decades. Hundreds of millions of people emerged from poverty as income per capita multiplied more than seven-fold in a single generation. Ezra Vogel, Deng's biographer, observed that "the structural changes that took place under Deng's leadership rank among the most basic changes since the Chinese empire took shape during the Han dynasty two millennia ago." But Deng could not have imagined that China by today would have amassed \$3.2 trillion in foreign exchange reserves, enabling it to finance the fiscal deficits of the United States and buy companies throughout the world. However, this intense development has degraded natural resources of land and water and brought new fragility to China's political system and its relations with the outside world.

China clearly has entered a phase of transition: a change in political leadership this year, with command of the Communist Party and government shifting to a younger generation; a change from a rural to urban social structure; a change from very fast economic growth to rhythms appropriate to an urbanized and aging society; a change to accommodate the escalating claims of citizenship, which is a concept alien to traditional Chinese society. Yet extraordinary prophecies continue to be made about China's future. In 2010 the Nobel economics laureate Robert Fogel of the University of Chicago boldly predicted: "In 2040 the Chinese economy will reach \$123 trillion, or nearly three times the economic output of the entire globe in 2000," with 40% of the world's GDP and its per capita income at \$85,000. In the intervening years, however, the Chinese people's prudence, creativity and survival instincts will be severely tested. This essay, based on six weeks of research in China, will focus on the scope of these challenges.

**Norman Gall** is executive director of the Fernand Braudel Institute of World Economics and editor of Braudel Papers.

# 1. “The power of water”

At the edge of the ancient city of Xi’an, China’s capital under three imperial dynasties, a huge statue of the Emperor Qin Shi Huang (259>210 BC) emerges from the haze of dust and soot that envelops many Chinese cities. The massive granite torso of the First August Emperor of Ch’in, ruler of “all under heaven,” is alive with action, his left hand resting on a great sword and his right hand pointing to a horizon crowded by phalanxes of high-rise apartment and office buildings, many of them unfinished and others standing empty and unsold in the backwash of China’s real estate mania. Clusters of new buildings are rising everywhere in China, many of them with construction cranes still perched on their rooftops. In Xi’an, as in other Chinese cities, a big question remains unanswered: How can water be provided for all the people who would live in the millions of empty apartments? As the poet W.H. Auden observed decades ago: “Thousands have lived without love, not one without water.”

## Adopt the enemy’s tactics

The Emperor Qin did many things. The kingdom of Ch’in, precursor to the name of China, was cradled by mountains on a fertile loess plateau bounded by the great bend of the Yellow River, one of some 170 petty states in constant conflict with one another until a series of conquests by Qin unified China. The small frontier state of Ch’in, defending itself against fierce incursions of nomadic horsemen from Mongolia, adopted the enemy’s tactics by training horse-borne archers in mobile armies that overwhelmed rival kingdoms.

Political unification gave rise to scale and standardization in laws, writing, weights and measures, coinage, bureaucratic practice and public works built by enormous levies of forced labor, evincing the Chinese genius for the creation of infrastructure that we see today in the multiplication of superhighways, superports, boulevards, hydroelectric dams, airports, high-speed trains and monumental railway terminals.

Remembered for his sternness and cruelty, the Emperor Qin was revered by some of China’s modern leaders, notably Mao Zedong, an avid reader of dynastic chronicles who compared himself to the First Emperor. Qin had 460 Confucian scholars buried alive for owning

forbidden books. On the Ch’in imperial highways, more extensive than the road system built by the Romans three centuries later, the Emperor Qin traversed China on five great inspection tours, dying on the last of these near the sea where, the chronicles say, he went searching for the elixir of immortality. The best-known relic of Qin’s rule is the now-famous army of 7,000 terracotta warriors, buried with their clay horses and chariots for more than 2,000 years to guard the Emperor’s tomb until discovered near Xi’an in 1974 by farmers digging for water.

## “Hydraulic civilization”

The Emperor Qin was said to have celebrated “the beginning of the power of water” as he was crowned in 221 BC. His capital, Xi’an, was strategically located at the confluence of northern China’s great rivers, connected by the Chang-an Canal to the Yellow River. Qin left behind complex networks of dams and irrigation and transport canals that have been in use for more than 2,000 years, linking the Yangtze and Yellow river basins and watering a vast agricultural heartland. The power of Ch’in was sustained by what became known as the Magic Transport Canal, over which barges were towed through 36 locks in the mountains of central China, connecting a network of lakes and rivers to transport grain, the main form of taxation, as well as troops and war supplies. The great Kuanhsien canal system cut through mountain rock to form an artificial river, providing irrigation from a thousand kilometers of channels and flood control from dikes and spillways for hundreds of thousands of hectares. According to one chronicle, “water wheels for hulling and grinding rice, and for spinning and weaving machinery, to the number of tens of thousands, were established along the canals and operated throughout the four seasons.”

For more than 2,000 years, large scale management of water resources was critical in developing and sustaining Chinese civilization. Since ancient times the seasonality of rainfall, concentrated in a few months, meant sudden flooding, while in other seasons rivers ran dry after waters flowed uselessly into the sea unless stored in reservoirs. The classic study by Karl Wittfogel of *Oriental Despotism* (1957) described the cultural matrix in which the political authority of China’s Communist

Party evolved. Wittfogel argued that a “hydraulic civilization” developed from the need for a strong central command to manage irrigation, flood control and transport in rivers and canals, producing large increases in agricultural wealth.

The historian Mark Elvin observed that premodern Chinese water management was “by world historical standards both successful and sustained,” adding that the price was high: “commitment to a system that required incessant and expensive maintenance....Man-made systems of water control are to a greater or lesser degree inherently unstable.” They are affected by rainfall, flooding, drought, deforestation, erosion, silting, salting, drainage of wetlands and incursions by the sea. “No other society reshaped its hydraulic landscape with such sustained energy as did the Chinese, nor on such a scale,” Elvin added, “but the dialectic of long-term interaction

with the environment transformed what had been a one-time strength into a source of weakness.”

China faces the same problems today under greater population pressures and scarcity. In those early days, less than 40 million people occupied China’s land mass, against 1.34 billion today, half of them now living in towns and cities. China is expected to add 350 million urban inhabitants by 2025, according to McKinsey, an increase equal to today’s entire population of the United States or twice Brazil’s population in 2000. By 2025, China would have one billion people living in towns and cities, including 221 cities with at least one million people each, a huge leap in a country where four-fifths of its people, most of them very poor, still lived in the countryside when the opening of its economy to the outside world began around 1980. This flow of people is creating a fragile balance between needs and resources.

## 2. “With Many People, Strength Is Great”

China’s population doubled in the four decades between the founding of the People’s Republic in 1949 and the Tiananmen Square pro-democracy uprising in 1989. The previous doubling of China’s population took not 40 years but two centuries (1750-1950). More recently, population grew by another one-third over the past two decades to 1.34 billion by 2010, as rapid economic growth pressured water and other natural resources, leaving China with only 0.08 hectare of arable land per capita, one of the world’s lowest man-land ratios, with farmland losses compounded by intense soil erosion and urbanization.

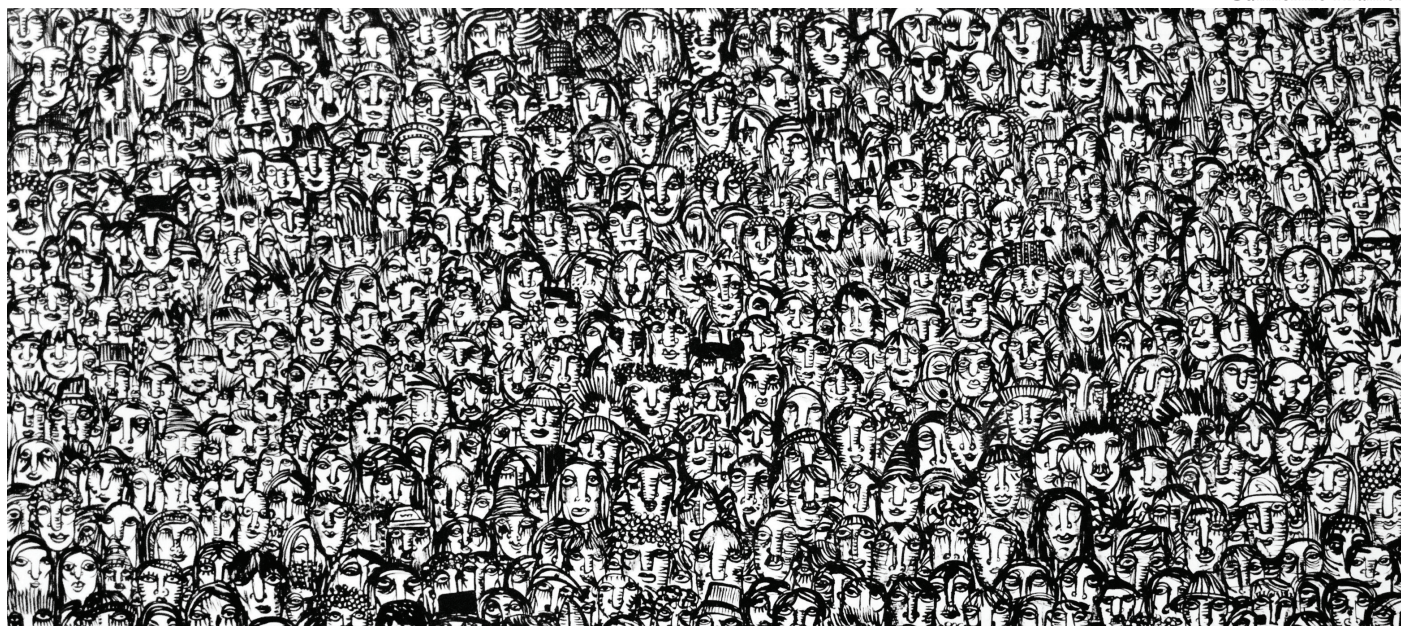
### “Vanguard of the revolution”

Mao Zedong, one of the leading political figures of the 20th Century, emerged bloody, bold and resolute from decades of civil war and revolution as his Communist armies marched into Beijing in 1949, installing himself in the residential pavilions and gardens of emperors at Zhongnanhai. Famed as a master of guerrilla warfare, with a strategy based on mobilization of peasants as “vanguard of the revolution,” Mao’s innovative Marxism fused with the anarchism and populism that were present at the creation of China’s Communist Party in the

1920s. In his celebrated *Report on the Peasant Movement in Hunan* (1927), Mao predicted that “several hundred million peasants will rise like a tornado, a force so extraordinarily swift and violent that no power, however great, will be able to suppress it.” Yet none of these ideological postures can explain Mao’s indifference to the suffering and death of many millions of people during his political campaigns. The people of China still are struggling to deal with consequences of the Great Leap Forward (1958-61) and Cultural Revolution (1966-76) under today’s population pressures and degradation of land and water resources. Soviet Communist Party boss Nikita Khrushchev recalled how in 1957 Mao explained to him the geopolitics of China’s population growth:

*We shouldn’t be afraid of atomic missiles. No matter what kind of war breaks out –conventional or thermonuclear – we’ll win. As for China, if the imperialists unleash war on us, we may lose more than 300 million people. So what? War is war. The years will pass and we’ll get to work producing more babies than ever before.*

There were many slogans and exhortations: “With Many People, Strength Is Great.” “Man Must Conquer Nature.” “When A Great Leader Emerges, the Yellow



River Will Run Clear.” In her study of *Mao’s War against Nature*, the anthropologist Judith Shapiro argued that “a great leap led China on a self-destructive rush toward ecosystem collapse and famine.” “Open the wilderness to plant grain,” Mao commanded. “Make the high mountain bow its head; make the river yield the way.” “Prepare for war. Prepare for famine, for the sake of the people.” Lakes were drained. Fragile grasslands became dustbowls after being plowed to sow wheat. Officials claimed that 100 million peasants provided irrigation systems for 7.8 million hectares, later increased to 32 million hectares. In Henan province, some 110 dams were built during the Leap, but half of them collapsed by 1966, made only of earth and designed by untrained peasants. Between 1957 and 1977, China lost 29 million hectares of farmland despite reclamation of 17 million hectares from “wasteland.” Forests were destroyed to plant grain on mountainsides and to fuel backyard furnaces as farmers melted household tools and utensils to smelt steel so China could overtake Britain, as Mao predicted:

*With 11 million tons of steel next year and 17 million the year after, the world will be shaken. If we can reach 40 million tons in five years, we may possibly catch up with Great Britain in seven years. Add another eight years and we will catch up with the U.S.*

By the autumn of 1958, the backyard furnaces produced 10.7 million tons of useless steel as rural

chaos led to the worst man-made famine in human experience. Officially, China’s population fell by 13.5 million in 1959-61, as rural death rates doubled in 1959-60, before later demographic research raised the estimated losses to between 30 and 40 million lives. Despite the famine, grain exports rose by nearly half in 1959, mainly to repay debts to the Soviet Union, even as farm output was falling by one-fourth in 1958-60 while agricultural labor was diverted into dam-building and backyard steel production. Starving people ate tree bark, seeds, roots, rodents and at times resorted to cannibalism. “There were no birds left in the trees, and the trees themselves had been stripped of their leaves and bark,” one survivor recalled. “At night there was no longer even the screeching of rats and mice, for they too had been eaten or starved to death.” In June 1959 Mao visited his native village of Shaoshan in Hunan Province, as told here by his personal physician:

*The men were away working on the backyard steel furnaces or water conservancy projects. Mao did not have to delve far to learn that life was hard for the families in Shaoshan. With the construction of backyard furnaces, everyone’s pots and pans had been confiscated and thrown into the furnace to make steel – and nothing had been returned. Everyone was eating in the public mess halls. The families had no cooking equipment... Everyone complained about the mess halls. The older people didn’t like them because the younger people always cut in and grabbed the food first. The younger people*

*didn't like the mess halls because there never was enough food. Fistfights often broke out, and much of the food was wasted when it ended up on the floor.*

*When Mao's questions stopped, the room fell silent. An air of gloom descended. The Great Leap Forward was not going well in Shaoshan. "If you can't fill your bellies at the public dining hall, then it's better just to disband it," Mao said. "It's a waste of food. As for the water conservancy project, I don't think every rural community has to build a reservoir. If reservoirs are not built well, there will be big problems. And if you cannot produce good steel, you might as well quit."*

Mao's comments never were publicized, but they spread quickly through word of mouth. Soon many communes were dismantling their projects. Mao was briefly sidelined in the early 1960s as a "rectification" by more cautious party leaders sought to correct the errors of the Great Leap Forward. Then he launched another mass mobilization, the Great Proletarian Cultural Revolution (1966-76). Students attacked their teachers as well as "capitalist" and "bourgeois" intellectuals and "revisionist" party leaders, breeding institutional chaos and sending millions into forced labor in the countryside.

### Red Guards attack officials

Youths in Red Guard uniforms massed in Tiananmen Square to worship the Great Helmsman, waving their Little Red Book of Mao's thoughts, before parading veteran party officials, forced to wear dunce caps, in processions along the streets of major cities on the back of flatbed trucks. In August-September 1966, 1,772 people in Beijing were murdered by Red Guards after beatings and torture. Deng Xiaoping's eldest son, a physics student at Peking University, was left paraplegic after being thrown from the fourth floor of a campus building. Liu Shaoqi, China's President and a veteran labor leader, suffered several public beatings by Red Guards while being denounced as a "renegade, traitor and scab hiding in the Party" before being stripped of all posts and left to die in solitary confinement without treatment for diabetes and pneumonia.

Only after Mao's death in 1976 was the new leadership able to freely discuss the consequences of the mass hysteria and to plan for the future. One of the first steps was to check population growth with a radical new



*An official victim of the Cultural Revolution (1966)*

policy, limiting births to one child per couple, which bred consequences of its own.

"China's demographic bullet train is racing into the unknown," observed Wang Feng, director of the Brookings-Tsinghua Center for Public Policy in Beijing. "Profound demographic changes in China are redrawing the parameters of the country's future. These changes include a substantial decline in the supply of young labor, the escalating financial burden of caring for the elderly, and an aging society with Chinese characteristics – namely a weakened family support system, caused in large part by China's three-decade one-child policy."

China's demographic transition began before enactment of the one-child policy, which accelerated the change. Since 1970, the total fertility rate (the number of births in women's lifetimes) collapsed by three-fourths, from 5.8 to 1.4, plunging to much lower levels



in cities such as Shanghai, where an average of only 0.6 live births per woman are registered. Fertility in China is far below the replacement rate (2.1) needed to stabilize numbers of people and roughly equal to countries like Russia, Japan, Germany and Italy, all with shrinking populations. China needed one-fourth of the time taken in the West to reach very low levels of fertility. At the same time, China is the first major economy set to grow old before growing rich. China raised life-expectancy from 40 to 70 years in only 50 years, a process that took twice as long in other industrialized countries. The speed and power of these changes pose major problems.

### Working population shrinking

The number of people of working age is shrinking while the elderly population is multiplying fast, abolishing the demographic dividend enjoyed by China over the past three decades: the blessing of a young workforce and few dependents, a mix that generated up to 25% of per capita economic growth. The number of people in ages 20-24 is expected to fall from 116 million in 2010 to only 67 million by 2030, while those over age 60 will double by 2030, from 180 million to 360 million. The needs of old people will

reduce savings far below today's nearly 50% of GDP while demanding big investments in health care and other services.

But the demographer Judith Bannister says that "China has myriad options for managing its shifting age structure," pointing out that its people aged 15-64 grew from 620 million in 1982 to 999 million in 2010, to one-seventh of the world's population, which would decline only marginally to 960 million by 2030, according to United Nations projections. "Huge productivity gains can be made from employing its enormous and current workforce more efficiently than it has done in the past," she argues. "Millions of farmers spend much of the year with little productive work to do, whiling away the time between the next planting season or harvest. Millions of urbanites are employed in unproductive jobs, especially in the state-owned sector. Many low-level bureaucrats seem to spend their working days slurping tea, reading the newspaper, and taking leisurely afternoon naps in their offices."

The needed gains in productivity will depend on major institutional changes without the kind of political eruptions that disorganized China's economy in the past. Then China may find ways of dealing with losses of its land and water resources.

## 3. More Great Walls

"What is to be done if the waters of the Yellow River rise sky-high?", Chairman Mao asked his entourage in 1952, on his first inspection tour of the country after decades of war and revolution, while standing on a hill overlooking the great river that is called the Mother of Chinese civilization.

The Yellow River is almost unique in the world because of its huge load of silt carried from northern China's loess plateau, more than a billion tons every year, which increased over time. Silting over the centuries lifted the bed of the Yellow River some 10 meters above its downstream floodplain in some places. Frequent floods and changes in the river's course led to building of extensive dikes, beginning in the 7<sup>th</sup> Century BC, now called "the second Great Wall of China," stretching over several hundred kilometers. Cutting down forests to clear land for crops intensified erosion, adding more silt to the rivers. Over the centuries levies and embankments were

reinforced many times, so more silt accumulated. When the river surged after heavy rains, or the dikes failed for lack of repairs, the waters burst beyond the silted channel to flood the surrounding countryside, reenacting a drama repeated many times in China's history.

In his great work on *Science and Civilization in China*, Joseph Needham observed that 'Chinese hydraulic engineering served its apprenticeship in the hard school of the Yellow River valleys, tackling problems which even modern technology has not yet solved.' Since 1949, so much water was diverted from the Yellow River by hydraulic projects that the weakened flow could not carry the silt downstream. In dry years, beginning in 1972, the great river failed to reach the sea. In 1997 a new record was set when the Yellow River's channel remained dry for 226 days along 700 kilometers inland from its mouth at Bohai Bay.

According to Vaclav Smil, a veteran analyst of China's

ecology, “destructive floods and droughts have molded the course of Chinese civilization as much as extensive irrigation and reliance on water transport.” In the Yangtze River Basin, severe floods came roughly every decade for the past 2,000 years, producing scenes like the one described in 1950 by the governor of Anhui province in a report to Mao:

*Thousands of people have no way to escape. Some have climbed trees but then fell into the water and drowned. Others were bitten by poisonous snakes that also sought safety in the trees. Some have climbed onto boats that were quickly capsized by the rush of the flood waters and the huge waves.*

The answer to Mao’s question came quickly from Wang Huayun, head of the Yellow River Conservation Commission, who proposed a grand scheme aligned with China’s enthusiasm for big projects: “If the 30 power stations planned for the main stream are completed, total reservoir capacity should be between 200 and 300 billion cubic meters. Under those conditions, if little or even no effort is put into controlling soil erosion and if not even one reservoir is built on the tributaries, the big dams themselves can function for well over 300 years.”

### A “staircase” of 29 dams

The complications embedded in the answer to Mao’s question came with construction of the Sanmenxia Dam

in a gorge embracing rapids created by two granite islands just below the big bend of the Yellow River near Xi’an, as the river started its descent toward the sea. Construction started in 1958, with relocation of 870,000 people, just as the Great Leap Forward was launched. A “staircase” sequence of 29 dams for flood control, irrigation and electric power in the Yellow River Basin was designed by Soviet engineers, who underestimated the volume of silt that would accumulate. By 1964, four years after the dam was finished and before any electricity was produced, a “big belly” of two billion tons of sediment amassed at the dam and the river bed rose dramatically, threatening to flood Xi’an and the surrounding plain.

Alarmed, Mao told Premier Zhou Enlai: “If nothing works, then just blow up the dam.” It took four decades of repairs to the dam to avoid flooding nearby cities and the surrounding countryside. In nearby Henan Province, with a population of 94 million today, more than 110 dams were built during the Great Leap Forward. Made of earth and designed by untrained peasants, half of these dams collapsed by 1966. To make way for Sanmenxia, some 280,000 farmers were removed from fertile lands that their families cultivated for centuries to be resettled on a wasteland at the edge of the Gobi Desert.

The silting and overflow of the Sanmenxia Dam was just the beginning of Xi’an’s water problems. Sprawling far beyond its ancient walls, Xi’an tripled its population in the first 25 years after the founding of the People’s Republic in 1949 and more than doubled it again since 2000 to embrace nearly nine million people. The Wei

## CHINA’S DAMS

When the Communists came to power in 1949, China had only 22 large dams. Since then it has built 87,000 dams, including half of the world’s 50,000 large dams (above heights of 15 meters), with many sacrifices.

Premier Wen Jiabao said in 2007 that China relocated 23 million people since 1949 to make way for water projects, to which another million may have been moved over the past five years.

The climax of these efforts was construction of the Three Gorges Dam on the Yangtze River, the world’s biggest power station with 21,000 megawatt capacity. To limit silting and regulate the flow of the Yangtze, four upstream dams are planned, totaling nearly twice the generating capacity of Three Gorges.

Already the world leader in hydropower generation, China seeks to increase water supplies in projects that increase tensions with neighboring countries, especially India, because of China’s plans to dam and divert the headwaters in Tibet of some of Asia’s big international rivers, the Brahmaputra, the Mekong and the Irrawaddy.

China is planning to build the Mutuo dam in the headwaters of the Brahmaputra in Tibet, to produce 38 gigawatts [38 billion watts] of electricity, nearly twice the capacity of Three Gorges. Internationally, 37 Chinese state companies are carrying out more than 100 dam projects in developing countries.

River, running past Xi'an before flowing into the Yellow, traditionally has been the main source of surface water for the city, but became so polluted that water quality at nine of its 13 monitoring stations was found to be unfit for any use. So people in Xi'an have been digging wells so intensively that the land began to sink. The sinking was first noticed in the 1960s and has intensified since then.

As the Yellow River and its tributaries dried, Xi'an's municipal government drilled thousands of wells to extract groundwater and bored tunnels in the Qin Mountains of Shaanxi Province to divert waters from other rivers. The thousands of wells caused surface cracks and craters and underground funnels and cones, damaging buildings, pipelines, electrical installations, bridges and pavements. Land sunk more than two meters deep in several places

within an area of 155 km<sup>2</sup>. Meanwhile, as the city grew spectacularly, the water problem struck hard throughout the North China Plain, according to Ma Jun, author of *China's Water Crisis* (2004):

*Water diversion projects were built helter-skelter with little or no regard for the cost, while continuing destruction of the forests, which offered the greatest protection of water resources, went unobserved. Soil erosion in Shaanxi Province currently affects nearly half the total amount of eroded land in the country. It also produces 920 million tons of sediment annually, or one-fifth of the soil erosion in the entire country. The situation has been made worse by the droughts that have plagued Shaanxi over the past several decades.*

## 4. Dry roots

“Climate change will lead to severe imbalances in China's water resources within each year and across the years,” the Second National Assessment on Climate Change reported in November 2011. “In most areas, precipitation will be increasingly concentrated in the summer and autumn rainy seasons, and floods and droughts will become increasingly frequent.” Most rain comes in the monsoons of July and August. Recurrent droughts over the past three centuries recently intensified.

Climate change is punishing China with an increase in droughts and sandstorms as the Gobi desert invades the North China Plain, where many rivers are dried and broken, losing their capacity to replenish groundwater and to carry away sand and salt. As population densities increased, the survival of cities and farms now depend on the pumping of groundwater from aquifers that now are receding. The depletion of groundwater poses a major threat to China's population and economy. The number of wells multiplied from 150,000 in 1965 to 4.7 million in 2003 and to tens of millions today, thanks to the pricing of water below the cost of recovery and the spread of cheap pumping technology.

By 2002, overpumping of groundwater had lowered shallow water tables by up to 50 meters and by up to 90 meters in deep aquifers, which are being drilled

to depths beyond 1,000 meters today. The depletion of aquifers hastens the drying of lakes and wetlands and increases salinity as seawater invades the emptying underground cavities. The compaction of exhausted aquifers destroys their storage capacity and thus their usefulness as a strategic reserve in dry years, worsening the impact of droughts and desertification in some areas.

The northern plain, home to more than 500 million people, embraces 65% of China's cropland but only 24% of its water resources to produce 80% of its corn and wheat. The loess plateau is very dry. Farmers rely on irrigation. But irrigation is so wasteful that only half of the water from the main canals reaches the fields. Between 1965 and 1975, despite the convulsions of the Cultural Revolution, irrigation area grew by nearly half as investments in water infrastructure rose by 10% yearly. But canals lack plastic lining to protect against seepage and are poorly maintained, causing structural decay of local irrigation systems throughout China, with dilapidated canals clogged by mud and debris. Irrigation supports four-fifths of China's farm output, mainly wheat, corn, rice, cotton and vegetables, grown by more than 245 million households on tiny plots. Pressure on water resources intensifies by double cropping, growing wheat in winter and corn in summer.

With 19 million hectares, China is second only to India in area equipped for irrigation by pumping groundwater. According to government research, the water table receded by up to one meter a year on the northern plain between 1974 and 2000 as extraction of groundwater increased by 2.5 billion cubic meters every year while pollution of the aquifers intensified. In southern China, groundwater is contaminated by heavy metals and other industrial pollutants. The China Geological Survey found that 90% of

groundwater is polluted, 60% of it seriously.

The depletion of groundwater is a global trend as economic activity intensifies and consumption levels rise, also affecting countries as varied as United States, India, Pakistan, Mexico, Saudi Arabia and Yemen, to name a few. China is especially vulnerable because of the size and density of its population and because of its sudden surge of urbanization, economic growth and living standards in recent decades. The pressures are most urgent in the cities.

## 5. Cities of the plain

Of the 20 most polluted cities in the world, 16 are in China. Moreover, two-thirds of China's 669 biggest cities are suffering from water shortages, according to the Water Resources Ministry, driving them to drill ever-deeper wells into the aquifers that form their last local sources of supply. The overpumping of groundwater, in volumes far greater than natural replenishment, caused the land to sink by at least two meters in some 50 cities in the North China Plain, the Yangtze River Delta and the terraces of the Wei River Valley, near the ancient capital of Xi'an, impacting a total area of some 100,000 km<sup>2</sup>. "Land subsidence due to excessive groundwater exploitation is a type of regional geological hazard that develops slowly and progresses to a disaster that is difficult to control, entailing great losses," the China Geological Survey reported.

In the cities of Beijing (population: 20 million) and Tianjin (13 million), the per capita water supply fell to 100 cubic meters in 2011, one-tenth of the international benchmark for scarcity, after 13 years of drought.

### Sinking of land

Beijing obtains two-thirds of its supplies from tens of thousands of wells, extracting groundwater that is receding fast. The sinking of land fractured underground water and gas pipes, undermining plans to triple the size of Beijing's subway system by 2020, which would make it the world's biggest. In Shanghai, with 25 million people, the sinking began in the 1920s but was curtailed in the 1960s by pumping restrictions

and by artificially refilling the aquifers, only for the sinking of land downtown to intensify since the 1990s by the pumping of water from excavation sites and by construction of some 5,000 high-rise buildings that overloaded the surface land above the hollowing aquifers. The sinking of land has threatened China's high-speed railway system, causing the collapse this year of 7 kilometers of new track on the Shanghai-Beijing route.

### "Whole forests burned"

Beijing poses the most serious problems. Emerging in historical records as a walled city about 3,000 years ago at the northern tip of a sprawling triangular plain, a place where Chinese rulers delivered tribute of silk and silver to placate Mongol warriors, Beijing became an important city in 936 AD, ruled by the Khitans, a northern tribe that controlled trade routes deep into Central Asia. By the time Kublai Khan (1215-94) made Beijing the seat of his Mongol dynasty, water was brought along canals from intermittent streams flowing from the nearby Western Hills. Later dynasties stripped the surrounding plain of its forest cover to plant crops and fuel ovens for baking bricks and forging iron as springs dried and the water table receded. "No tall trees were left on the mountains," an old chronicle reported, as "whole forests were burned."

Early in the 20<sup>th</sup> Century, Beijing was an imperial capital of low population density with extensive palaces, temples and gardens and about a million people. By the time the Communists came to power in 1949, its

population had grown to four million and since then multiplied five-fold in sudden bursts.

Mao Zedong's deep involvement with the future of Beijing began in 1918-19, as a poor library clerk at Peking University under the tutelage of Professor Li Ta-chao, a founder of the Chinese Communist Party. Three decades later, Mao returned in triumph at the head of a victorious army. "Chairman Mao wants a big modern city," the Beijing party secretary said, "he expects the sky to be filled with smokestacks," as 6,000 factories were built, producing steel, chemicals, electricity, cement and armaments, without local sources of water and power.

The new regime tore down the ancient city walls to create a 10-lane boulevard for military parades, while Tiananmen was remodeled in the style of Moscow's Red Square. Some 50 kilometers of tunnels were dug for bomb shelters against nuclear attack as well as a subway system that reached into the gray apartment blocks of new suburbs. Another wave of construction came over the past two decades, as China's opening to the world economy gained momentum, with foreign architects designing showcase hotels and office towers, climaxed

by the building spree that preceded the 2008 Beijing Olympics. In *City of Heavenly Tranquility*, a history of Beijing, Jasper Becker estimated that this great urban remodeling cost more than \$200 billion, apart from the \$40 billion spent on the 2008 Olympics.

Since Kublai Khan's time, Beijing traditionally was fed by groundwater from springs and shallow wells. The sprawling municipality of Beijing embraces five main rivers and more than 200 smaller streams, mostly now completely dry. With nearly all rain concentrated in a few summer months, sandstorms attack the metropolis each spring as the Gobi Desert invades the surrounding plain. In the half-century after the founding of the People's Republic in 1949, the government built 85 dams and reservoirs for Beijing and drilled 40,000 wells in its suburbs. In 1950 Mao ordered building of Guanting, China's first big reservoir, impounding 2.2 billion cubic meters of water for Beijing, which by 1997 was too polluted for human consumption thanks to effluents from fish hatcheries and local factories while receiving only one-tenth of its natural inflow when construction finished in 1954.

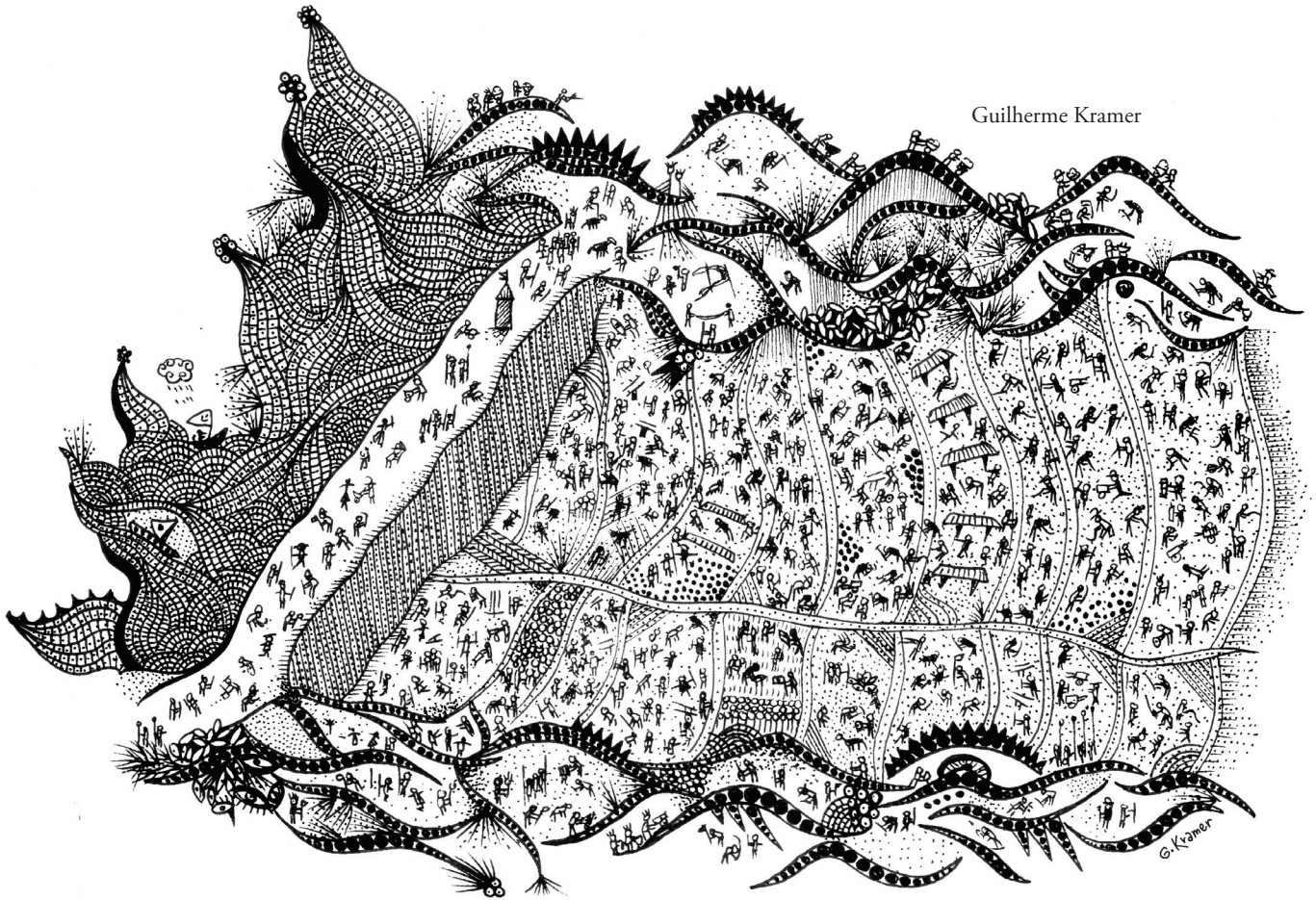
## 6. Big projects

As with much else in the People's Republic, Mao Zedong set the tone for what was to follow. "Southern China has too much water and the north has too little," the Great Helmsman said in 1952. "We should try to borrow some water from the south to help the north." That was the inspiration for one of the most complex hydraulic projects in world history, the US\$62 billion South-North Water Transfer Project to relieve the chronic water shortages of the 500 million people living on China's northern plain. The scheme was so grandiose and expensive that it was not launched until 2001 in a desperate effort to save Beijing from its water crisis.

The great rivers of China, rising in the mountains of Tibet, mostly flow from west to east, while its ancient system of canals trended south to north. The South-North Transfer Project modernizes the old route of the Grand Canal, one of the great thoroughfares of the ancient world, which stretched 1,800 kilometers from Hangzhou in the south to near Beijing on the northern plain, comparable to the distance between New York

and Florida. Like the South-North Transfer, the Grand Canal crossed five great rivers as a one-way channel for bringing resources from the economic heartland of the south to the political capital of the north. Some 100,000 peasants pulled some 11,000 barges along the canal each year. "The Great Khan has made very great channels, both broad and deep, from the one river to the other and from the one lake to the other," Marco Polo wrote seven centuries ago, "and makes the water go through the channels so that they seem a great river; and quite large ships go there with the grain loaded."

Like the Great Wall, the Grand Canal evolved from many additions over time, its oldest segment dating from the 4<sup>th</sup> Century BC. Bold engineering was needed to connect rivers and lakes with lock-gates to regulate water levels as the canal negotiated differences in altitude as it climbed from the lowlands of the Yangtze delta to the northern plateau. An imperial road, lined with trees, was opened along its banks, where boats were dragged by laborers and water buffaloes. Granaries were built in



*A million peasants modernize the Grand Canal (1970)*

many places along its route so rice could be stored safely if floods or low water impeded routine transport. When the Jesuit missionary Matteo Ricci traveled to Beijing on a boat along the Grand Canal in 1598, he saw flotillas of barges, commanded by eunuchs, carrying fruit, fish, clothes, silk cloth, tea and vegetables, with cities along the way ordered to supply ice to keep the food fresh.

The old route of the Grand Canal is being modernized as just one part of a scheme embracing some 2,500 kilometers of canals on three separate routes. At twice the cost of the Three Gorges Dam on the Yangtze and ten times more expensive than the transposition of Brazil's San Francisco River, the South-North project underwent 50 years of planning and debate before construction began in 2002. The project involves expansion and modernization of the Grand Canal, transfer of water from the Three Gorges and Danjiangkou reservoirs, as well as the construction of several tunnels, canals and pumping stations, one among these an eight-kilometer tunnel under the Yellow

River for the waters to reach Beijing. Half of the cost of the project will be spent on cleaning river waters that municipal wastes and factory and agricultural effluents have made useless. The metropolis of Tianjin near Beijing refuses to use the polluted waters from the South-North Transfer, investing instead in expensive desalination processes.

The South-North Water Transfer is one of several giant projects being undertaken by state corporations in China:

1. Some 26 nuclear power plants under construction, in addition to 15 already operating and another 35 approved;
2. From 13 to 15 "coal-power bases" in the western provinces to generate electricity near coal mines to send hundreds of billions of kilowatt-hours to eastern cities as "virtual coal," using ultra-high voltage (UHV) transmission to relieve congestion from moving hundreds of million tons of physical coal across China at great cost on railroads and highways, despite the

water scarcity in western China that limits growth of coal production.

3. A six-fold expansion of its highway network to 65,000 kilometers since 2000;

4. Building two-thirds of the airports now under construction around the world;

5. The laying of 32,000 kilometers of railroad track over the past five years, which includes building the world's largest high-speed rail network, with 9,700 kilometers of track laid and another 17,000 kilometers under construction. In terms of capacity utilization, "China's railways are probably the most burdened in the world," according to a study by Morgan Stanley, unable to keep pace with economic growth and carrying nearly four times as much cargo per kilometer of rail as in the United States. Due to inefficiencies, logistics costs in China absorb 18% of GDP, against 8% in the United States and Germany and 11.6% in Brazil. The bulk of rail cargo is coal carried to power stations and steel mills throughout China.

China's steel industry has grown beyond the wildest dreams of Mao Zedong, who hoped to out-produce Britain from the backyard furnaces in the Great Leap Forward. China's steel output multiplied from only 13 million tons (MT) in 1965 to 100 MT in 1996 and to 700 MT in 2011, or roughly half of world production. But water may be a limiting factor for the future. Next to iron and energy, water is the industry's most important commodity, requiring four tons of water to produce one ton of steel.

### Cancer villages

Along the Grand Canal is one of highest concentrations of "cancer villages," mainly rural communities in some of China's richest regions, impacted by carcinogens in industrial wastes dumped into rivers and canals by paper, petrochemical and electronics plants, in addition to pesticides used in the fields. Since the 1990s, cancer became China's leading killer, with one in five deaths. Compared with the world average, Chinese farmers are five times more likely to die of liver cancer and twice as likely to die of stomach cancer. Beginning in 1998, investigative reporting by Chinese media, especially CCTV and *Shenghuo Shibao* [*Life Times*], found near Tianjin the first of some 459 villages throughout China with surging cancer cases and deaths. These discoveries were documented by more reporting by

the media and by government-supported research that identified a "cancer village belt" in industrialized eastern China, where 84% of the outbreaks occurred. "Water contamination from industrial pollution is believed to be the main cause of cancer villages," according to Lee Liu, a geographer at Central Missouri University, "and there is a close relationship between China's major rivers and the location of cancer counties."

Responding to the multiple threats posed by ecological degradation, China has launched the most ambitious cleanup campaign in human experience. Under its 12<sup>th</sup> Five Year Plan (2011-15), the regime would (1) reduce pollution emissions, especially heavy metals, dangerous chemicals and organic pollutants; (2) safeguard drinking water; (3) upgrade urban infrastructure; (4) close backward industrial plants producing steel and iron, non-ferrous metals, building materials, chemicals, paper, coal and dyes. The Plan states its goals in considerable detail. However, in the past these efforts have been plagued by overlapping of responsibility among the central, provincial and local governments for management of water resources. Responsibility for water problems is shared by the ministries for Water Resources, Environmental Protection and Housing and Urban Development. These ministries decree plans and goals to be realized by provincial and local governments, which must provide much of the financing. But the real power is local. Centrally announced policies and goals may clash with local political and business interests. Most towns and cities are ill-equipped technically to deal with water pollution. "Only 40% of Chinese cities can test all 106 criteria listed," said Song Lanhe, chief scientist at the government's water quality monitoring center in Beijing. "The rest will have to send samples to nearby cities for testing, or conduct incomplete tests."

One of the main theaters of this struggle is the Huai River Basin, China's major granary and home to 170 million people, the scene of many natural and man-made calamities in the confluence of rivers in the heartland between the Yellow and the Yangtze. In 1950 Mao Zedong vowed to "harness the Huai," as emperors previously failed to do, according to one of his subordinates:

*Chairman Mao talked about Chinese history and stressed that the Huai River valley area was the place where peasants organized uprisings against existing regimes and from where many new emperors arose. Given that*

*the region is very poor and is often visited by natural disasters that spell trouble for a sitting government, peasants in this area are known to rebel, especially when driven by disaster and hunger.*

There were many disasters. In 1194, decades before Kublai Khan founded his dynasty in Beijing, the Yellow burst its banks and settled into the channel of the Huai, one of the 1,590 times it overflowed and one of the 26 major changes of its course over the past 2,500 years, blocking the Huai's outlet to the sea and depositing so much silt that, 700 years later, the Yellow was forced back into its old channel. In July-August 1931, after three years of drought, a deluge fed by heavy rains and melting snows swept over the Huai Basin, drowning millions and killing many more from cholera and typhus. In 1938 the Nationalist general Chiang Kai-shek ordered flooding of the region by dynamiting the dikes of the Yellow to stop the advance of the Japanese army, drowning many thousands of peasants and leaving many others homeless.

In the half-century after 1950, the new Communist regime invested heavily to prevent disaster in the Huai Basin, building 5,700 reservoirs, excavating 2,164 kilometers of canals, reinforcing 50,000 kilometers of embankments and preparing nine million hectares for irrigation. Photos of hundreds of thousands of peasants building dams with little more than their bare hands stirred awe around the world. On the upper reaches of the Huai, 13 large dams were built with storage capacity of 9.4 billion cubic meters by the mid-1970s, leaving officials confident that the Huai finally was harnessed. But a typhoon swept over the region in August 1975, breaching two big dams that were hastily built during the Great Leap Forward, releasing a water wall tens of meters high and drowning at least 86,000 people, according to official estimates. The New China News Agency reported: "Owing to lack of hydrographic data and the hurried start of construction, the standards of some important conservancy projects were too low and their quality was poor, whereas the sites of reservoirs were improperly selected."

Millions of people have fled the Huai Basin, which has become the leading source of internal migration in China. The Communist Party boss of Henan Province said that in 2008 alone the province exported 21 million people. "It was the human pool that filled cities like Shanghai with cheap labor," observed Jonathan Watts of

*The Guardian*. "There was little reason to stay. The area was often deluged with floods. In the post-reform era, it has become synonymous with pollution and sickness." "Human sewage in the Xiang River continues to exceed standards," said the manager of a water monitoring station in Hunan Province. "Mercury, arsenic, cadmium and other heavy metals exceed standards due to discharges from upstream factories."

Responding to public unrest over conditions like these, the government announced in June 2012 a 13,000-word National Human Rights Action Plan (2012-15), expanding upon a previous National Human Rights Action Plan (2009-10). The new plan covers a wide range of issues, including living standards, social security, health, education and rights of detainees and minorities. Documents like these in China are prepared with care, from a prodigious flow of memoranda, reports and drafts between bureaucracies of the party and national and provincial governments and their various research institutes. This one tries to define the rights of citizenship, a concept until lately alien to the main thrust of Chinese civilization.

"China will promote the construction of a monitoring network for the safety of drinking water," the plan stated, "and make its coverage extend to all cities divided into districts and over 90% of counties by 2015. The rural population with access to centralized water supply will be raised to 80%." The World Bank blames pervasive water pollution in China on "various institutional and policy failures" including poor law enforcement and compliance, failure to implement prevention and control plans, lack of incentives for wastewater treatment and conflict with local interests, such as factories owned by town and village governments. Institutional difficulties in implementing water conservation policies prevail in many countries, including Brazil, United States and India, but these problems are more acute in China because of the advanced degradation of its resource base.

The Huai Basin, where 85% of the river water in 2005 was unfit for human consumption even after treatment, was the first region where major investments in pollution control were made. Thousands of chemical and pulp/paper factories were closed in recent years, but effluents from households and farms far exceeded industrial pollution. Population densities and surging economic activity posed challenges for inspection and enforcement on a scale perhaps greater than those posed by control of deforestation in Amazônia.



## 7. “Unsustainable”?

The problem of population densities may be critical, overloading a deteriorating physical environment. The word “unsustainable” has become a watchword in public debate on what is seen by many in China as the threat of an economic and ecological impasse. In a joint report, *China 2030: Building a Modern, Harmonious, and Creative High-Income Society* (2012), the World Bank and the Development Research Center of the State Council stated: “There is broad recognition in China – as reflected in the 11th and 12th Five Year Plans – that the country’s pattern of investment and growth has become largely unsustainable.”

The body politic is groping for solutions, at many levels of society and government. “The China Model in economic growth is unsustainable because it creates waste of resources, heavy pollution, low wages and lack of protection of human rights,” said Zhu Zhongjun, a political analyst at the Chinese Academy of Social Sciences. “The current physical pattern of urbanization is unsustainable,” said Yang Weimin, head of the National Reform and Development Commission. President and Communist Party Chairman Hu Jintao, a hydraulic engineer by training, spoke of “unbalanced, uncoordinated and unsustainable development” in his opening speech in March 2012 to the National People’s Congress. The Congress was closed two weeks later by Premier Wen Jiabao with this warning: “We must press ahead with both economic structural reform and political structural reform, in particular reform of the leadership system of our party and country.” Or else, Wen added, “the gains we have made will be lost, new problems that have cropped up in China’s society will not be fundamentally resolved and such a historic tragedy as the Cultural Revolution may happen again.”

Fears of radicalization and disorder, combining with intensifying nationalism, add volatility to China’s dependence on the outside world. “We are surrounded by enemies,” a Chinese executive of a multinational company told me as we traveled together deep in the interior. Wang Jisi, dean of international studies at Peking University, wrote in 2011 that “China’s power and influence relative to those of other great states have outgrown the expectations of even its own leaders,” although Chinese history induced a “persistent sensitivity to domestic disorder caused by foreign threats.” A year

later, at a Brookings Institution forum in Washington on “strategic distrust” between China and the United States, Wang Jisi observed that “the China Model, or Beijing Consensus, features an all-powerful political leadership that effectively manages social and economic affairs, in sharp contrast to some countries where ‘color revolutions’ typically have led to national disunity and Western infringement on their sovereign rights.”

China faces a major test of adaptation to radical degradation of its resource base. Unity indeed may be critical. The long-term management of China’s water scarcity may demand consensual mobilization of collective effort on a scale last seen in the Great Leap Forward of the 1950s, which was futile and destructive. To succeed, a new collective effort would involve mobilization in the cause of moderation, technical sophistication and respect for the claims of citizenship. How these issues are managed politically may shape China’s future.