



On a
Different

Scale

Putting China's Environmental Crisis in Perspective

Need a puzzle to ponder? Consider the future of the People's Republic of China. China's astounding industrial growth over the past two decades has created a nation that could become one of the most powerful economies in the new century. Yet, at the same time, China is struggling with some of the most serious environmental health problems on the planet, which could curb its economic growth in the near future.

On the surface, China's list of environmentally related problems—air pollution, water pollution, shrinking arable land—does not look much different from the degradation inventories of other developing nations undergoing rapid industrialization. However, China differs from all other developing nations in one important respect: scale.

Today, China's population officially stands at 1.25 billion. As Lester Brown, chairman of the board of the Worldwatch Institute, puts it, "A billion of anything is big, huge. It's one thing if a country of 120 million people turns to the world market for most of its grain, but if a nation of 1.2 billion moves in this direction, it can quickly overwhelm the export capacity of the United States and other countries." And China is still growing at the rate of 14 million a year.

Over the past 50 years, China has mounted an aggressive campaign to eliminate hunger, improve primary health care, and tackle infectious diseases, with impressive results. "Since 1949, the average life span in China has risen from 35 years to the current 71," says Brown. According to the report *Selected Edition on Health Statistics of China, 1991–1995*, published in 1996 by the Chinese Ministry of Health, the infant mortality rate had dropped since 1949 from 200 per 1,000 to 31 per 1,000. The report also states that infectious diseases, while still a serious problem in some parts of the country, account for a small share of the deaths each year—only 0.0004% of the population.

Although some experts believe these figures may actually be higher, China's decrease in infectious disease morbidity and mortality rates is still a stunning achievement. This remarkable turnaround is generally credited to China's system of rural health care providers, established in 1949. Once called "barefoot doctors," these rural specialists are specifically trained to treat epidemics and common diseases.



Xu, Xiping/Harvard University

Air soup. Air pollution in cities such as Chongqing (above) comes largely from coal burning. The consequent lung disease is one of China's leading causes of death.

It is not uncommon for developing nations to look upon environmental protection as a luxury that they will attend to when they reach a more stable economic position, writes Chris Nielsen in issue 3 (1999/2000) of the *China Environment Series*, a series of reports issued by the Working Group on Environment in U.S.–China Relations of the Woodrow Wilson Center, an international institute for advanced study. Nielsen, executive director of the Harvard University Committee on Environment (UCE) China Project (a research program focused on energy-derived air pollution and greenhouse gas emissions in China), writes that the United States learned the hard way that it is far costlier to develop the economy first and clean up later than it is to prevent waste generation from the start. Many scientists worry that, due to China's huge population and its rapid industrialization process, this nation can even less afford the delay.

There is no question that China's first priority is economic growth. China shares the popular view that economic prosperity is crucial for the well-being of its people. Yet, China has also demonstrated a serious commitment to environmental protection. In recent decades, China has placed environmental protection into its constitution, built an extensive body of laws and statutes to protect the environment and natural resources, participated in the drafting of national and international environmental protection agreements, supported the development of science and technology to address environmental issues, and created government infrastructures to educate the public and enforce regulations.

Why, then, is China still so polluted? The nation's continued priority on rapid economic growth often conflicts with and undermines efforts to protect the environment. In addition, it is hard for the Chinese government to enforce environmental protection legislation, particularly in rural regions, because government control has become highly decentralized (in part to spur economic growth). Finally, China's environmental degradation is simply too great to turn around overnight.

Small-scale industrialization has contributed to environmental degradation and health problems in China since the nineteenth century, but the rate of environmental destruction escalated rapidly during the past 50 years. During the Great Leap Forward, from 1958 to 1960, the leaders of the Chinese Communist Party attempted to jump-start the economy by reorganizing its rural population of peasants into collective agricultural, industrial, and mining communes. Much of China's forests were cut down to fuel smelting foundries, contributing to unprecedented erosion, pollution, and flooding. The Great Leap Forward ended

with the worst famine in China's history—30 million Chinese starved to death.

The Cultural Revolution, from 1966 to 1976, was a renewed attempt to return China to a revolutionary path of reform. Among his many policies, revolution leader Mao Zedong encouraged large families. Before 1949, China's population stood at 540 million. Due to Mao's policies, the population has multiplied two-and-a-half times. Also during the Cultural Revolution, most scientific research was placed on hold.

Although the Great Leap Forward and the Cultural Revolution were short in duration, their impact on China's environmental conditions was profound. Environmental degradation did not stop with the end of the Cultural Revolution, however. Once again, China's renewed efforts to industrialize the country caused much degradation, despite the government's ambitious attempts to curb environmental damage and repair some of the damage from the previous three decades.

China's environmental health crisis can largely be traced to the same array of culprits plaguing most other developing nations. But some factors—including coal burning, the establishment of township and village enterprises (TVEs), and widespread deforestation—are especially characteristic of China.

China's Air

At least three of the world's ten cities with the worst air quality are in China (the actual number may be as high as eight). In Shanghai, tourists complain about burning eyes and sore throats. After a rain in the once beautiful city of Chongqing, cars and streets are coated with gray slime. Vicki Harris, a pollution specialist at the University of Wisconsin Sea Grant Institute in Green Bay, recently visited China's largest cities on a scientific exchange program with the Beijing Institute for Environmental Studies. She describes the slime that coats Chongqing as "slippery" and says the city is coated in soot mixed with whatever other pollutants are in the air that day.

Coal burning is a major source of the air pollution found in China. No other large developing country relies as heavily on coal burning to provide electrical energy and for simple cooking and heating as China does—the country currently relies on coal burning for three-quarters of its energy supply. China is the world's largest producer and consumer of bituminous coal, with consumption reaching 1.3 billion tons by 1995, according to the World Bank's 1997 report *Clear Water, Blue Skies*.

Coal burning exposes the population to high levels of benzopyrene, a known human carcinogen, and sulfur dioxide (SO₂). SO₂ is associated with respiratory disease—it irritates

the lining of the airways, causing inflammation and leading to a variety of chronic and acute respiratory conditions. Xu Xiping, a professor of occupational epidemiology at the Harvard University School of Public Health and a cochair of the UCE China Project, writes in the July/August 1994 issue of *Archives of Environmental Medicine* that he had found strong correlations between SO₂ exposure and chronic obstructive pulmonary disease (COPD), as well as other forms of heart and lung disease, in Beijing. According to Xu, for each doubling of SO₂ concentration, the risk of total mortality was estimated to increase by 11%.

The authors of the 1997 World Bank report *Can the Environment Wait? Priorities for East Asia* state that COPD has become the leading cause of death in China, and point to air pollution as the principal cause. Xu has been conducting large epidemiologic studies on the association between indoor and outdoor air pollution and occupational hazards with lung function, respiratory symptoms and diseases, mortality, hospital visits and admissions, cancer, and cardiovascular disease. In *Energizing China: Reconciling Environmental Protection and Economic Growth*, a series of articles by the UCE China Project, Xu shows that between 1981 and 1991, concentrations of particulate matter in five major Chinese cities ranged from two to five times the World Health Organization maximum of 150–230 micrograms per cubic meter.

Many experts suspect that indoor pollution is a greater factor in respiratory diseases than outdoor pollutants. Most humans spend the majority of their time in the home, particularly women, who spend a great deal of time inside near cooking stoves. People living in colder northern China spend even more hours exposed to indoor pollution during the winter months.

An estimated 64% of China's population use coal in their homes, and about 22% of rural homes rely on coal for domestic fuel. The effects of coal burning are magnified because coal often is not washed before it is used, and it is cooked in unvented stoves. Cooking with tainted coal can expose people to arsenic, fluorine, lead, and mercury.

In the July/August 1993 issue of *Archives of Environmental Health*, Xu confirms that indoor concentrations of SO₂, particulates, and benzopyrene are frequently much higher than outdoor levels of the same pollutants. Concentrations of these pollutants and inhalable particulates are much higher in homes using coal or biomass for energy than homes using natural gas. In winter months, indoor pollutant concentrations can rise up to tenfold over summer month concentrations. In the March 1988 *Journal of Beijing Medicine*, Wang Li-Hua, a professor of environmental

health at Beijing Medical University, describes a study demonstrating that Beijing women in coal-burning families have more respiratory symptoms than women in natural gas-dependent families.

Largely because of burning coal for electric power, China emits one-twentieth of the world's mercury pollution, a figure that is growing about 5% annually. In an article in the 1 July 2000 issue of *Environmental Science and Technology*, Wang Qichao and colleagues at the Chinese Academy of Science at Changchun calculate that China, the world leader in mercury pollution, emitted nearly 214 tons of mercury into the air in 1995, with another 90 tons landing up in cinder and ash. Chronic mercury exposure can cause reproductive problems, neurological dysfunction, and lung disease.

Coal burning has also made China the world's second-largest producer of carbon dioxide (CO₂). According to the Oak Ridge National Laboratory Carbon Dioxide Information Analysis Center, the 1995 estimate of industrial CO₂ emissions for China was 3.2 billion metric tons, compared to 5.5 billion metric tons for the United States. In the Natural Resources Defense Council's Winter 1998 *Amicus Journal*, staff members Barbara Finamore and Robert Watson write, "Between now and 2020, [China] will account for 50 percent of the growth in carbon dioxide emissions." CO₂ is one of the major greenhouse gases.

In the 23 November 1999 issue of *Proceedings of the National Academy of Sciences*, William L. Chameides, a professor in the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology, and colleagues describe how SO₂, nitrogen oxides (NO_x), and volatile organic compounds emitted through coal burning and other anthropogenic activities have created a regional haze that hangs over farm fields, blocking a good deal of the sun's radiation and reducing growth of nearly three-quarters of the country's crops by as much as 30%.

Crops are also affected by acid rain—caused by the SO₂ and NO_x released by burning coal—which covers about 30% of China. The yearly economic losses of agriculture, forestry, and construction materials caused by acid rain are more than US\$20 billion. Acid rain can result in great reduction of output of crops. For instance, acid rain with a pH of 3.5 can result in a 13.7% decrease in

wheat output. Additionally, acid rain withers forests and plants and exaggerates pest attacks, finally causing large areas of forests and plants to die. Acid rain can also increase the incidence of both chronic asthma and respiratory and eye diseases.

A Lack of Clean Water

China is also dealing with one of the world's worst water pollution problems—seven of the world's most polluted watersheds are in China. In the September/October 1999 issue of *The Bulletin of the Atomic Scientists*, Wu Changhua, senior associate and director for China studies at the World Resources Institute, says that nearly 700 million Chinese lack access to clean water, and consume drinking water contaminated with animal and human waste that exceeds the applicable maximum permissible levels for fecal coliforms by as much as 86% in rural areas and 28% in urban areas. In addition, the silt load of the Yangtze River exceeds 500 million metric tons per year.

Most of China's rural population relies on well water or water from rivers, lakes, and ponds, according to the *China 1997 State of the Environment Report*, published by the National Environmental Protection Agency

(NEPA; now known as SEPA, the State Environmental Protection Administration). Rivers are the most common source of urban drinking water, the report says, although 78% of the rivers flowing through the cities and 50% of the underground water in cities is polluted. Nonetheless, the people drink it because they must.

Harris describes open ditches she saw next to Chinese factories that "were filled with orange or yellow wastewater that was foaming before it even flowed into the river. . . . In less industrialized areas, sediment loads turned the water into a pinkish or yellowish chocolate-brown. Waters with more sewage looked more grayish." There is no way to positively identify the pollutants just from visual characteristics, however. Testing would be needed to identify each factory's contributions to the polluted groundwater, rivers, and streams.

As a developing nation, China lacks treatment plants and the infrastructure to properly treat sewage and purify drinking water. The nation's handful of wastewater treatment plants cannot keep pace with the increasing amounts of sewage. In 1995, Beijing had one secondary sewage treatment plant; China had a total of 100 plants. Only 5% of household waste and about 17% of industrial waste

Xu Fu-Xi/Guangzhou Environmental Education Center



Dangerous drinking water. Rivers are the most common source of drinking water in urban China, but 78% of the rivers flowing through cities, including this one in Zhangjiang, are polluted.

receives any treatment before entering local irrigation ditches, ponds, lakes, and streams.

TVEs may contribute as much as or more than urban industries to China's water pollution problem. The rapid development of TVEs over the past two decades became the backbone for China's huge industrial growth and is having an enormous impact on China's water quality. As of 1995, about seven million TVEs had been set up in towns and villages across China. They are owned by the communities and controlled by township and village governments.

TVEs include an array of industries such as paper and pulp milling, chemical manufacturing, metal casting, and brick making that produce large quantities of wastewater, adding nitrogen, phosphates, phenols, cyanide, lead, cadmium, mercury, and other pollutants to the water near rural residential areas—the same water that is used for drinking. According to a 1997 policy paper from NEPA, TVEs are estimated to discharge over 10 billion metric tons of wastewater per year, half of the industrial wastewater in China. In issue 2 (1998) of the *China Environment Series*, Crescencia Maurer, a research associate at the World Resources Institute, along with

Wu and colleagues, describes a number of studies linking wastewater from TVEs with such health effects as abnormal pregnancy outcomes (for example, spontaneous abortions, premature births, and birth defects) and elevated cancer rates.

Because TVEs are controlled by township government rather than the central government, their emissions are not centrally regulated. Industrial waste from TVEs is rarely treated before it is dumped into local waterways. A 1993 Asia Development Bank report titled *Environmental Challenges in the People's Republic of China and Scope for Bank Assistance*, states, "The main problem for TVEs is that they use outdated and inefficient technologies, lack of managerial and technical capabilities and [have] limited access to pollution control equipment and insufficient funds to invest in pollution control measures."

In issue 2 of the *China Environment Series*, Maurer and colleagues also describe the explosion of inappropriate use of chemical fertilizers and pesticides in rural areas, which has contributed to China's water problem. China is the world's largest consumer of nitrogen fertilizer. However, the use of such fertilizers can only increase crop production so much, and excess fertilizers wash into and pollute waterways, increasing the rate of eutrophication in lakes and ponds. In addition, most Chinese workers and farmers are not trained to handle pesticides safely.

According to Maurer, as developing nations shift toward industrialism, health problems associated with water pollution tend to shift from infectious and parasitic diseases to diseases such as cancer, heart disease, and respiratory disease, which are more likely to be associated with industrial pollutants. However, she says, China displays both sets of health risks.

Overall, the rate of mortality from infectious diseases in China has been declining. Yet the incidence of diseases associated with poor-quality drinking water remains relatively high, compared with many other countries, according to the report *China Public Health Statistics*, released in 1996 by the Chinese Ministry of Health. For the past 20 years, China's leading infectious diseases were diarrheal diseases and viral hepatitis, diseases associated with fecal pollution. China's polluted water has also served as the source for outbreaks of dysentery, typhoid fever, roundworm, guinea worm, leptospirosis, and schistosomiasis.

At the same time, cancers linked to infectious agents—liver, stomach, and esophageal cancers—are the leading causes of mortality in rural China, according to the 1996 *China Public Health Statistics* report by the Ministry of Health. The rate of liver cancer in China is twice that of other countries.

In the February 1990 issue of the *Journal of Chinese Preventative Medicine*, Su Delong describes a high rate of digestive system cancers found in southern Chinese populations, which have depended on ponds for drinking water. Microcystins and nodularin, toxins produced by cyanobacteria that are present in eutrophic water, have been linked to liver and other cancers. According to Li Wei, an associate professor of environmental sciences at Beijing Normal University, algal toxins are one of the main causes of liver cancer.

Li also notes that the high incidence of stomach and esophageal cancers is associated with the widespread use of industrial wastewater used to irrigate farmland. Irrigation with industrial wastes is especially common in the northern regions, where water is scarce. The modern use of industrial wastewater for irrigation has introduced problems with chemical and biological contaminants. Over years, Li says, toxic chemicals, including heavy metals, are concentrated into plants that people eat. This reduces crop productivity and affects the health of those who eat the crops, according to a 1996 report titled *Environmental Problems in China: Estimates of Economic Costs*, written by Vaclav Smil, a professor of geography at the University of Manitoba in Canada.

One of China's most urgent environmental crises is its shortage of water. China, which has 22% of the world's population, has only 7% of the earth's fresh water. Despite periodic flooding in the south, China faces chronic freshwater shortages. Some of the most frequent and severe shortages are in the northern part of the country. NEPA's 1996 *Report on the State of the Environment* indicates that 300 of the 640 major cities in China face water shortages and 100 face severe scarcities.

But China's rapidly growing water demand is only part of the water shortage picture. Nearly 80% of China's water use is for agriculture. Much of this water is wasted through evaporation or system leakage. And erosion from poor farming practices adds sedimentation to waterways, reducing human access to clean water.

This situation is likely to get far worse as the economy and population continue to grow. As the quantity and quality of China's surface water has dropped, many communities are extracting more groundwater to meet their needs. Overextraction of groundwater has become a serious problem in a number of cities, especially in coastal cities dealing with saltwater intrusion.

Changing Land Use Needs

A third high-profile environmental health problem is deforestation. Along with overgrazing and poor farm practices, deforestation can cause heavy erosion, desertification,



Zeng Xian-Hui/Guangzhou Environmental Education Center

Mixed blessing. TVEs have been invaluable to boosting China's economy, but their untreated emissions cause significant environmental harm.

Lu Jin-Guo/Guangzhou Environmental Education Center



Zu Ya-Min/Guangzhou Environmental Education Center



Stripped land. Practices such as deforestation (as in these hills in Xinhui [left]) and overgrazing (as in this pastureland in Sanshui [right]) have left fragile, desertified land that is vulnerable to severe erosion. The result is a loss of badly needed farmland, as well as air and water pollution.

salinization, and alkalinization. Despite attempts by China's forestry departments to replant the stripped forests, only 13.9% of the land has tree cover compared with the international average of 31%. Without adequate groundcover to hold the soil, China's watersheds are less able to absorb water and slow erosion. On denuded land, rainwater washes over the soil crust as runoff, carrying soil into lakes, streams, and rivers as silt.

Many experts are concerned that dust and sand blown into cities and towns from nearby arid, desertified regions may also be significant threats to urban and rural health. Beijing residents suffered several blinding sandstorms during the spring of 2000 alone. Small dust particles can penetrate deep into the lungs, causing a myriad of respiratory health problems, for instance by introducing bacterial infections.

As China's population grows, its farmland is shrinking. In addition to overfertilization, many farmers attempt to replace shrinking cropland by planting crops on marginal lands that are too fragile for crops; the outcome is often desertification. Towns and villages are expanding onto existing croplands, reducing China's already limited source of food crops. With new settlements come small industries and new roads, taking up still more of China's limited and precious arable land.

In the June 1999 issue of *The China Quarterly*, Smil estimates there are 130–140

million hectares of farmland in China. In *Environmental Problems in China*, he writes, "In China, only about 30% of the farmland is very productive, and at least one-tenth of the cropped area is affected regularly by drought and floods. Few environmental changes have been as critical in affecting China's well-being as the combination of quantitative and qualitative decline."

Throughout their history, China's rivers have been susceptible to flooding and drought due to the country's highly variable rainfall patterns. During the summer of 1998, China suffered the most damaging floods of the century as water levels on the Yangtze River reached record highs—37.5% above normal. The floods claimed 3,000 lives and affected the lives of 230 million others, according to the Fall 1999 *Earth Island Journal*. Rainfall in 1998 was not unusually heavy, however; instead, the flooding along the Yangtze was blamed on the effects of deforestation.

As sediment, silt, and pollution gradually fill in lakes along the Yangtze and other rivers, and as villagers reclaim the land for housing and farms, the lakes are shrinking. No longer able to contain as much floodwater as they did in the past, the Yangtze's lakes can flood with even moderate rains.

One of China's most controversial land use issues concerns the Three Gorges Dam. This colossal hydrology project is designed to

control the floods of the lower Yangtze River, generate hydroelectric power (thereby reducing coal burning), and create a river channel deep enough for large ships. The Three Gorges Dam will be the largest hydroelectric dam in the world, towering 575 feet above the world's longest river and stretching nearly a mile across. Construction began in 1994 and is scheduled to take 20 years. The project is expected to cost at least US\$24 billion, while some experts project the bill will exceed US\$70 billion. The dam reservoir will flood 350 miles, displacing as many as 1.9 million people, eliminating the habitats of several endangered species, and flooding hundreds of archaeological sites.

Heavy opposition to the dam has come from scientists, politicians, and citizens inside and outside of China. Critics point to the high cost, technical problems, and the social and health problems associated with human relocation, as well as the environmental losses. Some critics claim that the dam will have only limited ability to control floodwaters and siltation. In addition, many species of wildlife will be put at risk, including two species of endangered freshwater dolphins.

Resettlement issues have been especially problematic. Many of the people slated for resettlement are placed in nearby regions that are already overcrowded, have inadequate sanitation services, and lack opportunities for new residents to farm or find jobs.

There is also concern that the large-scale alterations in water conditions could result in infectious disease epidemics. For example, rather than passing through the river, some waste material will be caught in slow-moving waters behind the dam, creating ideal conditions for the spread of disease vectors that favor slower waters, such as mosquitoes. The Chinese Ministry of Health is examining the long-term health effects and risks associated with the dam.

China Moves Ahead

China has committed itself to two paths that are not entirely compatible—rapid economic development as a means to material prosperity, and environmental protection to ensure a sustainable economy. Whatever steps China takes now will have both local and global repercussions.

At the national level, China has been passing new environmental regulations and reconstructing its governing and enforcement infrastructure at a rate that would make most governments look sluggish. Yet, despite China's rapidly evolving and complex network of environmental policies and laws, compliance with environmental regulations remains low.

The poor success rate of many pollution emission regulation programs is generally blamed on a lack of funding and the decentralized government's limited ability to enforce environmental regulations in a consistent manner. The core problem is that SEPA does not have direct authority over the local

environmental protection bureaus that are responsible for communicating and enforcing environmental protection legislation at a local level. Nielsen says, "Local [bureaus] get their money from and report to local government, not SEPA. The aim of local government is more [in line with] local business economy. They don't have the same commitment to enforce the law that SEPA does. So environmental regulations are ignored."

Many experts hail SEPA's recent elevation to ministerial status as a significant reflection of the government's commitment to resolving environmental issues. As a ministry, SEPA will have more leverage and authority in law enforcement.

Today, China, the very nation that had suspended most scientific research during the 1960s and 1970s, relies on scientific exchange with western scientists to deal with its environmental crisis. Following the Cultural Revolution, in the early 1980s, China's reinstated premier Deng Xiaoping visited universities and research facilities in the United States and came away with a decision to promote scientific exchange with the western countries. China began sending its younger scientists to train at western research institutes while inviting foreign scientists to visit Chinese institutes. Chinese scientists were also encouraged to collaborate with foreign scientists. Issue 3 of the *China Environment Series* lists 479 collaborative projects on energy and environmental protection between Chinese and U.S. institutes.

Today, many Chinese scientists are highly trained and use methods similar to those of their western colleagues. China's environmental protection agencies are also learning from the experiences of industrialized countries such as the United States.

Says Nielsen, "[China's] political evolution has allowed the Chinese central government to move from general wariness of the West to purposely encouraging exchanges as a means of national capacity building, and this has undoubtedly increased the numbers [of Chinese scientists] in the West." Nielsen says that, while it may seem that China embraces scientific exchange more than other countries, China is also a very large country and already has indigenous scientific capacities and a science-oriented educational system that many other developing countries do not. "[China] may have more of a basis to begin with for the pursuit of such exchanges," he says.

Nielsen also says that China seems to have a fairly open door for individuals who can qualify to pursue research and training exchanges. "Harvard is awash with Chinese graduate students, almost all of them in the sciences," he says. "We've hosted a stream of folks from China who seem to have been encouraged by the Chinese government to come to the U.S. to gather information and build expertise, for instance, on some of the more obscure or complex elements of the Kyoto Protocol."

China has assumed an active role in international environmental protection discussions,



Xie-Jia Rong, Chen Ya-Qiong



Peng Qi Chang



Peng Qi Chang

Health begins at home. For years, Chinese households have burned coal in open stoves for heating and cooking (right, bottom). Because coal burning causes a host of health problems, people are being encouraged to convert to natural gas (above). Educational efforts can be as simple as painting slogans where townsfolk can see them. For instance, this outdoor notice (right, top) urges people to stop burning coal and switch to natural gas.

starting with the 1992 United Nations Conference on Environment and Development and the Kyoto Protocol. Although China has not signed most international environmental agreements, it has been a major participant in the scientific information exchange process. Nielsen describes China's approach to the international environmental agreements as "cautious and conservative, not unlike other developing nations." However, he does contend that China deserves credit for being a great student at the drafting table, taking careful notes on the science and political enforcement approaches that other nations and international organizations are exploring.

Nielsen has witnessed the Chinese government soften its official position toward energy-saving programs such as the Clean Development Mechanism and carbon trading. "These are policy mechanisms are based on economic incentives that have become popular in western policy circles," he says. "The Chinese government has started to explore how there might be some advantage in them for China."

In 2000, China increased its investment in environmental protection from 0.8% to 1% of its gross domestic product (GDP). But this figure still falls far short of the actual costs. Smil estimates that the annual cost of China's environmental degradation and pollution equals 10% of its GDP, while the Chinese Academy of Social Sciences puts the cost at 8.5% of the GDP. These costs include pollution's effects on human health, crop and forest damage, reduced agricultural and aquatic production, loss of food sales and industrial production, and economic losses due to water shortages, soil erosion, land degradation, and loss of wetlands, forests, and grasslands.

The next real hope comes with China's recognition of the need for public awareness about environmental issues. In a recent speech, China's Premier Zhu Rongji announced that efforts should be made to increase public awareness of the importance of environmental protection and making efforts to control and treat pollution. "For years, scientific studies and reports on the environment were published in journals, yet never communicated to the public," says Ji Weizhi, director of the Kunming Institute of Zoology of the Chinese Academy of Science. "But now that the government has a more complete picture of what is happening to the environment, newspapers are allowed to print daily reports on pollution levels and on some research."



Reaching toward the future. By teaching children about the benefits of using natural gas and implementing sustainable agriculture, Chinese forestry workers are able to raise the environmental consciousness of both the next generation of farmers and homeowners as well as their parents.

Two decades' worth of research has produced a body of scientific evidence of China's degraded environmental conditions and its costs. Many experts contend that costly disasters such as the 1998 flooding of the Yangtze River alerted the Chinese government that these issues are in urgent need of attention, and that the government is therefore releasing more information about the environment to enlist public support for their efforts to enforce regulations and shut down inefficient and polluting industries. Some experts believe that by informing the public about select environmental problems such as air pollution, the media are helping the government galvanize public support.

General awareness of environmental issues is still spotty, though. For example, only certain schools in the larger cities such as Beijing have environmental education programs. According to Li, the Chinese Ministry of Education is working with groups such as the World Wildlife Fund and companies such as BP Amoco to explore the inclusion of environmental protection coursework in the national school curriculum.

Environmental awareness is building in rural communities, however. Chen Ya-Qiong, a staff member of the Yunnan Wildlife Conservation Association, creates environmental education programs for rural communities in highly sensitive ecological areas. This project is funded by the Global Environment Facility. Chen teaches children and their parents about the importance of switching from

wood and coal for fuel to natural gas. She introduces village leaders to the idea of sustainable agriculture by working with their children. Says Chen, "We have a saying—'the small hand pushes the big bag'—which means that through the children, we encourage the parents' education."

It is impossible to predict the outcome of the China's combined path of priorities. "China is in the middle of major social, economic, and government reforms, and is in the early stages of industrialization," says Li. "I see the upcoming decade as an unstable period for China's environment, public health conditions, economy, and social structure."

Nielsen believes that Premier Rongji understands that China's environmental problems are serious and that many government officials are sincere about acting to protect the environment. However, Nielsen points out, China is still a new player in the industrialized world. He predicts that it will take China decades to develop a governing system that can address the environmental crises. "You can't create a legal system overnight," he says.

As much as China looks to outside scientific and financial sources for information, Li predicts that China will find its own paths to deal with its problems. Considering how far-reaching China's decisions are, each move that China makes in solving its environmental puzzle is likely to draw a large international audience of anxious onlookers.

Corliss Karasov