**CURRENCY EQUIVALENTS**  
(As of June 1, 1991)

Currency Unit = Yuan (Y)  

\[
\begin{align*}
\$1.00 &= Y 5.33 \\
Y 1.00 &= \$0.19
\end{align*}
\]

**FISCAL YEAR**  
January 1 - December 31

**WEIGHTS AND MEASURES**  
Metric System

**ABBREVIATIONS AND ACRONYMS**

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<tr>
<td>ABC</td>
<td>Agricultural Bank of China</td>
</tr>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
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<tr>
<td>BOD</td>
<td>Biochemical oxygen demand</td>
</tr>
<tr>
<td>CAS</td>
<td>Chinese Academy of Sciences</td>
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<tr>
<td>CFCs</td>
<td>Chlorofluorocarbons</td>
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<tr>
<td>CH₄</td>
<td>Methane</td>
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<tr>
<td>CIB</td>
<td>China Investment Bank</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon monoxide</td>
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<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical oxygen demand</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic obstructive pulmonary disease</td>
</tr>
<tr>
<td>CRAES</td>
<td>China Research Academy of Environmental Sciences</td>
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<tr>
<td>DO</td>
<td>Dissolved oxygen</td>
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<tr>
<td>DRC</td>
<td>Development Research Center</td>
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<td>EIA</td>
<td>Environmental impact assessment</td>
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<td>EPB</td>
<td>Environmental Protection Bureau</td>
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<td>EPL</td>
<td>Environmental Protection Law</td>
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<td>ESMAP</td>
<td>Energy Sector Management Assistance Program (World Bank/UNDP/Bilateral)</td>
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<td>ESP</td>
<td>Environmental Strategy Paper</td>
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<td>ESW</td>
<td>Economic and Sector Work Program of the World Bank</td>
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<td>FAO</td>
<td>Food and Agricultural Organization</td>
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<td>FY</td>
<td>Fiscal year</td>
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<tr>
<td>GDP</td>
<td>Gross domestic product</td>
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<td>GEF</td>
<td>Global Environment Fund</td>
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<td>GEMS</td>
<td>Global Environmental Monitoring System</td>
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<td>GHG</td>
<td>Greenhouse gases</td>
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<td>GNP</td>
<td>Gross national product</td>
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<tr>
<td>HC</td>
<td>Hydrocarbon</td>
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<tr>
<td>IDA</td>
<td>International Development Association</td>
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<tr>
<td>IPAS</td>
<td>Integrated Protected Areas System</td>
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<td>IPM</td>
<td>Integrated pest management</td>
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<tr>
<td>LRMC</td>
<td>Long-run marginal cost</td>
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<tr>
<td>MFO</td>
<td>Ministry of Forestry</td>
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<tr>
<td>MOA</td>
<td>Ministry of Agriculture</td>
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<tr>
<td>MOPH</td>
<td>Ministry of Public Health</td>
</tr>
<tr>
<td>MIPF</td>
<td>Montreal Protocol Interim Fund</td>
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<tr>
<td>MWR</td>
<td>Ministry of Water Resources</td>
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<td>NEPA</td>
<td>National Environmental Protection Agency</td>
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<tr>
<td>NH₄⁺</td>
<td>Ammonium</td>
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<td>N₂O</td>
<td>Nitrous oxide</td>
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<tr>
<td>NO₂</td>
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<tr>
<td>NOₓ</td>
<td>Nitrogen oxides</td>
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<td>NPDES</td>
<td>National Pollutant Discharge Elimination System (US)</td>
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<td>O₃</td>
<td>Ambient ozone</td>
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<td>OECD</td>
<td>Organization of Economic Cooperation and Development</td>
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<tr>
<td>Pb</td>
<td>Lead</td>
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<td>SEPC</td>
<td>State Environmental Protection Commission</td>
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<tr>
<td>SO₂</td>
<td>Sulfur dioxide</td>
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<tr>
<td>SO₄²⁻</td>
<td>Sulfate</td>
</tr>
<tr>
<td>SOA</td>
<td>State Oceanographic Administration</td>
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<tr>
<td>SPC</td>
<td>State Planning Commission</td>
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<tr>
<td>SSTC</td>
<td>State Science and Technology Commission</td>
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<tr>
<td>TSP</td>
<td>Total suspended particulates</td>
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<tr>
<td>TVIEs</td>
<td>Township and village industrial enterprises</td>
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<tr>
<td>UNDP</td>
<td>United Nations Development Program</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environmental Program</td>
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# CHINA

## ENVIRONMENTAL STRATEGY PAPER

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The members of the Bank team would like to acknowledge the invaluable support given by their Chinese colleagues in conducting this study, including organizing the discussions with experts from various cities and provinces in China, and the subsequent review and comments given on the initial draft of this report by various government ministries and agencies. Without them, this report would not have been possible. Special thanks go to the National Environmental Protection Agency, which was the principal collaborative institution in China, as well as to the Ministry of Agriculture (Department of Rural Energy and Environment), Ministry of Water Resources, Ministry of Forestry, Ministry of Energy, Ministry of Metallurgy, Ministry of Chemical Industry, and the Chinese Academy of Sciences. In addition, discussions were held with the Ministry of Construction, Ministry of Communication, Ministry of Light Industry, State Oceanographic Administration, Ministry of Textiles, Ministry of Public Health, State Meteorological Administration, State Science and Technology Commission, and the State Planning Commission.
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A. Introduction

i. The problems of environmental pollution, and damage or destruction of natural resource systems that accompany increased economic development and spreading populations in developed countries are only exacerbated in countries where population is growing rapidly, per capita income is low, and technologies lag by decades those available to more developed countries. China has not been immune to such problems.

ii. For example, drinking water in many cities is polluted and/or in short supply, and the shortages have been aggravated by excessive use of groundwater by industries, even as these industries contaminate the supply through waste dumps. The air, also, in cities is heavily polluted by particulates and sulfur dioxide because the country must depend on coal as the chief source of fuel and energy. Most wastewater from industries and cities is dumped untreated into rivers, lakes, and oceans, and domestic garbage and industrial solid waste are piling up at the edge of cities.

iii. In the countryside, excessive use of water, and inappropriate use of fertilizers and pesticides in some areas have begun to create environmental problems. Problems with irrigation and poor drainage are turning millions of acres into salt beds; wetlands, aquatic systems, and grasslands that are the source of a rich biological diversity and future resources are being destroyed through pollution or conversion to economic development; soil is being lost through improper agricultural practices, or overgrazing, especially on marginal lands where cropping has been intensified to levels that are unsustainable under current practices. The increasing and often conflicting demand for water for irrigation, industrial, and municipal uses has also created a pressing environmental issue.

iv. This paper identifies the most serious problems (and the importance the Chinese attach to them), analyzes the underlying causes, assesses Chinese policies and programs, suggests measures that will improve their effectiveness and, finally, proposes an agenda of Bank activities over the next three years that will assist China in addressing its most pressing environmental and ecological problems.

v. The interrelationship between environmental issues and economic growth and development is central to any discussion of environmental matters. The structure of the economy, and general economic policies and management, largely determine the nature of environmental problems and the framework for environmental policies and programs in any particular country. These interrelationships in China are discussed throughout this report.
Unlike many developing countries, China has a comprehensive set of laws based on reasonable concepts to guide environmental policy development; a range of command-and-control as well as economic incentive approaches to implement the law; and an impressive network for administering, monitoring and enforcing environmental policy. However, while past efforts have somewhat reduced pollution per unit output and have helped to prevent an abrupt worsening of environmental degradation during the past decade, these gains unfortunately have been mostly canceled by the rapid growth of the economy and the population, and by industry's continued high share in gross domestic product (46 percent). Most of this is technologically outmoded and highly polluting heavy industry. These problems threaten to swamp China's significant, recent achievements in environmental policies and programs, and pose the principal challenge for sustainable development in the future. With increasing attention being focused on environmental problems globally, this is an opportune time to assess the country's needs and review its strategies as part of an assistance program.

China has an institutional framework in place that can be used as a foundation in designing approaches for dealing with environmental and ecological problems. The State Environmental Protection Commission (SEPC), which includes the heads of all relevant ministries and agencies, and ultimately the State Council are at the apex of decision-making on environmental policy in China. SEPC provides policy direction at times and resolves interagency disputes, but it meets only quarterly and hence cannot regularly set overall policy. The commission relies heavily on the National Environmental Protection Agency (NEPA), which functions as its secretariat. This agency is responsible for all aspects of environmental policy, although it shares authority with other agencies for certain specific natural resources; for example, the marine environment is managed primarily by the State Oceanographic Administration and the Ministry of Agriculture (fishing). Authority in conservation issues rests primarily with the natural resources ministries. The agency liaises with the environmental protection units within most other ministries and agencies, and sets the overall policies and regulations governing the provincial and municipal environmental protection bureaus.

Most environmental protection policy is implemented at the subnational level. Provinces are responsible for implementing national policy and are authorized to act in the absence of preemptive national standards; where warranted by local conditions, they may also impose more stringent standards than those required by the national government. In all provinces and municipalities and in most counties around the country, environmental protection bureaus now have been established under local environmental commissions headed by a vice-governor or vice-magistrate.

B. Major Pollution Problems

The Chinese have identified three pollution problems as their principal concern: urban water quality, urban air quality, and rural industrial pollution (see Chapter II for a full discussion). While rural drinking water is not included in this list, it also appears to be another major problem.
Urban Problems

Water Quality

x. Coastal waters and rivers are polluted, and both surface and ground waters are contaminated in many areas. Thirteen out of 15 sections of the 7 major rivers that flow past cities are seriously polluted. There have been sharp drops in prawns, jellyfish, and scallops in coastal waters, and an increase in the frequency of red tides, all of which are attributed to sewage in the water.

xi. In most large urban areas of China, industrial wastewater is the predominant source of pollution, in some cases contributing up to 70-80 percent of the pollutant load. Of the estimated 25 billion tons of industrial wastewater discharged over all of China in 1990, only about 32 percent was treated (often only to the extent of pretreatment). After treatment, only somewhat more than half of this water meets effluent discharge standards. The situation is even worse for municipal sewage. Municipal wastewater treatment capacity is currently only about 2 million tons per day, or a very small fraction of the total municipal wastewater discharge. Fewer than half of NEPA's monitoring stations for urban water quality register water flows that meet minimum standards for dissolved oxygen or for biochemical oxygen demand. Urban groundwater sources are being increasingly polluted as contaminated surface water filters down and water is leached from dumps for hazardous and toxic wastes.

xii. While several ministries have differing views on how severe the problem is, the quality of drinking water in cities appears to be at risk. In rural areas, the problem is acute. The Ministry of Public Health estimates imply that only about one in seven rural Chinese have safe drinking water.

Air Quality

xiii. China is almost entirely dependent on coal for energy and fuel, and inefficient industrial and domestic use of this material has made coal a major source of air pollution, in particular for sulfur dioxide, nitrogen oxides, and suspended particulates. The average energy intensity of China's industrial sector has dropped over the past decade, but it remains high. While cross-country comparisons of energy use per unit GDP provide only a rough picture of relative energy intensities (due to problems arising from differences in statistical methods and conversions to comparable output value units at official exchange rates), they indicate that China's energy intensity remains higher than that of most developing and developed nations.

xiv. Air quality is particularly poor. Monitors operated by both NEPA and the Global Environmental Monitoring System of the World Health Organization (WHO) show frequent violations of Chinese and WHO air quality standards, and by large margins. For instance, the annual average total suspended particulates (TSP) are 526 micrograms/m$^3$ in the north of China and 318 micrograms/m$^3$ in the south, compared with WHO guidelines of 60-90 micrograms/m$^3$; sulfur dioxide is 93 micrograms/m$^3$ in the north and 119 micrograms/m$^3$ in the south, compared with WHO guidelines of 40-60 micrograms/m$^3$. 
Data from the Ministry of Public Health indicate that chronic obstructive pulmonary disease (which has been linked to exposure to fine suspended particulates and sulfur dioxide) was the leading cause of death in China in 1988, with a death rate of 162.6 per 100,000, which is 26 percent of all deaths. When standardized and compared with figures for the United States, the rate in China is more than five times greater—105/100,000 in China, and 19/100,000 in the United States. Fine and ultrafine particulates (as opposed to TSP) are considered most dangerous to health and should be the highest priority in regard to air pollution abatement.

Industries also release toxic substances into the air, but as some international studies have shown, the relatively slight reduction in mortality that would result from a 90 percent reduction in toxic emissions suggests that this source may not be a primary concern. Exposure in the workplace is another matter because the exposure is much higher and the effects of accidental releases much greater. Precautions and mitigation measures should be adopted as a matter of high priority.

Rural Pollution

As indicated earlier, the quality of drinking water in rural areas is a serious problem. While township and village industrial enterprises (TVIEs) receive a large share of the blame, fertilizer runoff from farms also contributes to water pollution.

The TVIEs have grown rapidly—from 4.8 million in 1984 to 7.7 million in 1988. Their output currently represents 28 percent of China’s total industrial output. These small firms often use outdated technologies and their design and engineering are often poor. In spite of this, and difficulties in regulating them, it is not clear that they are more polluting per unit of output than other enterprises.

Emerging Issues

Other pollution issues are becoming increasingly important in China. They include: acid rain, industrial and domestic solid waste disposal, hazardous and toxic wastes, groundwater pollution, nonpoint-source pollution (principally from fertilizer runoff), greenhouse gases and ozone-depleting emissions (primarily carbon dioxide, CO₂ and chlorofluorocarbons, CFCs), and vehicular emissions.

Acid Rain. While both north and south China have acid precipitation, in the north, where most of the coal is burned and sulfur dioxide emissions are high, the sulfate concentrated in rainwater is tempered by the dust of the central Asian desert, which is highly alkaline and saline. In areas south of the Yangtze, however, the pH often falls below 5.6, and in some cities as low as 3.4, which is very acid.

Greenhouse Gases and Ozone-Depleting Emissions. The global problems of chlorofluorocarbons and greenhouse gas emissions are of increasing concern to Chinese scientists; because of the global costs involved, there is a general expectation that developed countries will help pay for reductions in CO₂ and will subsidize technology transfers to develop substitutes for CFCs in
Almost half of the total CO₂ emissions coming from the world’s developing countries comes from China. Coal, which is the dominant fuel in Chinese industry and in the power sector, is the primary source of these emissions. During the short- to medium-term transition phase of greenhouse gas control, the strategy will have to focus primarily on energy conservation and efficiency measures on the supply and demand side, increased electrification, increased (but limited) switching to natural gas for fuel, and increasing use of renewable energy resources.

**Solid and Hazardous Wastes.** By 1988, 6.6 billion tons of untreated solid waste had accumulated on the fringes of Chinese cities, taking up 55,400 hectares (ha) of land. Eighty percent of this waste comes from industry and energy sources and thus contains toxic heavy metals. At present, there is no system for controlling hazardous and toxic wastes, although a significant amount is generated each year. As indicated earlier, these dumps contaminate the groundwater supply as the metals and other toxic materials are leached out. Since these aquifers are the source of most drinking water, public health officials are seriously concerned about the threat to public health.

**C. Agricultural and Ecological Problems**

**Intensive Farming Practices**

With only 10 percent of China’s land area able to support crop cultivation, Chinese farmers have always had to use intensive farming techniques. Traditional farming systems were sustainable because only prime valley land was cultivated, organic matter was returned to the soil as fertilizer, and crop rotations included soil-enriching crops like legumes. Today, in most of China’s prime farming areas, the expansion of irrigation, the use of improved plant varieties and chemical fertilizers, combined with the institutional and pricing reforms in the agriculture sector of the past 10-12 years, have greatly increased production. However, the excessive use of water, and inappropriate use of fertilizers and pesticides in some areas, has begun to create environmental problems. These may worsen as population growth makes it necessary to further boost production on these lands.

The increased use of chemical fertilizer is responsible for about half of the 100-million-ton increase in grain production between 1978 and 1988, as well as much of the increase in cash and high-value crops. The main environmental problem associated with the use of chemical fertilizer is the leaching of nitrates into groundwater and in runoff to streams and rivers. Nitrate pollution of groundwater has already been detected in some high-use areas, but water monitoring in rural areas is very limited and it is difficult to assess the extent of contamination. Most experts believe that it is still rare but warrants close monitoring. The Government’s policies of subsidizing fertilizer and linking its supply to the production of certain crops encourage farmers to use it excessively or inefficiently. Because fertilizer use will certainly continue to increase, the absence of adequate monitoring and regulatory systems for rural water could permit serious water pollution to emerge in intensively farmed areas within five to ten years.
xxv. In certain farming areas, the soil's productivity has begun to decline because of the use of continuous cropping instead of crop rotations that sustain nutrient levels and limit pests and diseases. This specialization results partly from the Government's designation of certain areas as "bases" for grain or other crops, to achieve national production targets. The grain quota system still remains a central part of the Government's agriculture policy, although the agricultural reforms initiated in the late 1970s shifted agriculture production away from the previous overemphasis on "grain crops as the key link" to a more diversified agriculture base, including the dismantling of the commune system. Farmers cannot vary their crop rotations to include, for instance, a legume crop as green manure. Crop specialization also increases the need for pest control. While China is one of the world's leaders in research on integrated pest management -- the use of biological controls and other nonchemical measures in conjunction with chemical pesticides -- these techniques are only beginning to be widely applied due mainly to weak links between the research and extension systems.

xxvi. Nearly half of China's cropped land is irrigated, and the productivity of irrigated land is about double that of rainfed land. A major achievement of the Chinese Government since 1949 has been to more than double the cropland under irrigation. However, the rapidity of the development, combined with the scarcity of water resources and the heavy reliance on groundwater, has led -- particularly in the North China Plain -- to salinization, overexploitation of groundwater and pollution. Almost 7 million ha of irrigated farmland are affected by salinization and alkalinization as a result of indiscriminate irrigation without adequate drainage. Some of this land can no longer be farmed, and on the rest, crop yields are reduced by 10 to 25 percent. The uncontrolled and rapid development of groundwater for both irrigation and municipal use has led to excessive extraction. This has rendered many tube-wells inoperable or substantially lowered their yields. The water table can drop by several meters annually and eventually lead to land subsidence. Thousands of square kilometers have already subsided around Beijing and Tianjin. Some 1.4 million ha are irrigated by untreated wastewater. Acids and toxic heavy metals in much of this water impair the soil chemistry and render it useless for agriculture. Where agriculture is carried on using this water, the crops contain toxic residue.

Degradation of Marginal Lands

xxvii. Probably the most visible environmental problem that agriculture has created in China is soil and water loss due to the cultivation of semiarid or sloping lands. Some such lands have long been farmed, but large areas have been deforested or brought under cultivation since 1949. While the conversion process has recently slowed, large areas have already been severely eroded or degraded by cultivation. The most seriously affected areas are the loess plateau in the northwest, the red soils area south of the Yangtze, the northeast plains and the grasslands of the northwest. The problems in each are different, but in general, they possess a combination of soil types, slope, and rainfall patterns that makes sustained cultivation impossible unless careful preventive steps are taken. Without such steps, the soil rapidly erodes, loses nutrients and retains water poorly. Large gullies may form. Eventually, the land may have to be abandoned, as indeed has occurred on thousands of hectares of loess plateau and red soil lands.
Although effective measures exist to forestall degradation and rehabilitate damaged areas, they are not widely used, for a variety of reasons. Farmers who have only short-lived or uncertain title to their land have little incentive to plant trees or construct and maintain permanent earthworks. The state farms that control much of the grassland likewise have more incentive to maximize short-term production than to maintain sustainable grazing levels. The shortage of fuelwood compels people to remove trees, shrubs and even turf from erodible hillsides. The relatively poor returns that these hilly farms generate make it difficult for farmers to grow a green manure crop instead of a more lucrative grain or cash crop. Finally, governments at various levels, as well as state farms, continue to plan for further expansion of cultivation into fragile lands.

Ecolocical Problems

China has a very low resource base for the size of its population. A comparison with world levels (hectares per capita) shows this dramatically: for forests, China, 0.12, world, 0.77; for grasslands, China, 0.30, world, 0.61; wilderness, China, 0.16, world, 0.96; and for croplands, China, 0.08, world, 0.28 (see Table 4.1). The increasing pressure on this limited resource base to feed, house, and meet the energy needs of an expanding population has degraded the land; destroyed natural habitats; and polluted the land, water, and air. The critical factor is that while some types of damage can be reversed, this is not true for most of these resources. Once natural ecosystems are lost or degraded, they cannot be restored to their original richness and functioning at all, and can be repaired only at great cost in most cases.

If present trends continue, China will lose many natural ecosystems outside its nature reserves within the next few decades. Moreover, those areas already under protection are insufficiently managed and could also disappear. The rate at which specific natural ecosystems are disappearing in China varies according to the type of ecosystem and the value that government and society attach to it. The two ecosystems under the most immediate threat today are wetlands and, to a lesser extent, grasslands.

Grasslands

The conversion of grassland ecosystems to cropland, and overstocking and overgrazing have accelerated desertification. From 1950 to the 1970s, approximately 334,000 km² became desertified, expanding at a rate of 1,560 km² per year. Degraded grassland increased from 15 percent of the 250,000 ha of usable grassland in the 1970s to more than 30 percent in the middle 1980s. Currently, the area of degraded grassland is up to 86.6 million ha and is increasing at a rate of 1.3 million ha a year. The predicted trend is that grassland ecosystems will continue to be lost and modified, not only by continued conversion and overstocking, but also as a result of the pasture improvement programs that favor selected species and thus simplify the ecosystem, creating conditions more favorable for rodents and insects.
Lakes and Rivers

xxxii. Lakes are also disappearing, under the pressure for lakefront development, causing flooding, silting, and drying in the lower reaches of some rivers and consequent losses in aquatic resources and fish catch.

Wetlands

xxxiii. China has some of the most important wildlife habitats in the world in its wetlands. Although they comprise only one fourteenth of the total land area, they contain some 400 species of wildlife, of which 36 are rare and endangered. However, these lands are considered wastelands by both the population and the Government, and are targeted for economic development. Coastal wetlands are most at risk, from land reclamation and contamination by domestic, industrial, and agricultural effluents. Some 40,000 ha of mudflats in Jiangsu, Zhejiang, Fujian, Guangdong, and Liaoning have been reclaimed for grain, cotton, and sugarcane. On the coasts of Guangdong and Fujian, large tracts of mangrove forests have been cut to make room for farmland. Without policy changes, it is likely that most coastal wetlands will disappear within the next 10 to 20 years.

Soil Erosion

xxxiv. Soil erosion is very serious in China. Since the late 1940s, the eroded area has increased 38 percent, and areas subject to erosion now include one sixth of the total land area. For instance, only 4 percent of the total area in Jiangxi Province in the 1950s was affected by erosion, but the figure rose to 10 percent in 1960s, 13 percent in 1970s, and 23 percent in 1980s.

xxxv. Although some of this erosion is either natural or caused by inappropriate agricultural practices, much of it is the direct result of loss of vegetative cover through deforestation and clearing of marginal lands for agriculture. For example, soil erosion in the loess plateau has contributed to some 1.6 billion tons of sediment in the Yellow River, raising the riverbed 10 cm a year and increasing the cost of flood control measures.

Forests

xxxvi. Because the consequences of their destruction are so evident, forests have fared somewhat better than other ecosystems. The catastrophic floods, erosion, and siltation that resulted from massive illegal cutting of forests for lumber and fuel in the 1950s through the 1970s led the government to establish large-scale plantations, and forest cover has been slowly increasing. However, there are still shortages of fuelwood, and natural forests continue to be logged for commercially valuable timber.

Biological Diversity

xxxvii. As ecosystems are being lost or degraded, so is the diversity of species residing there. China is one of 12 countries in the world that are recognized for the amount of their biological diversity. These countries harbor 60-70 percent of the world’s plant and animal (including insects) species. Besides a diversity of ecosystem types, China contains 10 percent of
the world's plants (or 30,000 vascular species) and 10 percent (or over 2,100 species) of total mammals, birds, reptiles, and amphibians. The grasslands of China alone contain some 4,000 species of grasses.

xxxviii. China's rich biological diversity has intrinsic value, and also potential economic value. This diversity is necessary to sustain and improve agriculture, to provide sources of new medicines, and to preserve choices for addressing the unpredictable problems of future generations. The actual and potential economic productivity of the world's diverse biological endowment, in uses ranging from subsistence foraging to genetic engineering, can hardly be overstated. Closely related are essential ecosystem services, which include moderating climate; concentrating, fixing, and recycling nutrients; producing and preserving soils; controlling pests and diseases; and providing aesthetic enjoyment. Yet this rich resource base is gradually being destroyed through pollution, overgrazing, conversion to cropland, or to more highly valued economic uses.

Outlook

xxxix. If present trends continue, within the next few decades China will lose much of its wildlands. Not only will valuable plants and animals be lost, but many of the various ecosystem "services," such as the regulation of water discharge and the absorption and breakdown of pollutants, will disappear with them. The diverse gene pool crucial to maintaining or increasing agricultural productivity will be lost or severely diminished. The loss and degradation of ecosystems on this scale is a matter of immediate urgency and concern. However, China, like many developing countries, gives low priority to preserving its wildlands, in part because their importance to economic activity is not well appreciated at many centers of decision-making.

D. Chinese Response to Environmental Issues

xl. The level of China's commitment to environmental protection is indicated by the numbers of organizations and people and the budget it has assigned to the effort. The environmental protection agency network includes NEPA and provincial, county and municipal environmental protection bureaus. In addition, each ministry (at all levels) and most state enterprises have positions dedicated to environmental protection. The total staff allocated to pollution issues is large by any standard, except at the national level (perhaps because of the general administrative style of decision-making in China and the lack of nationwide environmental subsidies). However, it appears that the budget commitment, at least to NEPA, has been slipping. The 1988 budget of Y 110 million fell steadily to only Y 75 million in 1991.

xli. On the other hand, China plans to increase spending on pollution control during the next five-year economic plan period (combined central and local governments and industry) from Y 45 billion in the Seventh Five-Year Plan (1986-90) (0.67 percent of gross national product--GNP) to Y 83 billion (0.85 percent of projected GNP) in the Eighth Five-Year Plan (1991-95). It has been previously estimated by NEPA that China would need to allocate an amount equivalent to 1.5 percent of GNP just to control the current environmental degradation.
Approaches to Pollution Problems

xliii. The Chinese Environmental Protection Law and ancillary regulations emphasize prevention first (e.g., requirements for environmental impact assessments (EIAs)), polluter pays (fees, fines, compensation payments, etc.) and strong environmental management through the bureaucracy from the national to the local levels.

xliii. The country has adopted an eclectic assortment of command-and-control and incentive methods to reach its environmental goals. Command-and-control approaches include EIAs, relocation of industry from urban areas to rural ones, requirements for low polluting technologies in some industries, centralized treatment of wastes, waste allocation guidelines, vehicle inspection programs, and restrictions on TVIEs. Economic incentive approaches include a pollution levy system (the principal method), taxes on polluting inputs, tax rebates, and a system of responsibility contracts (with both voluntary and binding agreements with industrial enterprises and municipalities to achieve environmental targets). In addition, a system of standards and permits is the basis for a monitoring program.

xliv. Though there are positive features, these implementation tools need to be improved. The responsibility system is usually project- rather than performance-based and does not reward cost-effective ways of meeting pollution control goals or efforts that more than meet the goals; also, it is, in most cases, voluntary and therefore cannot be relied on to address the more painful solutions to problems. The levy system has similar drawbacks, and, in addition, fees usually are too low to provide much of an incentive to reduce pollution.

xlv. The main command-and-control policies each have significant drawbacks. The EIAs are often performed too late to influence project approval, location and design, and are too narrow in scope (project-specific rather than region-specific). The relocation policy does not adequately consider whether the moves, case-by-case, have a net positive impact on the new location. The policy of centralization of waste treatment and merger of small polluting companies does not examine whether this method is cost-effective in specific cases, or provide incentives for becoming so. The enforcement system of the policies needs improvement, as well.

xlvi. Low administered prices for raw materials and energy use have resulted in waste and overconsumption. In addition, because state enterprises are not held fully accountable for profits and losses, they have little motivation to control consumption. State control of credit markets and a cumbersome state approval process for project investments have indirectly resulted in a bias against high front-end costs that, in turn, encourages the use of less efficient technology and thus less efficient pollution control methods. China's current industrial development pattern has serious implications for air and water pollution; namely, tendencies toward resource-intensive processes, poor energy efficiency, and massive reliance on coal. At present, China does not have large scope for substituting cleaner fuels for coal in either industrial or residential applications, although there are still some resources (natural and coal-based gas) which are not being fully exploited because of low prices and insufficient capital commitments.
Much more needs to be done to improve the environment, but insufficient funds will probably impede pollution control for at least a decade. Therefore, the real issue is how to make the available funds more productive; how to allocate the money cost-effectively to priority problems; and how to improve environmental policy, the economic system and government bureaucracy to maximize pollution prevention and control efforts. Chapter II contains a detailed discussion of current control efforts and suggests ways that they can be improved.

**Approaches to Agricultural and Ecological Problems**

**Agriculture**

The Chinese Government recognizes that agricultural practices have created environmental problems. It has established institutions, laws and regulations; invested in infrastructure and research, and started monitoring a variety of indicators. These interventions, however, are still outside the mainstream of agricultural planning, which remains heavily oriented to meeting production targets. Moreover, the broader policy and economic environment creates incentives for environmentally unsound practices, such as overuse of water and, in some regions, inappropriate use of fertilizer. A major factor also influencing the adoption of sustainable agriculture practices at all levels is that economic and social attitudes and goals, at least currently and probably indefinitely, will take precedence over ecological goals. Only when it is obvious that benefits from ecologically sustainable use will be of equal or greater benefit will that approach to use of resources be taken.

The National Environmental Protection Agency and its provincial and local offices concentrate their efforts on problems of pollution, leaving ecological and land use problems as the responsibility of the Ministries of Agriculture, Water Resources and Forestry. Each of these ministries has established one or more units with responsibility for environmental matters. These units are generally small and underbudgeted in relation to the main operational departments of their ministries.

1. The environmentally sound development of prime irrigated lands has to include technological improvements, investments in water conservation, and changes in the economic and financial incentives affecting cropping. On marginal lands, future strategy has to include cultivation techniques that improve soil and water conservation, investments both on- and off-farm, and possibly resettlement of people living in unsalvageable areas. Research on these topics, and extension of findings to farmers, needs to be intensified.

II. The Environmental Protection Law, promulgated in 1979, calls for environmental impact assessments to be done for most development projects. EIAs have been used mainly to assess the pollution impacts of industrial projects; the requirement has only recently been applied to agricultural projects. It typically covers pollution from agroprocessing plants and from agricultural chemicals, implications of large-scale water transfers, protection of historic sites, and similar issues. To date, EIAs have not been used to assess conversion of land to agricultural use, soil erosion and structure, deforestation and afforestation and other topics. The use of EIAs has considerable potential to improve the design of agricultural projects, particularly if done at
an early stage, and the Government should expand its scope of application, and make improvements where appropriate. Since the responsibility lies primarily with provincial agriculture bureaus and research institutes, attention should be paid to strengthening their capacities to do EIAs.

### Ecosystems

l.ii. There are major laws and regulations to protect natural ecosystems in China, except for coastal zones (including wetlands). The vertical institutional structures for environmental protection are in place and well developed; however, ecological issues are administered by the natural resource ministries, not the environmental protection agencies, and the environmental units within the former are often understaffed and underbudgeted—and ignored by the production side of the same ministries. Another obstacle to effective administration is fragmentation of responsibility and lack of coordination among ministries and agencies. Enforcement of laws and regulations has been understandably difficult, given China's vast land area.

l.iii. China's main ecological strategy has been twofold: to promote a type of sustainable agricultural development and to establish nature reserves. Although this strategy does little to prevent conversion of natural areas, it does attempt to ensure that conversion to a new use is based on the inherent capability of the land and water resources. Another strategy the government has undertaken is the restoration of damaged sites (this is very costly and, unfortunately, usually too little and too late to have widespread impact).

l.iv. At present, China has 606 nature reserves (40 million ha or 4.3 percent of total land area) and the numbers are expected to grow. However, the reserves are low in government priority and do not have adequate budgets or the necessary baseline data for effective management and protection. In addition, some reserves are probably too small to be effective and some ecosystems are overrepresented, while others are underrepresented.

l.v. While current efforts are beginning to stabilize the problem of deforestation, a number of issues—from long-term agricultural sustainability to loss of grasslands and wetlands and associated biodiversity—are more problematic and need greater attention. China's present efforts to conserve natural ecosystems also need to be substantially strengthened. Natural ecosystems are still undervalued by both policymakers and the general public in China and are still being planned for conversion. This is particularly true for wetlands. Since more than 70 percent of the population depend on the land, water and other biological resources contained in these natural ecosystems, it would be risky for China to continue on a course of unsustainable exploitation of them. So far, China's response to its ecological problems (as to its pollution problems) has been directed more at the consequences (such as restoring degraded lands) than at the underlying causes (such as economic policies). This approach is not only costly, it may prolong the problems and lead to more severe consequences in the future. A closely connected concern is China's inadequate system of ecosystem monitoring. Chapters III and IV contain detailed assessments of these problems.
Public Education

lvi. Public education on environmental and ecological issues is an important element in environmental management in many countries. In China, during the early stages of environmental regulation in the 1970s, mass education campaigns were used extensively as an alternative to policy. Then, as awareness of the structural causes of environmental problems grew, this emphasis shifted. However, China still maintains a strong public education or popularization program to encourage environmentally conscious behavior. This program could be made more effective by expanding the environmental curricula in the education system. Experience in other countries has demonstrated that autonomous citizens' groups can be effective in promoting environmental consciousness among the populace, and while this process has not developed in China, some professional scientific associations and societies are promoting civic awareness of environmental issues.

Overall Assessment

lvii. Economic Aspects of Environmental Management. The interrelationships between environmental issues and economic growth and development are central to any discussion of environmental matters. The structure of the economy, and general economic policies and management, largely determine the nature of environmental problems and the framework for environmental policies and programs in any particular country. In China, the impacts of economic policies (e.g., a population policy between 1950-65 that encouraged high birth rates and the continued emphasis on basic heavy industry in industrial policy) have not always been conducive to sound environmental policies and management. The explosive growth of industry has been a major factor in water, air, and soil pollution, and the impact of this growth has been exacerbated by the fact that China has pursued an industrial strategy that has consistently emphasized basic heavy industrial sectors that are the worst polluters (heavy industry now accounts for nearly half of China's industrial output). In addition, both the desire for local self-sufficiency and the planned, administered nature of the Chinese economic system have introduced economic inefficiencies that have hampered efforts at environmental improvement. The waste, pollution and inefficiency associated with low, state-controlled prices for coal and water, illustrate the effect of inappropriate economic policies on day-to-day environmental problems. These problems threaten to swamp China's significant, recent achievements in environmental policies and programs, and pose the principal challenge for sustainable economic development in the future. Environmental problems in China are more severe than at comparable periods of economic development in most industrialized countries, primarily because of the population size and natural resource constraints, and as a result are likely to have a more severe "braking" effect on economic growth unless action is taken soon to address both the direct and underlying causes.

lviii. In general, until price and enterprise reforms are more extensively undertaken, neither pollution fees or fines nor administrative regulations are likely to carry sufficient force or be systematically applied to encourage the most cost-effective means to reduce environmental degradation. In the meantime, however, administrative regulations such as industrial and municipal emissions and effluent standards and industrial equipment standards will need to be strengthened and enforced more effectively. The mix of command-and-
control regulatory measures and economic incentives and the underlying economic links to environmental management are areas which need increased focus in China. While continued enforcement of China's emission standards, and pollution levies and fines are indispensable elements of environmental policy, increasing attention should be given to the structural and technological changes needed in the industrial sector, and the economic policies needed to encourage these changes, in order to obtain both environmental benefits and economic growth at least cost to the economy.

lix. In the short term, the objectives of promoting economic growth, alleviating poverty and protecting the environment are not always compatible, and governments, both central and local, often confront difficult choices in pursuing them simultaneously; however, in the long run, they are mutually supportive objectives. Environmental protection and economic development are not unalterably opposed to each other; they can go together. Improving one can enhance the other. Much environmental damage is the result of either lack of knowledge or short-sighted policies. Systemic evaluations and assessments quite often show that economic improvements can be achieved through more sensible policies and actions that protect and enhance the environment at the same time.

lx. Another economic issue is the changing nature of the division of responsibility between the central and provincial governments in managing the economy and what this implies for environmental management and regulatory policy. In particular, the role of cities appears to be key to investment decision-making in China and therefore the level at which environmental management policies must be effective. One example of this has been that land allocation and use are increasingly the responsibility of provincial and municipal authorities, who make most of the decisions in relation to industrial sites, urban encroachment and loss of agricultural land. Many environmental issues, however, such as water quality in river basins (the Chinese have seven major river basin commissions) or degradation of agricultural land, are regional in nature and might be better addressed at a provincial or regional level. Decentralisation of environmental management and the more active involvement of key institutions, in addition to the NEPA network, will be one of the major challenges ahead.

lx1. There is also an element of socialist economic tradition that might significantly affect the way environmental policy is implemented in China but which is harder to assess; namely, government regulators in China are integrated into the process of economic development through national sector ministries and provincial or local governments. Therefore, it is often difficult for them to carry out objective reviews or assessments of state actions, or to take an adverse view. The government is both the principal polluter and the regulator. It has been suggested, however, that in the case of environmental management in China, this tendency is somewhat mitigated by the two-track environmental administrative network that includes a quasi-autonomous network of environmental protection bureaus. Also, if damage to sustainable economic development can be demonstrated, and if higher national policy reinforces this concern, then the relevant or responsible ministry or government agency will try to find a solution to the problem (e.g., the cleanup program begun in the early 1980s within the Ministry of Metallurgy). There are also some indications that environmental issues and government policies and progr-
address them are occasionally the object of discussion in national, provincial and local people’s congresses.

lxii. While the organization of environmental institutions and the structure of administrative measures must be custom-tailored to China’s requirements, the experience of other countries can provide guidance. For example, an independent inspectorate located in the environmental bureau network should be considered as a way to mitigate possible conflicts of interest between the state as both polluter and regulator. On a more fundamental institutional level, in many countries responsibility for environmental tasks is given to the lowest level of government that can meet its responsibility without conflicts of interest, and that has an adequate financial (tax) base. This means that the greatest number of tasks are usually performed at the provincial or regional level, as is common practice in most Western countries. If responsibility for certain functions, such as monitoring and inspection, is assigned to the municipal level, powerful constituents are likely to be able to prevent regulations from being enforced. Thus, environment ministries at the national level normally establish the regulatory framework, while provincial-level agencies oversee enforcement. Management of domestic water and sewerage and parks is typically carried out at the municipal level. The Chinese environmental institutional organization is somewhat of a hybrid, but its predominant emphasis is on the municipal levels, especially for implementation and enforcement.

lxiii. In summary, environmental management should be viewed as part of the larger process of reforming China’s economy and restructuring its industry. Systemic economic reform has an impact in three principal ways: it should improve efficiency generally, including energy efficiency and agricultural productivity (thus reducing environmental pressures); it should make it easier to enforce environmental policies; and over the longer term, it should generate greater profitability and therefore funds for environmental investments. The main task ahead for China is to address its environmental and ecological problems through a program that focuses on the underlying causes: resource pricing; institutional incentives and organization (especially industrial enterprise structure); enforcement of regulations; implementation of pollution control measures; and least-cost, long-range planning. An important new initiative that should help to focus environmental policy and programs on these issues is the recent establishment of an Environment and Economic Policy Research Center, under the auspices of NEPA. China can avoid the mistake made by most developed countries of considering every environmental problem a priority, or readjusting priorities with the winds of public opinion. Developing countries such as China must identify those areas where improvements are most cost-effective. The least-cost approach will normally consist of first introducing economic incentives and institutional modifications, in order to reduce the reliance on costly investments.

lxiv. In addition, among the major tasks ahead for China will be: (a) to improve the coordination—at least at the strategic level of setting major environmental targets and policies—of the two environmental administrative networks (NEPA network and environmental units within sector ministries); (b) strengthen the independence and enforcement role of the NEPA network; and (c) strengthen the environmental units within the sector ministries and inte-
grate environmental concerns into the mainstream operations of the ministries, especially at the subnational levels.

E. Recommendations

lxv. Chapters II, III and IV each contain detailed recommendations for addressing the most pressing of the problems they discuss. These recommendations are briefly summarized here.

Urban and Industrial Pollution

lxvi. Priority Recommendations. This report contains a number of recommendations covering a wide range of environmental problems and pollution control strategies. Of these, five are recommended for priority attention by the Government:

(a) the reorientation of China's industrial development policy away from basic heavy industry, toward more economically dynamic, as well as less polluting, manufacturing and service sectors;

(b) an early phasing in of key enterprise and price reforms for economic reasons, but which will also complement the expansion of economic policy instruments for pollution control (e.g., pollution levies) that are aimed primarily at reducing inefficient and uneconomic industries that consume large quantities of materials and energy, and that are the main source of heavy pollution; and fiscal reforms to provide provinces and municipalities, which are responsible for preparing long-range environmental master plans and investment programs, with more revenue for financing infrastructure investments in pollution control;

(c) increases in the pollution levy in stages over a period of years and improvements in the administration of the pollution levy fund to make more funds available for investments in waste minimization technology and combined wastewater treatment facilities;

(d) establishment of subcommissions under the SEPC with the task of reviewing the sectoral policies of other environmentally important ministries and improving coordination between the NEPA network and the sector ministries in setting major environmental targets and policies; and

(e) development of long-range environmental master plans at the local level that focus on least-cost alternatives for water, air, and solid and liquid waste management (including hazardous and toxic wastes). Most pollution problems are most effectively tackled at the local level (municipal and regional) because individual sources of pollutants and, therefore, appropriate solutions, will vary.

lxvii. There are also a great variety of ways to increase the effectiveness of current efforts at pollution control and to supplement them. A number of them apply to the levy system, which is one of the most important elements of urban pollution control strategy in China. These include: (a) increasing the
levy over a period of years to approach the marginal cost of control for each primary pollutant; (b) imposing fees on all primary pollutants, not just the largest, and covering all waste streams; (c) changing the noncompliance penalty into a traditional emissions fee system in which fees are paid on emissions both above and below the standard; (d) requiring all enterprises to pay the fee out of retained profits (many enterprises are allowed to deduct the fee as a cost, for tax purposes); (e) involving banks in evaluating the financial qualifications of enterprises applying for levy funds; (f) shifting the use of levy funds from end-of-pipe treatment to plant renovation, low-waste technologies, or energy efficiency; and (g) using credit funds at market interest rates to supplement the fund as an incentive for firms to invest in cost-effective pollution control measures.

lxviii. Other suggested changes include: (a) raising taxes on polluting inputs to production processes (for example, Sichuan Province is imposing additional fees on the basis of the quantity and quality of coal used by industry) or on polluting outputs; (b) giving enterprises accelerated depreciation for tax deduction purposes if they invest in energy efficiency and pollution control; (c) removing the ownership and management of municipal enterprises that provide commercial goods and services from the direct control of municipal authorities, thus allowing municipalities to focus on more efficient ways of providing the highest-priority urban public services, including environmental infrastructure; (d) making more funds available for urban public services through adjustment of tax retention rates, improved local taxation, municipal borrowing and increased user fees; (e) giving cities the flexibility and freedom to raise local taxes as in other countries through rate adjustments or untapped tax bases so there can be accountability for the services provided; and (f) initiating a program that will allow cities to borrow funds on a long-term basis, if they have developed long-term, least-cost environmental master plans. User fees are too low in both the urban and the agricultural sectors and could be used to conserve resources and reduce pollution.

lxix. Master plans can be made more cost-effective through careful economic and financial analysis. The enforcement capabilities of the environmental protection bureaus could be strengthened by reorganizing them to a higher level to give them greater authority. The focus of both NEPA and the environmental protection bureaus should be expanded to deal with pollution control in a more comprehensive, system-wide, manner. Finally, there is much scope for closer cooperation of all government agencies in developing public environmental strategies and policies, and in encouraging investments in resource conservation and pollution mitigation.

lxx. In regard to coal use and pollution control, the strategy should include a mixture of price incentives, mandatory standards, and financial resources focused primarily on improving the quality of the coal supply and efficiency of coal use. Fine and ultrafine particulates (as opposed to TSP) are considered most dangerous to health; therefore, they should be of highest priority in regard to air pollution abatement. This suggests that environmental authorities should give priority to investments that reduce ambient concentrations of fine particulates. That means: identifying low-level sources of pollutants, improving the quality of coal and targeting different types or forms of coal to specific users, improving energy combustion or industrial processes, and/or installing more effective control equipment. Precombustion
solutions may be less costly than postcombustion control (especially if they can improve energy efficiency as well). Better scale of boilers and plants should help improve energy efficiency (a precombustion solution) and also make it easier to afford control equipment (a post-combustion solution). Also, indoor air pollution, while not studied in this exercise, appears to be very serious; obtaining a better understanding of its effects and taking immediate measures to reduce it are also priorities. The major indoor activity is household cooking; in winter, there is heating also. These are small-scale uses of coal. One of the challenges is how to improve energy supplies to such small-scale users.

Agricultural Resources

lxxi. Priority Recommendations. To deal with the environmental problems stemming from agriculture, four main recommendations require the Government’s immediate attention:

(a) as irrigated cropping is further intensified, the use of fertilizers, pesticides and irrigation water (especially groundwater) will inevitably increase. Both local and central governments should design and install systems and procedures to monitor the quality and quantity of water. They should also have long-term plans to prevent the quality and rate of exploitation from reaching unacceptable levels;

(b) the central government should phase out the use of crop production targets and the linkage of targets to input supply;

(c) on marginal lands already under cultivation, comprehensive rehabilitation programs should be implemented that involve changes in cropping patterns, changes in land tenure arrangements, and improved extension of known techniques; and

(d) the general policy on further conversion of marginal lands to cropping should be reviewed and strict environmental guidelines established. The policies and practices of state farms, county governments and other local entities should be reviewed in this context.

lxxii. Land Use. Current government policies to increase grain production and to promote provincial self-sufficiency in grain encourage the conversion of unsuitable land to crops and discourage the use of potentially regenerative cropping patterns. The Bank has recommended in the context of agriculture sector reports that the use of quota procurement be gradually replaced by the creation of buffer stocks of grain, that projections not be used as the basis for imposing production targets, and that current restrictions on international and domestic trade in grains be relaxed. Government policies should provide incentives to adjust and improve the cropping systems and replenish the soil (for example, replacing some areas devoted to wheat and maize with soybeans, sorghum and millet).

lxxiii. In regard to grazing land, Chinese agricultural administrators believe that development means accentuating primary production through crops rather than secondary production through having grazing animals harvest native
forage. If the grazing land with the highest potential productivity were converted to perennial forage crops adapted to growing conditions, not only would soils be protected, but the increased productivity could potentially allow increases in livestock while reducing pressure on the marginal land.

lxxiv. Development of marginal lands is likely to continue but it should be oriented to sustainable farming systems based on the land's capabilities. An integrated ecological and socioeconomic approach will increase the opportunities for better management and longer-term sustainability. (This is discussed further in the ecological section.) In order to slow the destruction of natural forests, more high-yielding fuelwood plantations have to be established, alternative forms of energy such as biogas need to be developed, and energy conservation measures need to be increased.

lxxv. **Agricultural Inputs.** The Government's policy of linking allocation of inputs, and at subsidized prices, to specified crop production encourages wasteful use and, in the case of fertilizer, runoff and pollution of streams and lakes, which is beginning to be a problem in some areas.

lxxvi. **Water charges** that are low and uniform also lead to overuse, with the problems described earlier. The Government should evaluate experiments with volume-based rates for groups of farmers and use them in water-scarce areas. The excessive drawdown of groundwater would be limited by improved pricing and tighter regulation. Water conservation projects should be based on comprehensive plans that incorporate drainage, conjunctive use of surface and groundwater, and improved management and control procedures.

lxxvii. **Investments.** In selecting and preparing agriculture investment projects, all levels of government should take a more systematic account of environmental costs and the prospects for sustainability. The environmental aspects of agricultural development should not be solely the concern of small, marginal "environment departments," but should be integrated into mainstream operations.

lxxviii. **Research and Extension.** Finally, the Government should analyze more closely the extent to which improved extension services, access to technical assistance and training, civil works and equipment, and other investments could contribute to wider dissemination of known techniques. Since China is a leader in integrated pest management research, more efforts should be devoted to disseminating this practice and less on increasing pesticide use indiscriminately. Further analysis of pesticide pricing and distribution is necessary.

**Ecological Resources**

lxxix. Any changes to protect biodiversity, wetlands, and other natural systems of necessity will involve changes in agricultural policy since the major cause of ecological deterioration is policies that encourage the conversion and exploitation of natural ecosystems.

lxxx. **Commission for the Environment and Natural Resources.** An important step in improving protection of ecological resources would be the creation of a Commission for the Environment and Natural Resources under the State Coun-
cil, or a special commission under the SEPC. The executive arm of the commis-
sion could be a task force of representatives from the land and water and
environmental protection agencies.

lxxxı. Its first task should be to prepare an Environment and Natural
Resource Action Plan that includes a national ecological monitoring and
reporting system; an assessment of economic, financial and macroeconomic poli-
cies, and institutional/organizational structures to affect natural resource
use; an action program for environmental problems associated with agriculture;
and an action program to conserve and protect biological diversity. The task
force should also recommend ways to reduce conflicts between agricultural
production and conservation (see, e.g., the recommendations on grain policy in
the preceding section).

lxxxıı. Review of Agricultural Practices. A leading group drawn from the
Ministry of Agriculture should be created to examine the sustainability of
current agricultural practices, particularly those on forest land and marginal
grassland; to assess alternative approaches such as ecological farming, iden-
tify obstacles to adopting them, and recommend necessary action.

lxxxııı. Nature Reserves. Given the rapid pace of conversion, the only nat-
ural areas likely to be left are those already set aside as nature reserves.
It is urgent to complete this system, to strengthen its management, and to
carry out the research needed to increase awareness of the value of natural
ecosystems. It is also important to develop guidelines for comprehensive
management of the remaining natural areas outside of the nature reserves.

lxxxıv. Wetlands. Coastal wetlands may well be the first ecosystem type in
China to disappear altogether. The most immediate action that can be taken is
to ensure that the State Oceanographic Administration coastal zone development
plan pays sufficient attention to conserving and protecting wetlands. The
primary need is a plan that will maintain fisheries and agricultural produc-
tion at a sustainable level while safeguarding wetlands as nurseries for fish,
sinks for pollutants, buffers from storms, and habitat for diverse plants and
animals. Several pristine areas inland are under threat from development, and
management plans should ensure that the goods and services that they offer as
wetlands per se are not lost.

F. Future World Bank Environment Program

lxxxv. Based on the analysis, assessments and recommendations in this
report, the World Bank has discussed with the Government of China an expanded
program of environmental assistance that will focus on: (a) the formulation
of long-term environmental protection and natural resource conservation poli-
cies and programs; and (b) assistance for immediate investments that will
produce improvements in the short term. More specifically, the multiyear pro-
gram of World Bank environmental assistance will consist of: (a) environmen-
tal sector studies to provide the analysis, especially of underlying causes,
necessary for formulating policy, regulatory, and institutional action plans
and investment programs to address specific problems; (b) technical assistance
(from the World Bank Technical Cooperation Credits and bilateral trust funds,
as well as project-related technical assistance) to strengthen those institu-
tions in China that are dealing with environmental and ecological matters; and
(c) an environment lending program to support appropriate investments to fur-
ther these objectives and to produce measurable (and monitorable) results in
improving the efficiency of resource use and in reducing pollution and degra-
dation of natural resources. Mechanisms to increase coordination with other
multilateral and bilateral donors will be explored.

lxxxvi. The strategy of this program is to focus assistance to Chinese
institutions and enterprises in four priority sectors in which environmental
problems are particularly severe and in which the World Bank has a comparative
advantage in expertise and international experience. These are: energy,
industry, urban and agriculture (including forestry and water resources).
These four sectors also are likely to comprise about two thirds of the World
Bank's overall lending program to China over the next four years. In these
sectors, the principal environmental issues, some of which cut across all
sectors, are: (a) water resource management, including water quality; (b) air
quality management; (c) solid and liquid waste management, including hazardous
and toxic wastes; (d) energy conservation and industrial efficiency, and pol-
lution control; (e) natural resource management and conservation (especially
forest and soil resources); and (f) sustainable agriculture practices on mar-
ginal lands. Institutional issues and environmental expenditures and finance
(cost recovery, pricing policies, budget allocations) are important issues in
all four sectors. These would be examined in several of the follow-up envi-
ronmental studies proposed for inclusion in the World Bank's FY92-95 Economic
and Sector Work (ESW) program; for example, a study of provincial and urban
environmental management (urbanization trends, institutional arrangements,
environmental strategies and investment planning, and environmental expendi-
tures and finance).

lxxxvii. In order to implement this strategy, two to three environmental
projects per year will be proposed for inclusion in the Bank's lending program
to China. Among those proposed for the next four years are: three aimed at
comprehensive control of urban pollution and two at provincial pollution, a
project focused on provincial coal use and pollution control, an environmental
technical assistance project, a forestry project, two projects on agricultural
development of marginal lands and management of watersheds, a project to con-
trol pollution from ships' waste disposal and in marine ports, and a project
to phase out the use of substances that deplete the ozone layer. Most of
these are already under preparation, and most focus on regional environmental
issues with components and policies that have countrywide implications.
Least-cost, long-range environmental management strategies would be included
in most of these projects.
I. INTRODUCTION

A. Objectives of the Environmental Strategy Paper (ESP)

Objectives

1.1 The increasingly severe pressures that economic development is putting on the natural resource base, and the effects of this pressure on air and water quality, have produced a heightened awareness of environmental problems in China, in the World Bank, and in the international community. In order to help member countries address these problems, an increasing proportion of International Development Association (IDA) resources will be designated for environmental projects. Therefore, the World Bank will increase the proportion of resources allocated to environmental projects in its aid program for China.

1.2 This ESP has three main objectives. The first objective is to describe the priority environmental and ecological problems that China faces, identifying the scale of the problems, factors influencing trends, and the underlying causes. The second objective is to assess China's current policies for addressing these problems, including its institutional ability to deal with them, and to identify areas for further study and analysis. The third objective is to propose a multiyear World Bank program of environmental assistance that is based on this assessment. This program would identify: (a) environmental sector studies that will provide support to the government in formulating plans for policy, regulatory, and institutional actions that are technically and economically sound and administratively practical, and an investment program that is financially affordable; (b) technical assistance (obtained from IDA technical assistance credits and bilateral trust funds as well as project-related technical assistance) to strengthen those institutions in China that are dealing with environmental and ecological matters; and (c) a multiyear environmental lending program that supports appropriate investments to further these objectives, and that produces results—in the form of more efficient resource use and reduced pollution—that can be monitored and measured.

Scope

1.3 The ESP is organized around two main sets of issues: environmental and ecological. Chapter II analyzes environmental problems which stem primarily from urban and industrial sources, in terms of land and water pollution and atmospheric pollution.1/ Ecological problems are analyzed in terms of

1/ An environmental workshop (February 12-18, 1990), held in China under the auspices of the National Environmental Protection Agency (NEPA) and the State Science and Technology Commission (SSTC) and financed by the United Nations Development Program (UNDP), focused on technological aspects of water, air and hazardous and toxic waste pollution problems; therefore Chapter II of this document focuses more on the other aspects (economic, financial, institutional, policy framework) of environmental management related to these problems, while incorporating some of the workshop's conclusions on technological solutions.
problems of sustainable agriculture and land degradation (Chapter III) and
destruction of natural habitat (Chapter IV). Chapter V proposes a program of
World Bank environmental assistance. The National Environmental Protection
Agency was the lead counterpart agency and, along with relevant sector minis-
tries and other agencies and the Chinese Academy of Sciences (CAS), assisted
the Bank team.

1.4 Several caveats apply to the scope of the ESP. In many cases, the
effectiveness of Chinese responses to environmental problems cannot be confi-
dently assessed because only limited information is available, or our experi-
ence in China to date has been limited. It is more difficult to assess any
country's effectiveness in the environmental field than in other fields or
sectors because of the complexity and intersectoral nature of environmental
and ecological issues. China poses special problems and not just those of
access to information, but also because of the changing nature and structure
of the Chinese economy, the relative newness of environmental initiatives in
the country, and the possibility that the nature of societal responses in
China may be different than elsewhere.

B. Environmental Management and Economic Development

Complementarities and Tradeoffs

1.5 The interrelationship between environmental issues and economic
growth and development is central to any discussion of environmental matters.
The structure of the economy, and general economic policies and management,
largely determine the nature of environmental problems and the framework for
environmental policies and programs in any particular country. These interre-
lationships in China are discussed throughout this report.

1.6 In the short term, the objectives of promoting economic growth,
alleviating poverty and protecting the environment are not always compatible,
and governments, both central and local, often confront difficult choices in
pursuing them simultaneously; however, in the long run, they are mutually
supportive objectives. As a recent report of the Development Committee 2/
stated: "Rather than address environmental issues in isolation, decisionmak-
ers in governments and international institutions should consider the preser-
vation of the environment along with other issues central to the formulation
of development policy. In so doing, they should take maximum advantage of the
complementarities in order to help the poor, promote better resource manage-

2/ Established in October 1974, the Development Committee is known formally
as the Joint Ministerial Committee of the Boards of Governors of the
World Bank and the International Monetary Fund on the Transfer of Real
Resources to Developing Countries. The Committee's members, usually
Ministers of Finance, are appointed in turn for successive periods of two
years by one of the countries or groups of countries represented on the
Bank's or the Fund's Board of Executive Directors. The Committee is
required to advise and report to the Boards of Governors of the Bank and
the Fund on all aspects of the broad questions of the transfer of real
resources to developing countries, and to make suggestions for consider-
aton by those concerned regarding the implementation of its conclusions.
ment and contribute to sustainable development." It is a principal objective of this report to try to identify some of those complementarities in China and in those cases of tradeoffs between environmental protection and economic growth, to suggest approaches that will help achieve an appropriate balance. This also should be one of the principal objectives in the establishment of sectoral subcommissions under the State Environmental Protection Commission (SEPC) which is one of this report's priority recommendations (paras 1.11, 2.110(d), and 4.90).

Economic Aspects of China's Environmental Management

1.7 In China, the impacts of economic policies (e.g., a population policy between 1950-65 that encouraged high birth rates and the continued emphasis on basic heavy industry in industrial policy) have not always been conducive to sound environmental policies and management. The explosive growth of industry has been a major factor in water, air, and soil pollution and the impact of this growth has been exacerbated by the fact that China has pursued an industrial strategy that has consistently emphasized basic, heavy industrial sectors that are the worst polluters (heavy industry now accounts for nearly half of China's industrial output). In addition, both the desire for local self-sufficiency and some elements of the planned, administered nature of the Chinese economic system have introduced economic inefficiencies that have hampered efforts at environmental improvement. The waste, pollution and inefficiency associated with low, state-controlled prices for coal and water illustrate the effect of inappropriate economic policies on day-to-day environmental problems.

1.8 In the agriculture sector, economic policies have a big impact on how agriculture affects the environment. Chapter III discusses a number of issues related to economic policies and environmental issues in the agriculture sector in China; for example, pricing and distribution of agricultural inputs (fertilizers, pesticides, water charges), and land tenure and land use patterns. In all these areas, reforms that are recommended for reasons of improved long-term agricultural sustainability also have important complementarities and desirable effects for improved economic efficiency. Policies can be improved in ways that promote resource conservation, reduce environmental damage and simultaneously raise economic productivity, decrease government budget deficits and ameliorate rural poverty. For example, national policies in China on grain production and distribution have a substantial impact on the environment. The Government has set a target of producing 500 million tonnes of grain by the year 2000 in order to achieve self-sufficiency. Achieving this target would almost certainly require the continued conversion of marginal land into cropland or intensification of cropping on marginal land. The financial and environmental cost of doing this would be very high. The Government also has established quotas for the obligatory delivery of grain by


each province. The central Government also promotes provincial self-sufficiency in grain production, rather than encouraging specialization in crops that have a regional or geographical comparative advantage. These policies encourage the conversion of unsuitable land to cropping and discourage the use of alternative, potentially regenerative cropping patterns. Thus, current grain policy in China has unintended detrimental ecological side effects.

1.9 Many of these detrimental ecological side effects would be reduced if grain policy were to be changed for reasons of economic efficiency. The World Bank has suggested in a recent agriculture sector report that the demand for grain in China could be met in a more efficient and less costly manner through: (a) allowing market forces to operate more fully; (b) gradually replacing the use of quota procurement by the creation of buffer stocks of grain; and (c) relaxing current restrictions on international and domestic trade in grains. If these reforms were implemented for financial and economic reasons, they could also be expected to have a favorable environmental impact by reducing artificial pressure to intensify grain cultivation and to meet nationally set targets, irrespective of local conditions.

1.10 In summary, environmental management should be viewed as a part of the larger process of reforming China's economy and restructuring its industry. Systemic economic reform has an impact in three principal ways: it should improve efficiency generally, including energy efficiency and agriculture productivity (thus reducing environmental pressures); it should make it easier to enforce environmental policies; and over the longer term, it should generate greater profitability and therefore funds for environmental investments. In general, until price and enterprise reforms are more extensively undertaken, neither pollution fees or fines nor administrative regulations are likely to carry sufficient force or be systematically applied to encourage the most cost-effective means of reducing environmental degradation. The underlying economic links to environmental management are areas which need increased focus in China. While continued enforcement of China's emission standards and regulations, and pollution levies and fines are indispensable elements of environmental policy, increasing attention should be given to the structural and technological changes needed in the industrial and agricultural sectors, and the economic policies needed to encourage these changes, in order to obtain both environmental benefits and economic growth at least cost to the economy. Environmental protection and economic development are not unalterably opposed to each other, they can go together. Improving one can enhance the other. Much environmental damage is the result of either lack of knowledge or short-sighted policies. Systemic evaluations and assessments quite often show that economic improvements can be achieved through more sensible policies and actions that protect and enhance the environment at the same time.
C. China's Environmental Institutional Framework

State Environmental Protection Commission

1.11 The State Environmental Protection Commission, which includes the heads of all relevant ministries and agencies, and ultimately the State Council (the highest executive level of government in China), are at the apex of decision-making and interagency coordination on environmental policy in China. The SEPC provides policy direction at times and resolves interagency disputes, but it meets only quarterly and hence cannot regularly set overall policy. The commission relies heavily on NEPA, which functions as its secretariat. As the analysis in the subsequent chapters suggests, consideration should be given to more effective ways to coordinate environmental policy below the SEPC level since this group can deal with only a limited number of issues, and probably only at a general level, at its four annual meetings. Specifically, subcommittees under the SEPC could be given the task of reviewing other sectoral policies from an environmental viewpoint and recommending to the SEPC or State Council what changes should be made. These subcommittees should be of fixed duration and disbanded when their reports are completed. Such reviews would involve the participation of the other relevant ministries, and the reviews should be arranged in such a way that only one or two sectoral policies at a time are under consideration, with the most important getting priority. A principal objective of the subcommittees should be to identify some of the complementarities between economic reforms and environmental improvement and, in cases of tradeoffs between environmental protection and economic growth, to suggest approaches that will help achieve an appropriate balance.

National Environmental Protection Agency

Responsibilities and Authority

1.12 The National Environmental Protection Agency became an independent agency in 1988, although it still does not have full rank as a ministry. It reports to both the State Council and the SEPC. It is responsible for all aspects of environmental policy and comprehensive supervision and management of environmental protection, although it shares authority with other agencies for certain specific natural resources; for example, the marine environment is managed primarily by the State Oceanographic Administration and the Ministry of Agriculture (fishing). Authority in conservation issues primarily rests with the natural resources ministries such as the Ministry of Forestry. The agency liaises with the environmental protection units within most other ministries and agencies, and sets the overall policies and regulations governing the provincial and municipal environmental protection bureaus. In addition, there are two research institutes affiliated with NEPA: the Chinese Research Academy of Environmental Sciences and the recently established Environment and Economic Policy Research Center.

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5/ See Annex 2 for a diagram of the administrative networks for environmental control.
Internal Organization

1.13 The National Environmental Protection Agency is organized into four general areas: policy, enforcement, support, and supervision. The two policy sections are the Planning Section and the Policy and Legal Section. The five enforcement bureaus are Pollution Management, Development Supervision, Nature Conservation, Science and Technology Standards, and Propaganda and Education. A recently created Foreign Economic Cooperation Office liaises with and coordinates assistance from the World Bank, the Asian Development Bank (ADB), UNDP and the government of Japan. The agency is very thinly staffed, with fewer than 300 authorized personnel at the national level (1988); however, there are many more personnel in auxiliary units at the subnational level.

Subnational Environmental Management

Subnational Environmental Protection Bureaus

1.14 Most environmental protection policy is implemented at the subnational level. Provinces are responsible for implementing national policy and are authorized to act in the absence of preemptive national standards; where warranted by local conditions, they may also impose more stringent standards than those required by the national government. In all provinces and municipalities and in most counties around the country, environmental protection bureaus now have been established under local environmental policy commissions headed by a vice-governor or vice-magistrate. At the end of 1989, local bureaus had about 54,000 personnel, of whom almost 38,000 were classified as scientific and technical, while another 10,000 were classified as administrative cadres. Probably at least the same number of staff are involved in the environment offices within sector ministries. Chapter II describes how this system implements environmental policies.

Transboundary Problems

1.15 Environmental problems do not respect administrative boundaries; however, China customarily attaches great importance to jurisdictional integrity. The resolution of environmental problems that transcend administrative boundaries, such as long-distance water transfers, depends upon extensive bargaining and frequently requires administrative realignments or the expansion of municipal boundaries. The only exception appears to be the seven river basin commissions responsible for China's major rivers, but even these commissions have difficulty coordinating the main stream with its tributaries. The Government should consider creating special districts or authorities (e.g., air quality control and solid waste management districts) and strengthening the role and functions of others (e.g., the river basin commissions) to alleviate the problems caused by transboundary issues and to address multiple concerns in a more flexible manner.

D. Role of the Public in China's Environmental Issues

Public Education

1.16 During the early stages of environmental regulation in the 1970s, mass educational campaigns were considered an effective alternative to policy
implementation and enforcement. That perception changed with growing recognition of the structural causes of environmental problems. However, China maintains a strong public education or popularization program to encourage environmentally conscious and law-abiding behavior among children and adults through the mass media, billboards, public praise and other mechanisms. This effort could be made more effective by additional funding and research in environmental psychology and sociology, especially in relation to the design of environmental curricula in the education system. Some elements of the older mass campaigns (which still can be effective) remain, especially in rural construction and the obligatory tree planting program, but they are now a comparatively small part of China's regulatory efforts.

1.17 There are 71 universities or institutes of higher learning in China in which environmental protection disciplines or specialties have been established and from which some 8,000 students graduate annually. More than 100 environment-related newspapers and journals, including the *China Environmental News* with an annual circulation of 500,000 copies, are published in China.

Expanding the Role of the Public

1.18 Although the Administrative Litigation Law (1989) authorizes private lawsuits against government agencies and officials, China generally expects the public to mobilize in behalf of only government-approved purposes. However, experience in developed countries demonstrates that autonomous citizens' groups can be effective in promoting environmental consciousness among the populace, raising the quality of dialogue on environmental issues, and identifying actions actually or potentially harmful to the environment. Some professional scientific associations or societies in China are promoting civil awareness of environmental issues, but citizens' groups generally are not allowed autonomy in this regard. This could lead to an erosion of public trust, which may in turn lead to unconstructive direct actions against environmental offenders.

Resettlement Principles and Guidelines

1.19 Government policy on resettlement of populations that are displaced by proposed projects (e.g., hydroelectric or highway construction) is comprehensive and covered under national and provincial laws and regulations. While the subject was beyond the scope of this study, Bank assessment of Chinese resettlement efforts during Bank-assisted highway, urban and hydroelectric power projects is generally favorable. The Chinese pay more attention to compensation measures and detailed resettlement planning than most developing countries. The Ministry of Water Resources recently completed a review of its resettlement experience and has called for increased budgetary resources to implement resettlement schemes more adequately. The framework of policy guidelines is laid down by State Council regulations and provides for: (a) the social and economic reestablishment of affected communities, with living standards not lowered and preferably raised; (b) resettlement within the same county and, if possible, the same township; (c) resumption of original employment, or training for alternatives; (d) realistic compensation levels; and (e) reconstruction of public facilities.
II. POLLUTION CONTROL STRATEGY

A. Introduction

2.1 This chapter describes the pollution problems identified by Chinese government officials, scientists and researchers as having a high priority, and analyzes these priorities on the basis of available data and information. In addition, it examines and assesses policy responses already under way and future plans.

2.2 Pollution associated with China's growing population, burgeoning industrial growth, and reliance on high-polluting heavy industry continues to take a heavy toll on the Chinese people and the environment. China's problems are made more difficult to solve by (a) its reliance on coal as the major energy source and the need for winter space heating in much of the country; (b) the scarcity of water in much of the country; and (c) its reliance on planning and administrative direction. Both the desire for local self-sufficiency and certain elements of the planned nature of the Chinese economic system have introduced economic inefficiencies that have hampered efforts at environmental improvement. The waste, pollution, and inefficiency associated with low, state-controlled prices for coal and water illustrate the effect of inappropriate economic policies on day-to-day environmental problems.

2.3 On the other hand, China has not been ignoring its environmental difficulties. Unlike many developing countries, China has a comprehensive set of laws based on reasonable concepts to guide environmental policy development, a range of command-and-control as well as economic incentive approaches to implement the law, and an impressive network for administering, monitoring and enforcing environmental policy.

2.4 However, while past efforts have reduced pollution per unit output, these gains unfortunately have been mostly canceled by the rapid growth of industry and the population. The failure of control measures to reduce air pollution concentrations over the five cities in the Global Environmental Monitoring System (GEMS) during the 1980-89 period is evidence of the difficulties that lie ahead (see para. 2.29).

2.5 China's leadership recognizes that much more will need to be done to significantly improve the environment. At current and anticipated levels of

\[\text{With economic growth at approximately 10 percent per year in the 1980s,}
\text{wastewater discharge and solid wastes per yuan of industrial output fell}
\text{38 percent and 26 percent (1983 to 1988), respectively; compliance with}
\text{industrial effluent standards increased 9 percent; processed industrial}
\text{wastewater increased from 3.1 to 7.2 billion tons (1981-88); and compre-
\text{hensive analyses of water quality control in polluted lakes and reser-
\text{voirs were undertaken. See Qu Gaping, "China's Strategic Option in Envi-
\text{ronmental Policy for the 1990s" (undated manuscript) and Zhang Shen and}
\text{Tang Yijuan, "The Tendency of Environmental Pollution and Control Strate-
\text{gies in China," Institute of Geography, Chinese Academy of Sciences}
\text{(undated manuscript).}}\]
investment for pollution control, further progress will be slow for at least a
decade, unless a number of policy initiatives discussed in this report are
implemented. Even so, it will be important to make the most productive use of
available funds by allocating the money to priority problems and ensuring that
the funds that are allocated to pollution control are used in the most cost-
effective way. Most important for the future state of environmental pollution
in China, increased attention should be given to structural and technological
changes in the economy and industrial sector, and the policies needed to
encourage these changes, in order to obtain environmental benefits and eco-
nomic growth at least cost to the economy. In particular, China needs to
consider the reorientation of its industrial sector away from heavy industry,
which is technologically outdated and highly polluting, toward more economically
dynamic and less polluting manufacturing and service sectors.

B. Pollution Issues

Major Pollution Problems

2.6 The three high-priority pollution problems identified by the Chinese
are urban water quality, urban air quality (which is polluted by suspended
particulates and sulfur dioxide), and rural industrial pollution. While data
limitations preclude a definitive ordering of these priorities, they also
appear to be the major pollution problems. Contamination of rural drinking
water—primarily by human and animal wastes—appears to be another major prob-
lem.

2.7 Indoor air pollution and occupational exposure also are important
concerns in China, but are not discussed in this report because they are out-
side the scope of this study. Indoor air pollution can cause major health
problems where coal is used for internal space heating and wood or coal is
used for cooking.2/ Occupational health is also an important priority,
since exposures to toxic chemicals are often very high, with inadequate con-
trols to protect workers’ health.

2.8 Other pollution problems which are assuming an ever-increasing prom-
minence in China include: acid rain from sulfur dioxide (SO₂) and nitrogen
oxides (NOₓ); industrial and domestic solid wastes; hazardous waste; ground-
water pollution; vehicle emissions; and, because of international concerns,
greenhouse gases such as carbon dioxide (CO₂) and chlorofluorocarbons (CFCs).

Urban Water Pollution

2.9 Water quality problems are of two general types: (a) damage to
aquatic resources, including contamination of food supplies;3/ and (b) con-
tamination of drinking water supplies—either surface or ground waters.

2/ Kirk R. Smith, Biofuels, Air Pollution, and Health: A Global View (New
York: Plenum, 1987).

3/ In addition, productivity is affected by having to pretreat water for
industrial and domestic use (for which no data were available), as is
ture for irrigation water (see Chapter III for the latter).
**Damage to Aquatic Resources**

2.10 In China, the first problem is unquestionably serious in stretches of rivers passing through cities, and in lakes and bays receiving urban and industrial discharges (effluents). According to one estimate,4 of the 15 sections of the 7 major rivers flowing past cities, 13 are "seriously polluted." In northern China's coastal waters, sharp drops in prawns, jellyfish, and scallops, as well as the more frequent appearance of red tides--all attributed to exposure to sewage--indicate the increasing seriousness of the problem. A major outbreak of hepatitis A in Shanghai caused by seafood contaminated by sewage (300,000 people were taken ill) is powerful anecdotal evidence of the high levels of conventional pollutants (fecal bacteria, such as *E. coli*, and other pollutants associated with biological activities) present in Chinese water bodies.

2.11 There are, unfortunately, no systematic analyses linking pollution of urban surface water in China to health, aesthetics, and biological effects. However, there are data that relate monitored concentrations of pollutants in water bodies to water quality standards.5 Specifically, NEPA data for 96 monitors of water quality in urban areas show (Figure 2.1) that only 35 of the 96 stations meet minimum levels of dissolved oxygen (DO; 5 mg/l, a level that will support fish) 100 percent of the time; at the other extreme, 14 stations report samples violating the DO standard 100 percent of the time. The story is similar for biochemical oxygen demand (BOD),6 with only 24 of 91 stations reporting all samples meeting the standard (5 mg/l) and 21 reporting all samples violating the standard. Unfortunately, available data do not permit further characterization of BOD and DO levels (as well as fecal coliform counts)--for example, the number of samples with DO of zero or one.

2.12 In contrast, pollution from heavy metals seems much less extensive, although the consequences of violations are probably much more severe than for conventional pollutants. Seventy-seven of 92 stations report mercury concentrations meeting the standards in all samples, and 79 of 93 stations report the same for lead. These data are, however, not necessarily representative of many other toxic chemicals which are discharged from industry into the environment, but which are not routinely monitored.

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5/ China has established five classes of surface water quality for different categories of end use. Ambient standards for 35 pollutants have been established for these five classes.

6/ Biochemical oxygen demand is a measure used to describe the oxygen demand of sewage and other organic wastes. It is the amount of oxygen required to aerobically decompose biologically degradable compounds. The higher the BOD, the more oxygen required, and the poorer the water quality.

7/ An indicator measure for the presence of human and animal fecal matter in water.
In most large urban areas of China, industrial wastewater is the predominant source of pollution, in some cases contributing up to 70-80 percent of the pollutant load. Most industrial and household wastewater is dis-
charged without treatment. Data for 82 major cities in 1988 indicate that the chemical industry discharged the largest share of industrial wastewater (30 percent) at 3.8 billion tons, followed by the metal manufacturing industry (20.4 percent), at 2.6 billion tons per year. Other sectors have far lower discharges. Of the estimated 25 billion tons of industrial wastewater discharged over all of China in 1990, about 32 percent was treated (often only to the extent of pretreatment). After treatment, only somewhat more than half of this water meets effluent standards. The situation is even worse for municipal sewage. Municipal wastewater treatment capacity in 1986 was only 1 million tons per day and, although this had increased to about 2 million tons by 1990, it represents a very small fraction of the total municipal wastewater discharge. In many cities nightsoil collection reduces the waste load, but this practice is becoming less common as the overall standard of living improves.

2.14 The full extent of the pollution of surface water in China cannot be measured because there are no data, but anecdotal evidence about polluted irrigation water (see Chapter III) and general statements made in Chinese literature, such as "of 532 rivers surveyed, 436 have been polluted," are clear indicators of the seriousness of the problem.

**Contamination of Urban Drinking Water**

2.15 The second type of water pollution problem is contamination of drinking water, whether from surface or groundwater sources. This can directly affect health. From the above discussion, it is clear that urban surface waters are heavily polluted. Urban groundwater sources are being polluted to an increasing extent as a result of infiltration of polluted surface waters and leaching from solid and hazardous waste dumps (Table 2.1). The problems of water quality are also compounded by water shortages. Of 434 cities, "are short of water and 40 suffer a severe shortage." Excessive groundwater withdrawals in Beijing for domestic and industrial use are reducing the water table 6 feet a year.

2.16 Nevertheless, according to some Chinese authorities, the ability of municipal governments to deliver "safe" drinking water to their residents has been unaffected, although it is becoming increasingly difficult in some water-short areas. The Ministry of Public Health (MOPH) estimates that 30 percent

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8/ Qu and Li, *An Outline of Study*. 

9/ Data provided by NEPA. 


12/ In Shenyang, for instance, of 252 wells, 27 percent of samples exceeded the tightest standard for nitrate (10 mg/l), with one sample as high as 75 mg/l. 

Table 2.1: GROUNDWATER SAMPLES VIOLATING THE NITRATE (NO$_3$-N) STANDARD (for selected cities)

<table>
<thead>
<tr>
<th>City</th>
<th>Number of Wells</th>
<th>Concentration Mean (mg/l)</th>
<th>Range (%)</th>
<th>Percent of Wells in Violation of Standard (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shenyang</td>
<td>252</td>
<td>14.90</td>
<td>0.00-74.70</td>
<td>27.0</td>
</tr>
<tr>
<td>Tanshan</td>
<td>14</td>
<td>6.00</td>
<td>0.70-14.40</td>
<td>7.1</td>
</tr>
<tr>
<td>Wuxi</td>
<td>27</td>
<td>0.56</td>
<td>0.00-2.89</td>
<td>0.0</td>
</tr>
<tr>
<td>Suzhou</td>
<td>52</td>
<td>0.07</td>
<td>0.00-1.33</td>
<td>0.0</td>
</tr>
<tr>
<td>Guilin</td>
<td>91</td>
<td>3.70</td>
<td>0.05-20.30</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Note: Although the drinking water standard for nitrates is 20 mg/l, NEPA has adopted 10 mg/l as the groundwater quality standard for China.

of China's population has safe drinking water (the water meets the standards after leaving the treatment plant), and that almost all of the population in major cities has "safe" water. The Sichuan Provincial Environmental Protection Bureau also claims that most of its cities are provided with a safe drinking water supply.

2.17 In contrast, information from other sources is more pessimistic about the urban problem, with one source estimating that only 115 million people are supplied "safe" drinking water. Since there are 280 million urban Chinese, only about 40 percent would have safe water. Further, reports of urban arsenic poisoning accidents through drinking water sources serve as anecdotal evidence of a drinking water problem in some urban areas. This more pessimistic view is supported by a nationwide survey of Chinese drinking water during 1983-88; 28,000 sites were sampled in both rainy and dry seasons for 15 characteristics. This survey found that, out of 200 million urban residents served by centralized supply, only about half received high-quality water.15/

Rural Drinking Water

2.18 The evidence of a rural drinking water problem is less in dispute. The MOPH estimates imply that only about 1 in 7 rural Chinese have safe water. If true, this would make the rural drinking water problem a very high priority problem. Indeed, in Xinjiang Autonomous Region, from 1986 to 1988, 100,000 people caught epidemic diseases from drinking polluted water.16/ There are

14/ See para. 2.53.


16/ NEPA, "Some Problems about the Protection of Drinking Water Source," (undated manuscript).
additional data that also shed some light on the rural drinking water problem, albeit only indirectly. One source shows that 76 percent of the Chinese population drinks water with fecal coliform counts exceeding the Chinese drinking water quality standard, and 59 percent drink water exceeding the World Health Organization's (WHO) less stringent "acceptable" drinking water standard. The corresponding percentages for chemical oxygen demand (COD, a measure of organic pollution) are 17 percent and 8 percent, with much lower percentages of drinking water samples in violation of other pollution indicators.\textsuperscript{17} Thus, the coliform counts indicate that human and animal contamination of rural drinking water appears to be the most significant water pollution problem in China, although since there are no data, this judgment should not be made hastily.

2.19 More research is needed on both rural and urban drinking water quality to distinguish carefully between adequate water supplies and water quality, and to define the meaning of "safe." For instance, when drinking water is categorized as safe, it should be specified whether this means direct from the tap, or after boiling by the household.

\textbf{Urban Air Quality}

\textbf{Causes}

2.20 One of the chief causes of China's air pollution problems (particulates, $\text{SO}_2$, and $\text{NO}_x$) is undoubtedly its primary dependence on coal for energy. Its dependence on coal is greater than that of any other country for a number of reasons--its large coal reserves relative to other energy reserves, its northern latitude, and its antiquated industrial system. In 1989, China met 76 percent of its commercial energy needs with coal, compared with 53 percent for India, 18-19 percent for Europe and Japan, and 24 percent for the United States. Its energy intensity is also high, owing to inefficient energy conversion and use, and a high proportion of heavy industry. The average energy intensity of China's industrial sector has dropped over the past decade, but it remains high. While cross-country comparisons of energy use per unit GDP provide only a rough picture of relative energy intensities (due to problems arising from differences in statistical methods and conversions to comparable output value units at official exchange rates), they indicate that China's energy intensity remains higher than that of most developing and developed nations.\textsuperscript{18}

2.21 Other factors contributing to the continued high energy intensity in the economy include:

(a) the substantial share of small-scale, inefficient plants, even in the energy and heavy industries, that employ older technologies and inefficient equipment;

\textsuperscript{17} Chen, "Situation of Drinking Water."

\textsuperscript{18} For a more detailed discussion of energy intensity issues, see paras. 2.90-2.95.
(b) unfinished enterprise and fiscal reforms, which do not go far enough in creating the right incentives in the economy and that slow additional gains in productivity and efficiency.

2.22 Much of the coal is burned in places where people live and work. Of just under 1 billion tons of coal burned per year, households and commercial establishments use 22 percent, with the urban share of this over 50 percent. Industrial boilers take the major share (43 percent), while only 26 percent of the coal is used to generate electric power. Power utilities mainly use tall stacks that result in lower exposures in the local area per unit of emissions than other sources of air pollutants. In terms of dust emissions, the individual space heating boilers with simple cyclone collectors are estimated to remove the lowest percentage of particulates--only 60 percent, while industrial boilers remove 75 percent, and the power utility boilers remove between 85 and 93 percent on average.19/ However, the low-efficiency dust collectors installed on industrial and space heating boilers remove only a small percentage of the very fine particulates (less than 10 microns), which cause human health problems and reduce visibility. Virtually no sulfur is removed, except in making the briquettes used for household purposes.

2.23 Coal is not the only contributor to high urban levels of total suspended particulates (TSP) and SO₂. Diesel fuel burned by trucks and buses also results in high levels of these pollutants as well as toxic emissions, such as polycyclic aromatics.

2.24 The latest research in the United States suggests that toxic emissions from industry may be of lower priority than initially expected, even though the recently completed U.S. Environmental Protection Agency inventory of toxic air pollutants revealed emissions higher than had been expected. The analysis of these data 20/ showed that reducing toxic emissions by 90 percent from their uncontrolled levels would reduce premature mortality in the general population by only 500 statistical cases. Since U.S. toxic emissions are, like those of developing countries, currently uncontrolled (although U.S. industry presumably emits less per unit output because of more efficient production processes), these findings suggest that toxic emissions from industry may not be a primary concern in developing countries, such as China. However, in relation to worker health, where the exposure is much higher, and where accidental releases of toxic gases (e.g., Bhopal) can occur, special precautions and mitigation measures have to be adopted in China as a matter of high priority.

2.25 Another factor in urban air pollution, which is often overlooked, is the mixing height available for dilution of low-level emissions. In the case of Beijing and many cities in China, the mixing height is often low, especially during the winter months. During frequent low-level inversions, the mixing height over the urban area of Beijing is only 100 m compared with 200 m over rural areas. Thus, except for discharges through high stacks (chimneys),


which can penetrate the inversion layer, all low-level emissions are trapped in a stagnant urban air mass and build up over the period of the inversion to quite high concentrations. The longer the duration of the inversion, the more serious the buildup becomes.

Impacts

2.26 There are several major areas that are affected by air quality: health (acute effects, increased risk of developing chronic illness, and increased risk of premature death), materials (soiling, corrosion, and decay), atmospheric visibility (which is reduced), forests and other vegetation (visible damage, reduced growth rates), and water quality (which can be degraded by atmospheric deposition of pollutants in lakes—primarily as acid rain).

2.27 In urban areas, the focus is usually on health effects and reduced visibility. The pollutants affecting health include the following: total suspended particulates; fine suspended particulates; sulfur dioxide; nitrogen dioxide (NO₂); ambient ozone (O₃, which is formed by hydrocarbon (HC) compounds and NO₂ in the presence of sunlight); carbon monoxide (CO); heavy metals (especially lead, Pb); and carcinogenic hydrocarbons. Recent evidence conclusively shows that the fine suspended particulates (less than or equal to 10 microns as opposed to TSP) are more closely related to health effects because they penetrate more deeply into the lungs. More recent research in the United States is focusing on very fine particulates in the form of acid aerosols (such as sulfuric acid and nitric acid particles less than or equal to 2 microns) as the active agents for the observed health effects of particulates. Heavy metals, such as lead, arsenic, and cadmium, have been linked to a range of congenital and health problems, including increased risk of cancer and learning disabilities.

Status

2.28 The poor state of air quality in Chinese cities, especially in the north, is not in dispute. Both NEPA and GEMS monitors show frequent violations of Chinese and WHO air quality standards, and by large margins. For instance, annual average TSP is 526 micrograms/m³ in the north of China and 318 micrograms/m³ in the south, compared with WHO guidelines of 60-90 micrograms/m³; annual average SO₂ is 93 micrograms/m³ in the north and 119 micrograms/m³ in the south, compared with WHO guidelines of 40-60 micrograms/m³. The regional disparity in concentrations is worth

21/ In addition, there are global problems of CO₂ (greenhouse effect and global warming) and CFC emissions (ozone-depleting substances).


23/ Indeed, China's cities have some of the highest TSP and SO₂ readings in the world. See World Bank, "Efficiency and Environmental Impact," Tables 3.5 and 3.6.

noting. In at least some northern cities with exceedingly high TSP readings, high levels of background dust from natural sources (which may be as much as 60 percent of TSP in Beijing in the spring) exaggerate the implied health consequences because, although the readings are higher, the dust is less dangerous to lungs than particulates generated by human activities. Furthermore, in the north, the acid aerosols created in the TSP/SO$_2$/NO$_x$ mixture may be partly neutralized by the alkalinity of dust. The atmospheric pH in the north has been measured to be neutral or even basic. However, in some southern areas, the lack of alkaline dust and the higher sulfur content of coal burned is responsible, at least in part, for some of the highest acidity levels of rainfall in the world (pH of 3.9-4.1). This also suggests that the priority region for SO$_2$ reduction, because of the local health impact from acid aerosols, appears to be the central-south.

2.29 The GEMS data averaged over 1981-84 and 1985-89 can be used to examine whether progress has been made in controlling the two monitored pollutants (TSP and SO$_2$) in the five GEMS cities (Table 2.2 and Figure 2.2). For TSP, improvements are noted in average and peak concentrations in Beijing and Guangzhou, but conditions in Xian appear to be worsening. The other areas showed little change. In each city, average concentrations of SO$_2$ were virtually identical across the two multiyear periods. Peak yearly averages rose in three cities and fell in two. Thus, there is no general trend toward improved air quality.

2.30 Less is known about the concentrations of other pollutants. Ambient ozone (as distinguished from high-level, stratospheric ozone) apparently is not regularly monitored in China. Neither are nitrogen oxides, carbon monoxide, or lead. Since coal burning is a very significant source of NO$_x$ emissions, high levels of this gas are also expected in urban areas. Emissions of carbon monoxide, volatile organic compounds (an ambient ozone precursor), and possible lead from the relatively few gasoline vehicles are likely to be major sources of these pollutants in urban areas. With growth in urban populations and increasing affluence, this source of emissions can only grow in importance.

2.31 Data from the Ministry of Public Health indicate that chronic obstructive pulmonary disease (COPD) (which has been linked to exposure to fine TSP and SO$_2$) was the leading cause of death in China in 1988, with a death rate of 162.6 per 100,000, which is 26 percent of all deaths. When standardized and compared with figures for the United States, the rate in China is more than five times greater--103/100,000 in China, and 19/100,000 in the United States27/ The differences are even more dramatic in the 55-74 age group--600-700/100,000 in China, compared with 80/100,000 for females and

25/ See paras. 2.39-2.45 for further discussion on acid rain in China.


Table 2.2: COMPARISON OF LEVELS OF AIR QUALITY IN SELECTED CITIES IN CHINA (for 1981-84 and 1985-89) (micrograms/m³)

<table>
<thead>
<tr>
<th>City</th>
<th>1981-84</th>
<th>1985-89</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Minimum Maximum</td>
<td>Mean Minimum Maximum</td>
</tr>
<tr>
<td>Beijing</td>
<td>393 236 510</td>
<td>358 235 418</td>
</tr>
<tr>
<td>Guangzhou</td>
<td>209 92 375</td>
<td>205 103 324</td>
</tr>
<tr>
<td>Shanghai</td>
<td>227 151 330</td>
<td>251 155 340</td>
</tr>
<tr>
<td>Shenyang</td>
<td>415 221 545</td>
<td>415 233 554</td>
</tr>
<tr>
<td>Xian</td>
<td>418 235 531</td>
<td>520 356 642</td>
</tr>
</tbody>
</table>

Total Suspended Particulates

Sulfur Dioxide

Note: Process of Analysis

1. This presentation is based on monitored data from the Global Environmental Monitoring System, which covers five large cities in China (as above). Each city has four GEMS monitors for TSP and SO₂.

2. Data for 1981-89 are available for almost all monitors. To observe the trend of air quality in each city, monitored years are divided into two groups: 1981-84 and 1985-89.

3. The minimum and maximum of mean values are provided for each city and each year group. The weighted average is calculated using mean values and the number of monitoring samples in each year.

200/100,000 for males in the United States. Nevertheless, other factors are evidently influencing COPD rates in China (such as smoking and exposure to emissions from cooking fuel) because the COPD rate was lower for cities in China than for rural areas—the city rate being 86/100,000.28/

28/ The higher rural rate has two possible explanations: (a) rural people smoke more than those in urban areas, and (b) rural use of poorer quality fuel for cooking and heating plus inefficient ventilation of stoves and heating systems result in higher exposures than in the cities.
Figure 2.2: AVERAGE AND RANGES OF MEAN AIR QUALITY CONCENTRATIONS (for GEMS stations, by city)

<table>
<thead>
<tr>
<th>City/years</th>
<th>Total Suspended Particulates (micrograms/m³)</th>
<th>Sulfur Dioxide (micrograms/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 200 300 400 500 600</td>
<td>0 100 200 300</td>
</tr>
<tr>
<td>Beijing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81-84</td>
<td>236 393 510</td>
<td>6 75 165</td>
</tr>
<tr>
<td>85-89</td>
<td>235 358 418</td>
<td>25 78 133</td>
</tr>
<tr>
<td>Guangzhou</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81-84</td>
<td>92 209 375</td>
<td>13 71 128</td>
</tr>
<tr>
<td>85-89</td>
<td>103 205 324</td>
<td>7 76 154</td>
</tr>
<tr>
<td>Shanghai</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81-84</td>
<td>151 227 330</td>
<td>12 53 78</td>
</tr>
<tr>
<td>85-89</td>
<td>155 251 340</td>
<td>8 58 113</td>
</tr>
<tr>
<td>Shenyang</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81-84</td>
<td>221</td>
<td>22 130 293</td>
</tr>
<tr>
<td>85-89</td>
<td>233</td>
<td>24 129 343</td>
</tr>
<tr>
<td>Xian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81-84</td>
<td>235 418 531</td>
<td>22 81 160</td>
</tr>
<tr>
<td>85-89</td>
<td>356 520 642</td>
<td>27 79 131</td>
</tr>
</tbody>
</table>
Rural Industrial Pollution

Township and Village Industrial Enterprises (TVIEs)

2.32 The pollution of rural areas, particularly drinking and irrigation water, by industrial enterprises is another top priority for the Chinese government.\textsuperscript{29} Much of the blame for such pollution rests with the township and village industrial enterprises.\textsuperscript{30} The Chinese ascribe problems with the TVIEs to their rapid growth, dispersed activity, low level of technology, poor operation and management, lack of effective pollution control equipment, and difficulties in enforcing the environmental laws and regulations for these dispersed and small enterprises.

2.33 The growth of TVIEs has been staggering. By one account, industrial TVIEs numbered just 4.8 million in 1984, but as of 1988 totaled 7.7 million, with the value of output nearly quadrupling over this period and representing 28 percent of total industrial output. In particularly high growth areas, such as Jiangsu Province, TVIEs now represent 48 percent of total industrial output and generate about one third of the total amount of organic pollutants in the province.

TVIE Pollution Concerns

2.34 The National Environmental Protection Agency has little comprehensive data about compliance of the TVIEs with pollution controls. Most data obtained by NEPA on their performance come from the pollution levy program, and this program is not working very well for TVIEs. For instance, in many rural areas the levies collected are less than 30 percent of the potential amount due. The TVIEs contribute heavily to local tax revenues (in many towns and villages, TVIEs contribute 80 percent of tax revenues); thus, there is strong local pressure to treat such enterprises less stringently. In addition, the enforcement effort required is large, because the enterprises are small and dispersed, and the gain in fines may not be worth the effort, considering the very few staff that are assigned to this work.

2.35 The TVIEs often use outdated technologies, and the level of engineering design and construction is generally poor—so much so that a special regulation was written to prevent 20 specific, outdated, often highly polluting, technologies from being sold to them from other domestic enterprises and from abroad. Also, their regulation is divided between the Ministry of Agriculture (MOA) and NEPA, a potentially problematic arrangement, with the control and treatment of pollution from TVIEs primarily the responsibility of MOA. However, both MOA and NEPA cooperated in a major survey of rural industrial pollution control that was recently completed.

2.36 In spite of the problems with TVIEs, averaged over all the country, their emissions are less than state-run enterprises, given their share of

\textsuperscript{29} Also, see discussion of rural drinking water contamination, para. 2.18.

\textsuperscript{30} Water bodies may also be polluted by fertilizer runoff as well as industrial and domestic effluents. This is nonpoint-source pollution.
industrial output. The TVIEs contribute only 10.7 percent of the wastewater discharges, 9.4 percent of air emissions, and 11 percent of solid wastes—amounts below their share of output (28 percent). At this level of aggregation, however, this favorable condition is to be expected because TVIEs are in general concentrated more in the lighter, lower polluting industries, although this varies by industrial subsector and region. The TVIEs are responsible for 26 percent of the light industry output but only 23 percent of heavy industry output.\textsuperscript{31} They represent 15 percent of the chemical industry and 10 percent of metals manufacturing (smelting), the two sectors of state enterprises with the largest quantity of wastewater. The TVIEs in the pulp and paper sector are responsible for the largest share of TVIE wastewater (28 percent).

\textbf{2.37} Table 2.3 is more revealing because it compares discharges from TVIEs and total discharges disaggregated by type and location of industry. The wastewater discharges of TVIEs, standardized by output value, are compared with those of all enterprises for three sectors—food processing, textiles, and pulp and paper—and for five regions. The table shows that TVIE discharges per unit of output generally exceed those of all enterprises in Tianjin, Shanghai, and Chongqing, but that the reverse is true in Shenyang and Xian. Thus, these data do not support the idea that TVIEs are generally more polluting than other enterprises. However, there are three caveats. First, because TVIE output prices are largely uncontrolled, while those of state enterprises are primarily controlled, TVIE output value may exceed that of state enterprises for the same physical output. This implies that discharges per unit output (in yuan) would be biased downward for TVIEs. Second, in those cities where TVIEs outperform all enterprises, they do so in each of the three sectors, suggesting that some institutional or local policy-related factors may be at play. Third, only wastewater discharges, not airborne emissions, are being measured. If TVIEs are paying more for water than state enterprises, they would be economizing more on water use, resulting in lower discharges per unit of output (in yuan) relative to the state enterprises.

\textbf{Emerging Pollution Issues}

\textbf{2.38} Beyond these three major priorities, other pollution issues are becoming increasingly important in China. These include: acid rain, disposal of industrial and domestic solid wastes, hazardous and toxic wastes, groundwater pollution, noise, greenhouse gas and ozone-depleting emissions (primarily, CO\textsubscript{2} and CFCs), vehicular emissions, and nonpoint-source pollution.

\textbf{Acid Rain}

\textbf{2.39} A study of SO\textsubscript{2} and NO\textsubscript{x} emissions for a number of Asian countries,\textsuperscript{32} including India and Pakistan, estimates that for the years 1986, 2000, and 2010, 28, 53, and 76 million tons of sulfur dioxide, respectively, will be produced (assuming business as usual). Of these figures, China contributes 19, 34, and 49 million tons for each of the years, or approximately

\textsuperscript{31} China Statistical Abstract, p. 224.

\textsuperscript{32} Bhatti, Streets, and Foell, "Acid Rain in Asia" (Honolulu: East-West Center, 1991).
Table 2.3: COMPARISON OF TVIEs AND TOTAL ENTERPRISE DISCHARGES PER UNIT OF OUTPUT (kg/yuan)

<table>
<thead>
<tr>
<th>City</th>
<th>Food Processing</th>
<th></th>
<th>Textile</th>
<th></th>
<th>Puip and Paper</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total TVIEs</td>
<td>Total TVIEs</td>
<td>Total TVIEs</td>
<td>Total TVIEs</td>
<td>Total TVIEs</td>
<td>Total TVIEs</td>
</tr>
<tr>
<td>Tianjin</td>
<td>10.2</td>
<td>18.7</td>
<td>9.2</td>
<td>20.0</td>
<td>57.0</td>
<td>97.5</td>
</tr>
<tr>
<td>Shanghai</td>
<td>12.0</td>
<td>153.4</td>
<td>9.3</td>
<td>30.7</td>
<td>59.1</td>
<td>71.4</td>
</tr>
<tr>
<td>Chongqing</td>
<td>14.9</td>
<td>317.7</td>
<td>14.6</td>
<td>-</td>
<td>161.4</td>
<td>-</td>
</tr>
<tr>
<td>Shenyang</td>
<td>29.8</td>
<td>7.4</td>
<td>19.7</td>
<td>11.3</td>
<td>97.4</td>
<td>46.7</td>
</tr>
<tr>
<td>Xian</td>
<td>22.9</td>
<td>5.0</td>
<td>11.0</td>
<td>-</td>
<td>97.5</td>
<td>68.7</td>
</tr>
</tbody>
</table>


two thirds of the total (figures of 13, 19-21, and 26-30 million tons for these three years have been estimated by the Coal Research Academy under the Ministry of Energy, which did weighted-value calculations of coal weight based on an average sulfur content of China's coal at 1.12-1.20). By comparison, the estimated sulfur dioxide emissions from the United States in 1987 were 27 million tons. In the case of nitrogen oxide emissions, the estimates for these years were 14, 29, and 44 million tons, of which China contributes 8, 15, and 22 million tons, respectively, or approximately 50 percent of the total.

2.40 Isolated surveys of acidity levels and chemical composition of rainwater were begun in China in the 1970s, and nationwide acid rain measurements have been conducted since 1982. The results indicate that precipitation in the southern regions of China (south of the Yangtze River) often has pH values below 5.6, with average levels in some areas reaching 4.0. In northern regions of China, the pH is usually greater than 7.0 (i.e., basic), in spite of the fact that most of the coal combustion takes place here and sulfate (SO$_4^{2-}$) concentrations in rainwater and sulfur dioxide levels in many towns and cities in this region are often much higher than those in the south. The reason for this relatively high pH of rainwater is that, in the north, the proximity of the central Asian deserts with their highly alkaline, saline soils increases the neutralizing capability of the atmosphere. It has been observed that ammonium (NH$_4^+$) and calcium ion (Ca$^{++}$) concentrations in rainwater in northern areas are much higher than in the south of China and in the United States and other industrial nations. It is estimated that if the soil-derived bases (calcium carbonate and ammonia) were eliminated from the atmosphere, the precipitation pH in these northern sites would average approximately 3.5, which is very acidic. This implies that, if the precursors of acid deposition were to intensify and be transported into areas, such as southern China, where alkaline substances are not present in the air, the incidence and severity of acidic deposition would increase. This sort of long-range transport already occurs during the winter months as air moves from northern China into southern areas.
2.41 A study of precipitation pH in the remote eastern Tibetan plateau of Qinghai Province revealed pH levels as low as 2.25 (in the largest town in the region) and as high as 8.9. The low pH events were associated with high nitrate levels that may have been the result of long-range transport and/or the combustion of high-nitrogen coal found in this region. The high pH values were associated with areas with very alkaline, loose soils.

2.42 Another study of acid rain has been carried out in the southwestern Chinese province of Guizhou, which is surrounded by mountains on the north and southwest and therefore isolated from the prevailing winds in both the summer and winter. The acidity and composition of precipitation has been measured at 14 urban and rural sites in this region since 1981. The pH of precipitation has been found to be lowest in urban areas (where most high-sulfur coal is burned), reaching as low as 3.4. In rural areas, mean precipitation pH is approximately 4.6. It is generally believed that acid rain in Guizhou is mainly a local phenomenon (since most emissions are released at ground level) because there is a significant difference in acidity levels between rural and urban areas that are only a few hundred kilometers apart, and even between urban and suburban parts of the same city. However, remote parts of this province do receive acidic precipitation, suggesting that some long-distance transport occurs.

2.43 It appears that the most severe episodes of acid deposition are likely to occur in the winter downwind from the northeastern emission sources. This is because much more coal is used during this season than any other, particularly for heating. Because of the nature of the prevailing winds during this period, the receptor areas that would be most severely affected by an increase in emissions and higher stacks would probably be Japan, Korea, and southern China.

2.44 The mountainous portions of the above-mentioned receptor areas would likely receive some of the highest levels of acid deposition because they are located in the path of moisture-laden air masses which must rise over them, condensing out their moisture as they do. In addition, mountain areas are often enshrouded in fog and mist, both of which have been observed to contain higher concentrations of acid than other forms of precipitation.

2.45 It is extremely difficult to predict the magnitude and extent of the threat that acid deposition poses for the nations of the Asian region because of the complexities of the region's meteorology, the considerable gaps in knowledge of acid deposition—especially under tropical conditions—and the uncertainties in projecting future economic growth, energy efficiency improvements, and energy consumption. However, as long as these countries continue to pursue their goals of rapid economic and industrial development without implementing control measures, emissions of sulfur dioxide and nitrogen oxide will increase substantially, enhancing the formation of acidic pollutants and their potential to damage the environment.

Greenhouse Gases and Ozone-Depleting Emissions

2.46 The global problems of chlorofluorocarbons and greenhouse gas (GHG) emissions are of increasing concern to Chinese scientists (see Annex 11); because of the global costs (i.e., adverse effects) involved, there is a gen-
eral expectation that developed countries will help pay for reductions in CO₂ and will subsidize technology transfers to develop substitutes for CFCs in manufacturing. Energy conservation and improved coal use, which are priority concerns, can substantially reduce greenhouse gas emissions, although economic growth could reduce much of these gains.

2.47 Greenhouse gases are implicated in the slow heating of the planet's atmosphere. GHGs consist of a complex mix which includes CO₂, CH₄ (methane), N₂O (nitrous oxide), CFCs and other minor gases coming from both anthropogenic and natural sources. They originate from virtually all natural biological processes (agriculture and forestry) as well as human activity, primarily industry, power, residential, commercial and transport sources. Although on balance the developed countries contribute the largest share of these gases, growth in emissions has been sharply curtailed by efficiency improvements, fuel substitution and other measures enacted since the energy crisis of 1979. Currently, Asia is estimated to provide close to half of the world's new sources of greenhouse gases.

2.48 Figure 2.3 shows 1985 global anthropogenic greenhouse gas emissions of CO₂, CH₄, CFCs and N₂O. These five GHGs accounted for approximately 87 percent of the increase in heat-trapping capacity of the atmosphere during the 1980s. Since the heat-trapping impact of CH₄ is some 25 times greater than CO₂, N₂O some 200 times greater, and CFCs approximately 10,000 times greater, their relative quantities in the atmosphere are very important to obtaining an overall picture of the situation. The second column of Figure 2.3 shows the radiative trapping effect of these gases based on their occurrence in the atmosphere. It is clear that CO₂ from commercial energy remains by far the most important single source. These figures indicate that CO₂ emissions account for 62 percent of total impact, followed by methane and CFC emissions, which account for 30 percent. Nitrous oxide, which is mainly released from fertilizers, has a relatively minor share.

2.49 The Asia region's contribution to world CO₂ emissions was on the order of 20 percent in 1985 and can potentially increase to 28 percent by 2025, assuming there are no changes in current patterns of human activity. The share of emissions that is due to land use changes in agriculture is controversial given that it is derived from estimates of deforestation rates that were made in the late 1970s. Actual deforestation rates and thus total CO₂ emissions may be very different from those assumed here. Given the debate, and until a clearer picture emerges, the most prudent and practical approach would be to focus on reducing emissions from energy consumption.

2.50 Of all the countries in the Asia region, China is the largest emitter of CO₂. Anthropogenic CO₂ emissions for 1985 (the last year for which complete data sets exist) were approximately 540 million tons, which represents about 60 to 70 percent of total GHG emissions from China (the balance is made up of emissions from rice fields, rural residential cooking and heating, and livestock). Almost half of the total CO₂ emissions coming from the world's developing countries comes from China. Coal is the dominant fuel in Chinese industry and in the power sector. Figure 2.4 illustrates this by showing energy use by fuel type of the major industrial sectors in China. The three major CO₂ sources are industry (45 percent), electric power (17.9 percent), and residential heating and cooking (22.1 percent). Although these
**Figure 2.3: ESTIMATED 1985 GLOBAL ANTHROPOGENIC GREENHOUSE GAS EMISSIONS**

<table>
<thead>
<tr>
<th></th>
<th>Greenhouse gas emissions, MT/yr</th>
<th>CO₂-equivalent emissions, MT/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO₂ Emissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial energy</td>
<td>18,000</td>
<td>18,000</td>
</tr>
<tr>
<td>Tropical deforestation</td>
<td>2,600</td>
<td>2,600</td>
</tr>
<tr>
<td>Other</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>21,000</td>
<td>21,000</td>
</tr>
<tr>
<td><strong>CH₄ Emissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel production</td>
<td>60</td>
<td>1,300</td>
</tr>
<tr>
<td>Enteric fermentation</td>
<td>70</td>
<td>1,500</td>
</tr>
<tr>
<td>Rice cultivation</td>
<td>110</td>
<td>2,300</td>
</tr>
<tr>
<td>Landfill</td>
<td>30</td>
<td>600</td>
</tr>
<tr>
<td>Tropical deforestation</td>
<td>20</td>
<td>400</td>
</tr>
<tr>
<td>Other</td>
<td>600</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>890</td>
<td>6,100</td>
</tr>
<tr>
<td><strong>CFC-11 and CFC-12 emissions</strong></td>
<td>0.6</td>
<td>3,200</td>
</tr>
<tr>
<td><strong>N₂O Emissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal combustion</td>
<td>1.0</td>
<td>290</td>
</tr>
<tr>
<td>Fertilizer use</td>
<td>1.5</td>
<td>440</td>
</tr>
<tr>
<td>Gain of cultivated land</td>
<td>0.4</td>
<td>120</td>
</tr>
<tr>
<td>Tropical deforestation</td>
<td>0.5</td>
<td>150</td>
</tr>
<tr>
<td>Fuelwood and industrial biomass</td>
<td>0.2</td>
<td>60</td>
</tr>
<tr>
<td>Agricultural wastes</td>
<td>0.4</td>
<td>120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4.0</td>
<td>2,360</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td></td>
<td>32,660</td>
</tr>
</tbody>
</table>


Figures are for 1985, it can be assumed that, without major industrial restructuring, the relative contributions to total emissions in 1991 were the same.

**2.51** Future trends in China indicate a shift toward greater GHG emissions from an expanded power sector and from the transportation sector as a result of greatly expanded use of passenger vehicles. It is estimated that, under a "business as usual" scenario, China's CO₂ emissions would expand by a factor of nine by the year 2100, when it would be emitting more CO₂ than from all
countries combined in 1990. More than any other developing country, China faces some of the most complex, costly and difficult choices in developing a strategy for GHG emissions control that will allow continued economic growth and improved living conditions for its people.

2.52 During the short- to medium-term transition phase of GHG emissions control, this strategy will have to focus primarily on energy conservation and energy efficiency measures on the supply and demand side, increased electrification, increased (but limited) switching to natural gas for fuel, and increased use of renewable energy resources (see paras. 2.90-2.95 on energy conservation).

Solid Waste Disposal

2.53 The volume of solid waste in China is large, and little is recycled (24 percent in 1988 and 29 percent in 1990). Accordingly, by 1988, 6.6 billion tons of untreated solid waste had accumulated, occupying 55,400 hectares (ha) of land. Much of this is on the urban fringe, where land is particularly valuable and groundwater contamination is of greatest concern. Eighty percent of the solid waste comes from industry and energy sources, mostly coal (55 percent of the total).33/ Since coal ash contains impurities such as heavy metals, and, of particular concern, arsenic, the uncontrolled disposal of this waste presents a potentially high health risk to rural communities. The full extent of this problem cannot be gauged at this time, but it requires urgent attention.

33/ Huang and Zhao, "Environmental Pollution."
Hazardous and Toxic Wastes

2.54 There are few systems for controlling hazardous and toxic wastes in China, although considerable quantities are generated each year. Some are recycled and reused for purposes that endanger the health of the population, while much of the waste is deposited without treatment or controls in lakes, rivers, and canals, and on land. As the industrial base becomes more sophisticated, the quantity and toxicity of these wastes are increasing.

Groundwater Contamination

2.55 Groundwater contamination is a related problem, since infiltration from solid and hazardous waste dumps and polluted surface waters is a major source of aquifer contamination. Since groundwater is a preferred source of drinking water, such contamination presents a serious concern to public health officials in China. The whole issue of the management and protection of groundwater resources will need much greater attention in the future.

Noise

2.56 Noise pollution is a major concern to the Chinese. Two thirds of the urban population is exposed to high noise levels. Of 70 monitored cities, only 6 percent of the major cities meet noise standards, while 33 percent of "common" cities meet the standards.34/

Vehicular Emissions

2.57 One issue not mentioned by most Chinese sources, but which may be of growing importance in some cities (e.g., Beijing, Shanghai, Guangzhou), is pollution from vehicles. With over 80 percent of vehicles in China burning gasoline, the vehicular contribution of particulates and SO$_2$ is probably trivial. However, these vehicles may be contributing a large share of the precursor emissions to ambient ozone, volatile organic compounds and nitrogen dioxide, as well as carbon monoxide and toxic compounds, such as benzene. Because the vehicles use leaded gasoline, and a remarkably tight relationship between lead in gasoline and blood-lead levels in children has been found in the United States, vehicular emissions may also be a major source of lead.35/

Furthermore, these emissions will increase with growth in cities and in affluence. Further, the tremendous inroads in other parts of Asia that motor scooters have made as urban transport options for developing countries suggests that the same can happen to China as incomes rise. While this would result in some improvement in the Chinese transportation system, it will come at the price of increases in releases of hydrocarbons and other gaseous emissions (HC emissions from a scooter are 22 times greater per kilometer traveled than those from a gasoline-fueled automobile), assuming that scooters replace bicycles. Increases in numbers of automobiles may also follow increased

34/ Information provided by NEPA.

affluence, with attendant increases in hydrocarbons, carbon monoxide, lead (assuming leaded fuel is used), and nitrogen dioxide; the concentration of ambient ozone could also increase. Testing stations for vehicle emissions are already being set up in some large urban areas (e.g., Beijing).

Nonpoint-Source Pollution

2.58 Nonpoint-source pollution is primarily a problem of fertilizer run-off and subsequent excessively high levels of nutrients in water bodies. While not apparently widespread in China, this problem can be expected to become more serious as the use of fertilizer becomes more widespread (see Chapter III).

C. Current Government Policies Influencing Pollution Control

Legal Framework

2.59 Three key concepts appear in the Chinese Environmental Protection Law (EPL) and ancillary regulations: prevention first, polluters pay, and strong management (see also Annexes 1, 2, and 3).

Prevention

2.60 In China, environmental considerations are integrated into development planning and projects through a process called the "three simultaneous" steps--the incorporation of environmental protection into the design, construction and operation of facilities--and through the requirement for environmental impact assessments (EIAs) on all new, expansion, and renovation projects. To implement these concepts, the EPL states that locating new polluting projects near populated and protected areas is prohibited; an old industry may be relocated to comply with environmental law; recycling is to be promoted (in part by price or tax adjustments to goods made from recycled materials, with profits returned to the enterprise for pollution control uses); and goals are expanded use of low-polluting energy sources and development of district heating systems. Since EIAs were often performed too late to influence project approval, location, and design, regulations were recently modified to require their preparation earlier in the project cycle.

Polluter Pays

2.61 An equity principle adopted by countries belonging to the Organization of Economic Cooperation and Development (OECD) as well as some nonmembers is that those who pollute must control pollution, or pay for others to do it. To implement this concept, there is a 7 percent setaside requirement for environmental protection in the capital budgets of new projects; a setaside for renovation of existing enterprises (amounting to ¥ 1.21 billion in 1988); deadlines on pollution reductions by industry; and a levy system (a noncompliance penalty) based on the amount of emissions exceeding standards, coupled with a redistribution of monies to enterprises to finance pollution control investments. Fines are imposed for infractions; compensation may be assessed for damage caused by polluters; plants may be shut down; and leaders of units can be held personally responsible for pollution. The compensation feature of the EPL provides redress similar to liability proceedings in Western courts.
Such collections are usually made when some economic asset is damaged, such as an agricultural crop or a commercial fishery. Compensation payments are not generally assessed for damage to health.

Environmental Quality Standards and Permits

2.62 Standards for environmental quality, as well as industrial effluents and emissions, have been developed by NEPA and local authorities (see Annex 3). In all, 204 national standards have been issued; 12 for environmental quality (air, surface water, and noise standards), 46 industrial and vehicular emissions standards, and 146 standards relating to measurement methods. The emission and effluent standards are generally uniform for a given pollutant across industries. Local standards may be set if they are more strict than the national standards. About 300 such standards were issued during 1985-90. There are also 105 workplace labor (hygienic) standards. There are no standards for solid or hazardous wastes; they are being prepared. China's water and air standards are reasonable; that is, they are generally not so strict as to be unattainable, but strict enough to motivate sufficient reductions in pollution to protect public health. A wastewater discharge permit system (involving registration, monitoring, and issuance and evaluation of permits) is being established in 230 cities (about 60 percent of China's medium-to-large cities). While most effluent standards are currently based on concentration, China is switching to mass-based effluent standards in conjunction with the discharge permit system. It plans to complete this switch by 1995. By the end of 1992, NEPA plans to have registered most major polluters under the permit system in the 230 cities.

Strong Environmental Management

2.63 The EPL provides for environmental management as follows: (a) it mandates the creation of an environmental protection bureaucracy at the national level to draft regulations, policies, and standards and to supervise their enforcement, monitor pollution, promote research and development, and aid in technology transfer; (b) it requires that similar environmental protection bureaus be set up at the provincial and local level with principal responsibility for implementing the laws; and (c) it requires that environmental protection organizations be set up within all but the small enterprises. These provisions have resulted in a large bureaucracy for studying, supervising, monitoring, and enforcing environmental protection activities. It numbers some 200,000 full-time positions within the various levels of government and within the enterprises (see Annex 1). Monitoring of emissions and effluents, as well as ambient water and air conditions, is extensive and appears generally adequate for control, but the system (except for NEPA) is not unified. NEPA's monitoring network is well integrated and requires local areas to send data to Beijing quarterly or yearly. Sixty percent of its stations are computerized (see Annex 3 for a more detailed assessment of the monitoring systems).

Economic Incentive Approaches

2.64 The mainstay of the Chinese environmental policy effort is regulation in the form of effluent standards combined with a pollution levy system. In addition, the Chinese have adopted an "environmental responsibility system"
to improve the environment and provide some incentives for comprehensive waste use and recycling.

The Pollution Levy System

2.65 Industrial effluent fees have been advocated by economists to reduce pollution, but only Germany has what is considered a classic effluent fee system (see Box 2.1 for a description of the German system and Annex 4 for a description of the effluent fee system). Although it shares some similarities, the Chinese pollution levy system can best be characterized as a noncompliance fee system. This system involves charging enterprises a fee for violating the emissions standards. It is calculated on the basis of the polluting constituent that exceeds the standard by the greatest amount. The difference between the measured concentrations and the standard for that constituent is multiplied by a fee (factor) to arrive at the amount of the levy. Repeated violations can result in fines; the fine is doubled if a polluter is caught lying about emissions. Provinces have limited discretion over fee factors used to calculate the levy and the formula that is used, but they can raise or lower fines. Some provinces fine at three times the rate, some make exceptions and reduce the fine when equipment is not working or when other explanations are offered. The levy system also has an additional feature for encouraging compliance with the effluent standards—the computed levy is increased 5 percent per year starting from the third year in which the levy is assessed until the enterprise comes into compliance.

2.66 Most of the fees collected under this system are retained at the local level (fines are transmitted to the national government) and are placed into a fund for redistribution to enterprises in the form of loans (at more favorable conditions than market rates). These are used for pollution control or for operation and maintenance activities to reduce pollution. These funds are primarily intended for plant-level waste treatment facilities; municipal treatment facilities do not receive funds from this source. The current rules limit eligibility for loans to firms that have paid money into the system. The fund is limited to 80 percent of the amount paid in. Twenty percent is retained by the Environmental Protection Bureau (EPB) to support monitoring and enforcement activities.

2.67 While this system appears to have been successful at raising funds and channeling them into pollution control investments, there are several weaknesses in the system. First, the fee is far below the marginal cost of treatment to meet the effluent standard, and most firms pay the fee rather than investing in treatment equipment. While the level of the fees was increased by about 40 percent in 1991, they are still quite low and represent only a small proportion of most enterprises' production costs (about 0.1 percent). Second, it is not an effluent fee system, such as that used by Germany, which provides an incentive to reduce effluents, whether they are above or below the standard. The Chinese system provides an incentive only to meet the standard, not to do better. Rather than paying fees on each pollutant according to its toxicity, Chinese enterprises pay a fee equal to the maximum fee owed on only one polluting constituent in the waste dis-

Box 2.1: SUMMARY OF GERMAN EFFLUENT FEE SYSTEM

In the German effluent fee system, fees are based on permitted emissions and are built into the permit system in much the same way as the U.S. National Pollutant Discharge Elimination System (NPDES). There are heavy penalties if actual emissions violate the standards. This approach eases the monitoring burden and requires very little additional administrative resources for startup.

A task force that included industry representatives, municipal treatment authorities, and government officials at all levels, as well as academics, was assembled to set charge rates and to design monitoring protocols.

The rate is set nationally (although a "state" may charge a higher rate) and is based on the amount of pollutant in the discharge waters and a damage factor that is applied to each unit of pollutant. These are scaled according to the toxicity of the pollutant. The rate is specified on a damage unit basis and equals about $20 (at current exchange rates) per damage unit per year. For oxidized substances, as measured by COD, this is about $20 per pound, based on 2.2 damage units per every 100 kg of COD at $20 per damage unit, or about 2 percent of sales for direct dischargers and about $6 per person per year for municipalities. The average charge is about four times lower than average treatment costs.

Both municipalities and direct dischargers must pay the fee. The actual maximum emission level (say in any one day) cannot be more than twice the actual average. Dischargers exceeding this level are charged a higher rate. However, if firms or municipalities meet the emissions standard, the rate is reduced by half; if they reduce pollution by more than 25 percent below the standard, they pay the fee at the same discount rate but it is applied to actual rather than permitted emissions.

The German system started at $6 per damage unit in 1981 with gradual increases built in until five years later the rate topped out at $20. There was a large increase in investment spending for pollution control in the announcement phase. A gradual increase in rates over time can continually increase compliance incentives.

While fee waivers can be granted for three years if abatement equipment purchases are planned, individual dischargers cannot be exempted from the fees. It is possible to exempt industries, parts of industries, or regions, but such exemptions can only be granted through law based on the criterion of "significant detrimental economic conditions." Such exemptions have not been granted to date, although there have been many applications for them.

Rates and overall policies are set at the federal level, but the states have responsibility for enforcement, as well as the timing of implementation, collection, and disbursement of fee revenues. Thus the states have an incentive to enforce compliance because good enforcement can increase revenues (and the size of the enforcement agency's budget). Administrative costs are one third to one half of the revenues collected.

Thus, there is an incentive to emit each pollutant up to the point at which its charge equals that for the pollutant with the highest charge. There is no incentive to control pollutants that have low charges (whether from a low fee factor or a low quantity discharged, or both).

Third, it is questionable whether the fee creates much of an incentive, if any, to reduce pollution at minimum cost. The basic environmental law permits enterprises to pass along the fee (as well as, presumably, abatement expenditures) in the product price. Abatement costs apparently can

37/ Xingyuan Lu and Dongqin Wang, "System of Pollution Charges in China," NEPA (undated manuscript).

38/ Ibid.
also be picked up by the state (the soft budget constraint). Firms facing price competition have an incentive to find least-cost alternatives to comply, thereby paying no fee and keeping product prices competitive. If the state pays for the abatement costs, there is no incentive to adopt low-cost approaches to reducing emissions (e.g., improving operation and maintenance). Where there is no price competition, firms may well pay the fee, raise prices, and avoid increasing their costs by not treating or otherwise reducing effluents.

2.69 Many firms have apparently simply paid the fee. The reasons are not hard to find: by paying a fee they qualify for low-cost loans (only grants were given until recently) from the fund created by the levies and fines, which are primarily used for end-of-pipe pollution control. This tie of subsidy to levy payment further reduces the incentive for low-cost pollution control. In addition, the fund created by the levy system is small relative to the needs for major investments in new production processes. Only end-of-pipe treatment can be "afforded" using the levy fund. According to NEPA, about 10 percent of the enterprises from whom fees were collected during the past 10 years tapped the fund for pollution control investments.

2.70 The total yearly amount collected in levies and fines indicates the extent of pollutant standard violations and EPB's performance in collecting levies. In 1989, Y 452 million were collected for excess gaseous emissions to the atmosphere, Y 858 million for excess discharges to water, only Y 33 million and Y 36 million, respectively, for solid wastes and noise violations. In total, collections amounted to Y 1.4 billion, or about 0.1 percent of the gross national product. Since 1984, a total of Y 6.7 billion has been collected, somewhat more each year of the program. The major industrial contributors are chemicals, light industry, and metallurgy, with over 54 percent of the levies. In addition to the pollution levies, fines were collected for "raised levy standards," double levies (both of these are for cheating), for delaying payments (a penalty of 1 percent per day is added to the levy), and for damage reparations. In 1989, Y 239 million were collected in fines and Y 22 million were collected in reparations.

2.71 The extent to which enterprises are granted exemptions from the levy system varies considerably from province to province and municipality to municipality, even within a province. Moreover, it is very difficult to get a clear picture because this is usually not a topic that city administrators like to discuss. The tax and remittance systems in China have a heavy tradition of negotiation (see paras. 2.104 and 2.138) and this is also evident in pollution levy payments. Most applicants in Sichuan Province are allowed to postpone their payments, but apparently a few are granted an exemption (which can only be done if the state determines that they are in serious financial difficulty). For the most part, it appears that levies are collected at the municipal level at a reasonably high rate. The problem arises at the county, township, and village level, where environmental management is weak, administrative interference from economic interests is strong and levy collection is usually poor.
The Responsibility System

2.72 One is naturally concerned about the effectiveness of an emissions fee system for state-run enterprises that do not face hard budget constraints. As an alternative, the responsibility system is a Chinese approach to pollution control that is reasonably compatible with state-run enterprises because it operates with incentives at both the individual and enterprise levels.

2.73 There are currently two main types of responsibility systems: a comprehensive environmental responsibility system for local governments, line bureaus, and enterprises, which includes money and awards for meeting contractual obligations that set out environmental targets; and an enterprise environmental responsibility system, which is targeted more specifically at the enterprise and its web of economic regulations and administrative controls, including the right to be rated a well-performing or an outstanding enterprise (a level II, or level I designation). The comprehensive environmental responsibility system provides monetary grants (to individuals and local governments), bonuses (to enterprises), and accolades to both for fulfilling contractual obligations between provincial and local governments, between the local governments and local sector bureaus, and between the bureaus and the enterprises themselves. This contract specifies performance in meeting a variety of environmental targets or indices.

2.74 Under the first type of system, the contracting parties do not view the contract as enforceable, but as an agreement entered into voluntarily for mutual gain. There is little or no penalty for failure to live up to the terms. While the contracts sound very specific and quantitative, in practice, the decisions about whether the terms of the contracts have been fulfilled do not appear to be based on measurable criteria. This is not to say, however, that they could not be applied more strictly. In any event, the incentive can be large. In some areas, meeting the targets can result in bonuses to workers that equal their annual wage.

2.75 The comprehensive environmental responsibility system is relatively new and it is difficult to measure the extent to which contracts are being met. However, an even newer variation of this system, which provides bonuses to municipalities for meeting environmental goals (short of formalized contracts) is making an impact through a program for 32 provincial capital cities sponsored by NEPA. This program involves the capital cities in a competition to improve the urban environment by setting deadlines for meeting 20 environmental targets. As an example, Table 2.4 shows the targets for the city of Tianjin. Participation is voluntary (although the provinces are encouraged to make contractual obligations with the mayors) and results are published in the newspaper. While NEPA has little money for bonuses, some provinces are contributing funds. NEPA argues that the campaign has raised the environmental awareness of mayors at all levels of local governments. At a meeting of provincial and municipal Environmental Protection Bureau directors recently, it was reported that 60-70 percent of mayors are now giving more attention to environmental matters as a result of the program. According to provincial environmental protection officials, this system is now one of their most effective tools for reducing pollution and could play a more important role in the future because it provides the basis for increased mass education on environmental issues and awareness among the populace.
Table 2.4: SAMPLE CONTRACT FOR TIANJIN UNDER THE ENVIRONMENTAL RESPONSIBILITY SYSTEM

<table>
<thead>
<tr>
<th>A. Air Quality Indexes</th>
<th>1989</th>
<th>1990</th>
<th>1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TSP, Annual daily mean (micrograms/m³)</td>
<td>0.4</td>
<td>0.39</td>
<td>0.37</td>
</tr>
<tr>
<td>2. SO₂, Annual daily mean (micrograms/m³)</td>
<td>0.17</td>
<td>0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>3. Coverage of smoke control zone (%)</td>
<td>95</td>
<td>97.2</td>
<td>98.2</td>
</tr>
<tr>
<td>4. Central space heating supply rate (%)</td>
<td>-</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>5. Urban gasification rate (%)</td>
<td>92.4</td>
<td>91.2</td>
<td>88.9</td>
</tr>
<tr>
<td>6. Rate of briquettes for household use (%)</td>
<td>36.07</td>
<td>46.01</td>
<td>74.85</td>
</tr>
<tr>
<td>7. Percentage of dust emissions from production process meeting emission standards (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metallurgical Bureau</td>
<td>58.4</td>
<td>59.0</td>
<td>71.6</td>
</tr>
<tr>
<td>Building Materials Bureau</td>
<td>63.3</td>
<td>74.2</td>
<td>92.8</td>
</tr>
<tr>
<td>Municipal Engineering</td>
<td>20.0</td>
<td>30.0</td>
<td>40.0</td>
</tr>
<tr>
<td>8. Percentage of vehicles meeting exhaust/gas emission standards (%)</td>
<td>65</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>9. Per capita green area (m²/person)</td>
<td>2.15</td>
<td>2.31</td>
<td>3.1</td>
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<tbody>
<tr>
<td>10. Percentage of drinking water sources meeting quality standards (%)</td>
<td>92</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>11. Average COD in surface water (mg/l) Hai River</td>
<td>7.1-7.5</td>
<td>6.6-7.0</td>
<td>&lt;6</td>
</tr>
<tr>
<td>12. Industrial wastewater per Y 1,000 gross output value (t/Y 1,000)</td>
<td>105</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>13. Treatment rate of industrial wastewater (%)</td>
<td>42</td>
<td>51</td>
<td>65</td>
</tr>
<tr>
<td>14. Rate of treated industrial wastewater meeting standards (%)</td>
<td>60</td>
<td>70-79</td>
<td>80-90</td>
</tr>
<tr>
<td>15. Treatment rate of municipal sewage (%)</td>
<td>-</td>
<td>46</td>
<td>-</td>
</tr>
</tbody>
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<tr>
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<tbody>
<tr>
<td>16. Environmental noise (decibels, A weighted)</td>
<td>64</td>
<td>63</td>
<td>60</td>
</tr>
<tr>
<td>17. Traffic noise (decibels, A weighted)</td>
<td>73</td>
<td>72</td>
<td>70</td>
</tr>
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<tbody>
<tr>
<td>18. Utilization rate of industrial solid waste (%)</td>
<td>45</td>
<td>51</td>
<td>61.6</td>
</tr>
<tr>
<td>19. Treatment and disposal rate of industrial solid waste (%)</td>
<td>90</td>
<td>91</td>
<td>98.9</td>
</tr>
<tr>
<td>20. Disposal rate of domestic garbage (%)</td>
<td>20.95</td>
<td>31.83</td>
<td>51.92</td>
</tr>
</tbody>
</table>
2.76 The second type of responsibility system that applies specifically to enterprises is probably the more effective at present for a limited number of state enterprises, and is certainly more direct. This is the requirement that enterprises meet environmental emissions standards as a precondition to being considered for "level II or level I" economic status in the context of the overarching economic responsibility or contract system, which regulates an enterprise's overall economic affairs. Attainment of these levels is very important to the enterprise because it obtains greater autonomy from the central government--control over its own foreign exchange, more discretion over the fate of accumulated profits, tax breaks, increased status of managers, etc.

2.77 A principal problem with both types of responsibility systems is their voluntary nature. The size of the financial incentive may be too small to induce investments to reduce pollution. More important, greater reductions in emissions may be needed (depending on contract terms) to obtain the benefits of the system. There do not appear to be any rewards for minor improvements. An apparent strength, however, is the practice of conferring bonuses on individuals and environmental control "units." This is the appropriate level for targeting operating and maintenance incentives. However, low-cost options, such as improved operation and maintenance, may reduce emissions too little for any one enterprise to encourage it to meet the environmental preconditions for consideration as a level II enterprise. Also, within the same enterprise, the units eligible for the bonus may have little incentive to find other low-cost means of meeting their contract goals unless the same units also are held responsible for the costs of their polluting activities.

2.78 More broadly, a major concern is that unless enterprises are operating with cost accountability, the incentives for reducing pollution to meet goals will not extend to doing so at the lowest possible cost.

Pricing Policies

2.79 Low (administered) prices for raw materials, such as coal and water, are key macroeconomic policies that have major environmental implications. As an unintended consequence of these pricing policies, technologies are encouraged that require "too much" of these resources, and operation and maintenance practices that waste them, thus adding to the pollution burden. In the long run, both revenues and profits suffer. In the coal production industry, some of the consequences of controlled, low pricing have been a shortage of investment funds for washing coal and lack of incentives for the highest quality coal to be sold for its highest-valued end uses, such as cooking fuel in urban households.39/

2.80 Due largely (but not entirely) to low energy prices, in 1988 China's ratio of energy consumption to gross domestic product was twice as high as that for OECD countries, despite a 50 percent improvement over the preceding ten years. In an attempt to gradually decontrol coal prices, the Government established what was to be a transitory two-tier price system. However, because it has been difficult to eliminate administered prices, the two-tier

system continues in place and has led to many new inefficiencies rather than eliminating them.40/

2.81 In the two-tier system, at least half of the coal is sold at low government-mandated prices, below estimated long-run marginal costs of mining. The rest of the supply is sold at negotiated prices, which in coal-deficit East China can be higher than world market prices. The dual market creates various distortions. In the allocated market, good-quality coal (low ash, high calorific value) is sometimes sold at a lower price than that for poorer quality coal in the free market. Consumers use whatever fuel they can get at allocated prices, regardless of quality or suitability, and consumers in the allocated market, such as the household sector, can be neglected because there is an incentive for suppliers to sell what they can at the higher free-market prices. For example, good-quality and less-polluting anthracite needed in the household sector is going to industrial users (ammonia and cement producers) paying higher prices. There have been recent indications, however, that increases in coal prices are planned, and in some coastal counties there is even now little difference in administered and market prices for coal.

2.82 A further example of well-intended pricing policy working against better energy use and environmental mitigation is the low level of gas prices in the household sector. Low gas prices are discouraging investments to supply available natural gas and other sources of gas with medium calorific value (such as coke oven gas, gas generated in steel plants, and coal-bed methane gas). Suppliers cannot afford to make the necessary investments if prices are below costs. Yet, town gas is much more environmentally benign than directly burning coal for household use.

2.83 Water use and, therefore, water pollution, is affected by pricing policy. Many of China’s industries are water intensive and must compete for their supplies against extensive agricultural and equally intensive municipal uses. Competition for water is not decided through market mechanisms or price, but through licensing and planned allocation. Water supplies in China are a public good, but available quantities are often unpredictable and require significant capital investments in storage, distribution and treatment to normalize them, particularly in the water-scarce North China Plain. Raw water is taken from surface water or underground sources (groundwater) at little or no charge by single users such as large industries or power stations, or by intermediate supply agencies such as water companies or irrigation districts. The Minister of Water Resources believes that current water prices are too low to provide incentives to stimulate agricultural or industrial users to design and use improved water-saving technologies.

2.84 Despite a preponderance of demand from industry, urban supplies of treated water are typically subsidized because tariff levels are long outdated. Although they are structured progressively, tariffs do not generally provide for adequate recovery of operating costs, let alone long-run marginal costs. Not surprisingly, it is difficult to raise funds for investment and maintenance, although rationing is common in water-short areas as an administrative measure to restrict industrial use of water. Metering of individual

40/ Ibid.
connections is rare and leakage losses are high despite controls and campaigns. Even where metering is practical, the price is so low that there is no incentive for the consumer to conserve water. Groundwater is mined without adequate controls and damaging land subsidence sometimes follows. Relatively unrestricted use by upstream industrial and household users generates high levels of pollution, which impose significant costs on downstream users, for example, in the form of crop losses caused by toxic wastes in irrigation supplies and special treatment costs to produce potable water. As the community's standard of living improves, there will be an ever-increasing pressure on the water supply system and an even greater need to introduce pricing policies that reflect long-run marginal costs and that encourage conservation by all water users.

Policies for Reforming Enterprise Management

2.85 Central planning in China has been largely viewed by the Bank as having given enterprises and producers very little incentive to make economical use of raw materials or to develop and adopt more efficient technologies. Production increases are obtained by mobilizing additional labor and other resources, rather than by raising efficiency. This policy has particularly deleterious consequences for environmental quality because natural resources and raw materials are underpriced, encouraging wasteful consumption patterns, while discouraging resource renewal. For example, retail prices for timber were held constant from 1955 to 1972, despite severe shortages. Similar problems have affected water, coal and other resources, while inefficiency has been estimated to be responsible for 30 percent or more of all pollution.

2.86 While economic liberalization during the 1980s has clearly aggravated some problems because entire sectors of the economy have boomed without due consideration for external effects (e.g., rural small-scale industrialization), the economic reforms of that period have generally provided enterprises with an incentive to become more efficient, because instead of remitting profits to their parent bureaucracies, the enterprises are allowed to retain a larger share, with the aim of introducing independent accounting and individual responsibility for profits and losses. This should make enterprises more inclined to economize on the consumption of raw materials, which they usually have to purchase at market prices, and to find productive uses for their waste products.

2.87 From an institutional point of view, if enterprises are allowed to operate more independently, or at least are freed from control by the parent ministry and/or local government, they become partially detached from the protective, bureaucratic networks organized around them. It is hoped that this would increase the ability of the environmental protection bureaus to enforce environmental regulations and to coordinate environmental policy. However, this potential has not yet been fully exploited in relation to the TVIEs, which already are operating under the new regime.

2.88 State enterprises in China, however, rarely go out of business and are not fully accountable for profits and losses. At the same time, public ownership of major economic activities is still widely regarded as appropriate. Enterprise reform has proceeded by trying to increase accountability in the public ownership context. The more important reforms include: taxing profits instead of having the government retain them; separating ownership
from management using the responsibility system; various steps to increase enterprise autonomy; establishing a new bankruptcy law; expanding direct foreign trading rights; and other foreign exchange reforms.41/

2.89 Unfortunately, these reforms have not been extensive enough and, therefore, have had only a limited effect on improving enterprise performance. Economic incentives for pollution control require some degree of cost accountability and hard budget constraints if they are to deliver environmental improvements at low cost. In those cases where the most cost-effective solution is to close down a polluting enterprise, additional problems arise because state enterprises in China are the principal source of housing and social security services to their employees, and until reforms in these two areas are undertaken which separate these services from the enterprises, it will be very difficult to close down heavily polluting industries.

Industrial Structure and Energy Efficiency

2.90 The implications of China's current industrial development pattern for the environmental problems of water, air, and land pollution also need to be addressed; namely, tendencies toward resource-intensive processes, low energy efficiency and massive reliance on coal (see also para. 2.116). The average energy intensity of China's industrial sector has dropped, but there are indications that it remains higher than the intensity of most developing and developed nations.

2.91 As shown in Table 2.5, China's primary commercial energy consumption per unit of GDP is exceptionally high in comparison with other major countries. Cross-country comparisons of energy use per unit GDP can provide only a rough picture of relative energy intensities, due to problems arising from differences in statistical methods and conversion to comparable output value units at official exchange rates. They also cannot be used alone to measure the actual potential for energy conservation. However, they are useful as overall macroeconomic indicators, particularly because they can provide an aggregate picture of differences in energy demand caused by differences in economic structure. The magnitude of the difference in energy use per unit GDP between China and most other major countries points to a series of overlapping factors, which are both structural and technical.

2.92 One set of structural factors contributing to China's high energy intensity relative to GDP is its rather unique position as a low-income developing country with a very large industrial sector. As with other low-income countries, household energy use per unit GDP is substantially higher than in more developed countries. This is because per capita cooking requirements are of a similar order of magnitude, but per capita GDP is much lower. As development proceeds, household energy use per unit GDP falls because household energy use tends to grow slower than GDP over the long term. Unlike other low-income countries, however, the share of industry in China's GDP is among the highest in the world, at about 46 percent. Industry is dramatically more energy intensive than agriculture or services.

Table 2.5: INTERNATIONAL COMPARISONS OF PRIMARY COMMERCIAL ENERGY CONSUMPTION RELATIVE TO GDP, 1980-88
(kg of oil equivalent/1980 US$)

<table>
<thead>
<tr>
<th></th>
<th>1980</th>
<th>1988</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Developing Countries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>1.44</td>
<td>1.03</td>
</tr>
<tr>
<td>India (1980, 1987)</td>
<td>0.74</td>
<td>0.76</td>
</tr>
<tr>
<td>Korea, Republic of</td>
<td>0.74</td>
<td>0.59</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.43</td>
<td>0.41</td>
</tr>
<tr>
<td><strong>Developed Countries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>0.97</td>
<td>0.76</td>
</tr>
<tr>
<td>France</td>
<td>0.32</td>
<td>0.28</td>
</tr>
<tr>
<td>Germany</td>
<td>0.32</td>
<td>0.29</td>
</tr>
<tr>
<td>Japan</td>
<td>0.35</td>
<td>0.28</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.40</td>
<td>0.32</td>
</tr>
<tr>
<td>United States</td>
<td>0.73</td>
<td>0.57</td>
</tr>
</tbody>
</table>


2.93 Another set of structural factors, which may be more influenced by macroeconomic policies, includes the structure of Chinese industry. Particularly within individual subsectors (machine building, chemicals, etc.), Chinese industrial output appears more dominated by basic goods, which are relatively energy-intensive, than industrial output in more developed countries. Chinese industry does not appear to have the depth in creation of value added that characterizes the more mature industrial sectors of industrialized countries. Insufficient plant-level economies of scale, arising from the establishment of numerous small-scale plants to produce certain key heavy industrial commodities, also contributes to high energy intensities in industry.

2.94 Technical and physical factors include both use of energy-inefficient technologies and poor energy management practices. The relative inefficiency of China's current stock of coal-fired boilers is well known, as is China's relatively high energy consumption rates per ton of output for most key industrial commodities. Sources of the problem, however, are numerous, ranging from inadequate incentives (through deficiencies in pricing and enterprises accountability), to inadequate access to technology, to shortages of investment funds.

2.95 Structural factors clearly played an important role in the energy intensity reductions of the 1980s, especially during the early years. How-
ever, statistics on energy use per physical unit of output also generally show marked improvements in technical efficiencies. The shift in government policy from ignoring energy efficiency to active promotion of energy conservation has made a difference. Some of the direct measures to promote energy conservation have included administrative measures (such as tightening enterprise energy consumption quotas, and systems for levying energy use fines and bonuses), the creation of an institutional network to monitor adherence to energy use standards and provide technical support for conservation, and targeting specific investment funds for energy conservation projects. Improvements are definitely required, however. They include greater reliance on and a strengthening of nonadministrative, more systemic, measures to increase incentives for greater energy efficiency (see paras. 2.119-2.122).

2.96 In regard to fuel diversification, at present China does not have large scope for substituting cleaner fuels for coal in either industrial or residential applications, although there are still some resources (natural and coal-based gas) which are not being fully exploited because of low prices and insufficient capital commitments.

2.97 Opportunities to use natural gas could improve energy efficiency in a number of uses and reduce the environmental impact as well. However, it currently represents only 2 percent of commercial energy consumption. Natural gas production in 1988 was 14.3 billion m$^3$, of which about 9 billion m$^3$ were sold commercially; the rest was used in oil fields or flared. Production in 1989 increased only by 1 percent, to 14.5 billion m$^3$. Gas "resources" are estimated by Chinese authorities to be 33 trillion m$^3$, but only 2.6 percent is proven. In addition to underexploration in the petroleum sector generally, the state petroleum companies have not invested sufficiently in confirmation and development of gas resources because they are most interested in oil production. Low producer gas prices offer little incentive at the enterprise level to expand investments to find and use natural gas, despite central government calls to do so.

2.98 Though rich in hydro potential, China has harnessed less than 5 percent, primarily because most of the remaining resources are located in the southwest, some 1,500 km or more away from main demand centers. Hydro represents an important regional source of electric power, particularly to meet the needs of Sichuan Province, where 27 percent of the country's total hydro potential is located. Hydropower development involves large capital requirements and long construction periods, however. Thermal power investments are often easier to make because of lower capital costs and shorter lead times. Nevertheless, there are a number of hydro sites in Central-South China which are more economic and environmentally benign than alternative thermal power investments. Development of these sites takes priority in power investment plans for Sichuan, Yunnan and Guizhou, but substantial funding must be secured. East China, though, will continue to find it necessary to rely on thermal power to meet growing electricity demand.

2.99 Firewood and crop stalks account for about 57 percent of the rural energy supply; about 70 percent of all fuelwood is used for cooking. The

extent of use has caused serious deforestation (see Chapters III and IV). As the standard of living improves in rural areas, a growing number of rural households are switching to coal. Geothermal energy has been found in a number of locations, though most of it is undeveloped; a plant in Tibet supplies about 20 percent of Lhasa's electricity consumption. Over the next 5-10 years, there will be opportunities to invest in alternative sources of energy--solar and wind technologies and possibly biomass gasification. The costs of these technologies are declining with developmental learning. They hold promise for application in particular regions of the country. Known uranium reserves in China are sufficient to sustain about 15,000 MW of nuclear power capacity for 30 years. The government plans to commission a few plants over the next 10 years. As in other countries, the problems of safety and waste disposal remain concerns in nuclear power development; this is an area which merits further study, including the relationship between the National Nuclear Safety Administration and NEPA.

**Allocation Policies for Investment**

2.100 The administrative nature of the planning and investment allocation processes continues to emphasize supply targets rather than efficiency, market responsiveness, profitability, quality and innovation. Annual budgetary negotiations create a bias toward minimizing capital costs without considering operating savings; this tends to discourage upgrading of investments or acquiring more efficient technologies. This cumbersome state investment approval process encourages enterprises and local governments to invest in smaller, less efficient plants that do not require either clearance or a financial contribution by the central government.

**Credit Markets**

2.101 State control of credit markets, in both the criteria used to allocate funds and the interest rate charged for loans, has restricted the development of credit markets and resulted in the rationing of financial capital. This, and the aforementioned cumbersome state approval process and tendencies toward provincial self-sufficiency have resulted in a bias against incurring the high front-end costs of investment projects. This has led enterprises to forgo the benefits of economies of scale as well as the benefits of more efficient processes and equipment, and to favor less costly investments, which are also less efficient and produce much higher pollution loads. In addition, investments in waste treatment favor use of less efficient pollution control approaches. Without doubt, this bias also has worked against the government's policy of fostering the centralization of small enterprises and waste treatment facilities. The TVIEs face even greater constraints in securing funds from the credit markets, further adding to their inefficiency.

**Urban Management and Finance Reform Policies**

2.102 Doubts have been raised about the present and future efficiency of the provision of public goods in Chinese cities. In many cities, the basic infrastructure in the areas of transportation, sanitation, water supply, safety, energy provision (including space heating), health, education and environment, etc. is still deficient, given past neglect. In addition, the population and output of many cities appear to be growing rapidly. If urban
public services are not provided at a rate that is higher than that of population and output growth, the potential economic and social benefits of urbanization will be diminished greatly.

2.103 While city budgets, as well as their economic development plans, are (in principle at least) components of a unified national budget or plan, in practice, cities do have a degree of "official" autonomy, particularly in matters of expenditures. In fact, for reasons explained below, the degree of autonomy is even greater than it appears to be. There are numerous overlaps of responsibility in the system that has evolved since reforms were instituted in 1978. These overlaps occur between counties, municipalities, provinces and the central government. This leaves a great deal of room for negotiations and improvisations between and at each level of authority. Some of the features which are adversely affecting the cities' capability and capacity for efficient and timely delivery of public goods and services, and especially measures to protect the environment, include: (a) the existing tax system, (b) constraints on city borrowing, and (c) dispersed budgetary and accounting procedures and responsibilities.

**Tax System**

2.104 The tax system was introduced in 1978 and is still evolving. Unlike most Western economies, which are based on national tax administration and redistribution systems, the Chinese system is a "sharing tax system," operated by a local tax administration. However, the base and tax rates are set by the central government. A significant part of the shared taxes is sent by the municipality back to the province, which in turn transfers a share of these funds to the central government. A similar system operates in relation to foreign exchange earnings. At each transfer, a certain "retention ratio" is assessed according to a complex formula, which is constantly being renegotiated and, therefore, is constantly changing. Retention ratios vary considerably according to the economic conditions and perceived needs of the city. For example: Shanghai (1987) retains 23 percent, Changzhou (1986) 12 percent, Luoyang (1986) 54 percent, and Shashi (1986) 23 percent. The trend in the division of budgetary revenue between the center and localities over the past decade shows that the center's share has increased, despite the emphasis on decentralizing fiscal responsibility (the center's share in 1979 was 14.3 percent; by 1988 its share had increased to 36.4 percent). However, this ratio seems to have stabilized and may have been partially offset in aggregate terms by an increase over the same period in extrabudgetary revenues which are controlled primarily at local levels.43/ In recent years, renegotiations have resulted in higher retention rates at the local level, which would imply a further decentralization of the system. However, for those cities with low retention ratios, there is little incentive to collect taxes and maximum incentive to grant tax concessions to municipal enterprises (usually to the least efficient) just to shelter taxes. While tax reform has brought some improvements, continued distortions in the tax revenue system make it diffi-

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cult for cities to plan and implement long-term measures to provide public services, in particular pollution control. Moreover, this system of taxation precludes substantial transfers from the central government to municipalities for needed urban public services and environmental protection investments, as has been done in a number of developed countries.

Borrowings

2.105 Cities (and provinces) in China are in principle not allowed to borrow. However, "their" enterprises can borrow, and do. They borrow for the production of private goods, which is quite normal. However, they also borrow for the production of nonsellable, nonprofitable "public" goods. In order to help these enterprises repay such loans, the city will give them various tax concessions, subsidies, or preferential productive investment opportunities. Without such constraints on borrowing and the fragmentation of responsibility among various levels of government, it is difficult for city managers to allocate the very scarce resources available in the most efficient manner. Very few, if any, public investment decisions are made on the basis of sound economic, least-cost analysis. This particularly affects large-scale investments such as central wastewater treatment systems and central heating systems, etc., which are especially cost-effective in reducing water and air pollution.

Budgetary and Accounting Procedures

2.106 There are no unitary budgeting or accounting procedures for consolidation in Chinese cities. The "budget" of a municipality shows the taxes raised and the expenditures incurred by the Municipal Finance Bureau. However, it ignores a multitude of extrabudgetary funds controlled by other bureaus of the same municipality. Each of these bureaus has its own set of taxes and charges (not always known to the Finance Bureau), and undertakes expenditures independent of the municipal budget. In addition, a number of functions such as health, welfare, education and housing, etc., are performed by enterprises and do not appear in any municipal account. Budgeting, planning and accounting for municipal goods and services is, therefore, even more complex than necessary and introduces further inefficiencies into the system, constraining improvements in urban environmental management.

2.107 Reinforced by the administrative and taxing structure, the provinces and even municipalities often act like a network of subeconomies, preserving their self-sufficiency by inhibiting the flow of commodities and capital to other provinces and municipalities. This slows the development of larger, more efficient markets that would allow more firms to capitalize on the size of the country. This self-sufficiency also has a negative impact on some of the investments that would improve pollution control.

Future Plans

2.108 The general policies for addressing China's environmental problems are contained in the recently approved Eighth Five-Year Plan. While the detailed work programs and plans of the sector ministries were not completed when this report was being prepared, interviews with NEPA and several of the national-level ministries during the preparation stage of the Eighth Five-Year Plan indicate the directions to be taken insofar as environmental protection
is concerned (see Annex 5 for a summary of the environmental management objectives of some sector ministries). One important new development is the incorporation, for the first time, of environmental protection targets in the 1992 national economic and social plan for 30 provinces and 14 cities (e.g., daily and annual average value for atmospheric total suspended particulates and sulfur dioxides; a target rate of quality for drinking water sources; disposal, treatment and reuse rates for industrial wastes). This process also involved a working conference on environmental planning to specify pollution treatment projects and strengthen monitoring and management of serious pollution sources. It was cosponsored by the State Planning Commission (SPC) and NEPA, with participants from local planning commissions and environmental protection bureaus.

2.109 China plans to increase spending on pollution control during the next five-year economic plan period (combined central and local governments and industry) from Y 45 billion in the Seventh Five-Year Plan (0.67 percent of GNP) to Y 83 billion (0.85 percent of projected GNP) in the Eighth Five-Year Plan. It has been previously estimated by NEPA that China would need to allocate an amount equivalent to 1.5 percent of GNP just to control the current pollution. The focus of NEPA's efforts during the next five years is on:

(a) strengthening the water pollution permit system;
(b) increasing levies;
(c) improving implementation of the levy system, especially in regard to TVIEs;
(d) supporting urban and regional environmental planning;
(e) disseminating environmental planning models;
(f) improving regionalization of EIAs and associated management guidelines;
(g) updating air emissions standards, and adding noise and odor standards;
(h) obtaining better monitoring equipment and computerizing the system; and
(i) setting solid and hazardous waste standards and regulations.

2.110 The most important generalization that can be made about the ministries' environmental protection plans is that they do not apparently have a

44/ This estimate, as well as cross-country comparisons of environmental expenditures, should be taken with more than a few grains of salt. For one thing, they depend on the definition of environmental expenditure, which varies considerably. For another, accurate estimates of environmental expenditures are not available in most cases.
coordinated focus. According to the State Planning Commission, there is no overall environmental investment target, although the environment does have a higher priority in the new plan. Previous attempts to meet such targets, for example, in construction of sewage treatment plants, have not been successful. With each ministry establishing its own priorities, plans are not necessarily compatible with those of other ministries. This might suggest that greater emphasis on subnational (i.e., provincial and municipal) levels of coordination in environmental management, especially in least-cost investment planning, is necessary (see paras. 2.147-2.148).

D. Suggested Strategies for Improved Pollution Control

2.111 China's leadership recognizes that much more will need to be done to significantly improve the environment, and that a "lack of money" will probably slow further progress on pollution control for at least a decade. The real issue, therefore, is how to make the funds that are available be productive; how to allocate the money cost-effectively to priority problems; and how to improve environmental policy, the economic system and government bureaucracy to maximize pollution prevention and control efforts. Most important, China needs to consider the reorientation of its industrial sector away from basic heavy industry, which is technologically outdated and highly polluting, toward more economically dynamic and less polluting manufacturing and service sectors (see paras. 2.116-2.118).

2.112 China has developed an extensive legal and institutional framework for pollution control. However, much remains to be done in environmental management, particularly at the regional and local level. For the reasons given in the preceding sections and summarized below, it is now opportune to reevaluate and redirect strategies to address environmental problems in a more timely and cost-effective manner.

- The country is entering a phase of increasing marginal cost for pollution control in all environmental media.
- There is a need to systematically and comprehensively exploit low-cost pollution control options for all environmental media.
- The least-cost strategies for environmental management will include larger system-wide investments than previously, which can best be exploited through long-term strategic planning and optimal phasing of investments for all environmental media.
- China is now going through a transition phase in enterprise and fiscal reform and, therefore, needs to adjust its environmental strategies to be responsive to these reforms, in order to achieve the desired efficiency and other objectives.
- There is a need to address a broader array of environmental issues, which will add to the financial burden.
- There is a need to mobilize increased funds for pollution control just to maintain the status quo.
• Clearer objectives and priorities need to be set for pollution control at all levels of government.

• Finally, there is a need for improved coordination and cooperation across sectors and between levels of government, with more clearly defined responsibilities.

2.113 These issues are addressed below within the context of the fundamental changes occurring during this transitional phase of enterprise and fiscal reform, and the need to carefully phase adjustments in pollution control strategy to anticipate these changes. The adjustments in pollution control strategy are discussed under six headings:

(a) economic structure and environmental impact;

(b) improving the design of incentives for pollution control;

(c) increasing the availability of investment funds for pollution control;

(d) improving regulatory and administrative instruments for pollution control;

(e) improving institutional arrangements for pollution control; and

(f) suggested policy and technical options for coal, water, and TVIEs.

2.114 The following section contains a number of recommendations covering a wide range of environmental problems and pollution control strategies that this chapter has described. Of these, five are recommended for priority attention by the Government:

(a) a reorientation in China's industrial sector away from heavy industry, toward more economically dynamic, as well as less polluting, manufacturing and service sectors (see paras. 2.116-2.118);

(b) an early phasing in of key enterprise and price reforms to complement the expansion of economic policy instruments for pollution control (e.g., pollution levy) aimed primarily at reducing the inefficient and uneconomic industries that consume large quantities of materials and energy and that are the main source of heavy pollution (paras. 2.115 and 2.130-2.131), and fiscal reforms to provide provinces and municipalities, which are responsible for preparing long-range environmental master plans and investment programs, with more revenue for financing infrastructure investments in pollution control (paras. 2.130-2.135);

(c) increases in the pollution levy in stages over a period of years and improvements in the administration of the pollution levy fund to make more funds available for investments in waste minimization technology and combined wastewater treatment facilities (paras. 2.123-2.126, 2.133-2.135);
(d) establishment of subcommissions under the SEPC with the task of reviewing the sectoral policies of other environmentally important ministries and improving coordination between the NEPA network and the sector ministries in setting major environmental targets and policies ( paras. 2.151-2.154); and

(e) development of long-range environmental master plans at the local level that focus on least-cost alternatives for water, air, and solid and liquid waste management (including hazardous and toxic wastes) ( paras. 2.147-2.148). Most pollution problems are most effectively tackled at the local level (municipal and regional) because individual sources of pollutants and, therefore, appropriate solutions, will vary.

2.115 In general, until price and enterprise reforms are more extensively undertaken, neither pollution fees or fines, nor administrative regulations, are likely to carry sufficient force to improve energy use, treatment of industrial wastes and emissions, industrial efficiency, or conservation of natural resources. International experience indicates that both command-and-control regulatory measures and economic incentives are necessary for effective environmental management. The balance between these two broad types of policy measures and the macroeconomic links to environmental management are areas which need increased focus in China. The mix of policies and measures also will need to be periodically reviewed in light of the changing structure of the economic system. For instance, the responsibility systems may be less appropriate or effective as the economy becomes more decentralized; pollution levies and fees may then become a more important instrument of environmental management. In the meantime, during this period of economic transformation, indirect fiscal intervention may be especially useful for environmental policy; for example, taxation of polluting agricultural or industrial inputs or outputs.

Economic Structure and Environmental Impact

2.116 The implications of China's current and future industrial structure for the environmental problems of water, air and land pollution need to be addressed more explicitly; namely, tendencies toward material-intensive industries and production processes, and low energy efficiency (see paras. 2.90-2.95). The impact of explosive industrial growth over the past decade has been exacerbated by the fact that China has continued to pursue an industrial strategy that emphasizes sectors that are the worst polluters. While China has reduced its reliance on heavy industry as an engine of economic growth during the past decade, heavy industry (e.g., cement, steel and machinery) today still accounts for more than half of the country's industrial output and the industrial sector overall accounts for about 46 percent of GDP. Both figures are high compared with most other developing and developed countries (with the exception of the countries of Eastern Europe). Improved energy production and efficient coal use should be one of China's chief future energy objectives and a major means of reducing atmospheric and land pollution. The

The highly water-intensive nature of China's often outdated industrial processes is a major factor contributing to water shortages and pollution in most of the industrialized provinces. There is convincing evidence, from both industrialized and other developing countries, that technological and structural improvements in the industrial sector of the economy result in fewer input resources consumed per unit of output, as well as reduced production costs and waste loads. Therefore, while continued enforcement of emission standards, and pollution levies and fines are indispensable elements of China's environmental policy, increasing attention should be given to structural and technological changes in the industrial sector and the economic policies needed to encourage these changes, in order to obtain environmental benefits at least cost to the economy. Otherwise, pollution from the industrial sector will threaten to swamp China's recent achievements in environmental policies and programs.

2.117 The effects of industrial structure can be seen in a recent cross-country study of 31 Eastern and Western industrialized countries, which analyzed economic structures and environmental impacts. Using a set of four indicators (energy consumption, steel consumption, cement consumption and weight of freight transport) as a general indicator of the volume of production, the authors found in most of the countries over the period 1973-85 (most notable exceptions were the Soviet Union and Eastern European countries) a significant separation of economic growth from material-intensive production processes. These changes were primarily the result of a shift to a more service-oriented economy, not the result of changes within the heavy industry sector (i.e., intersectoral change). However, the study also points out that important additional benefits were achieved from using input resources more efficiently and reducing dependence on resources that were either scarce or that produced adverse environmental effects, which save resources and probably lower production costs. It also reduces pollution and environmental costs across the board during the production process, eliminating or reducing the need for expensive and limited end-of-pipe controls. Such an approach is more efficient and effective than treating pollutants at the end of the process. The study also cites cases in which the effectiveness of structural policy can be demonstrated for individual types of pollution. Structural changes in energy consumption in several industrialized countries have had greater positive environmental effects than end-of-pipe protection measures, especially for such critical emissions as $SO_2$ and $NO_x$. The authors of the study also point out that the 1985 OECD report on the state of the environment reflects this fact for several countries; for example, in the United States, France, and the United Kingdom, energy conservation has led to greater environmental protection than the installation of desulfurization plants. In Japan, where remedial environmental protection measures had significant effects during the 1970s, energy conservation was similarly successful. In this case, they conclude that remedial environmental protection has been supplanted by technological and structural change. Another example suggests that

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data from the Japanese Environmental Agency show that the effects of technological and structural change in water use were equivalent to those of end-of-pipe purification equipment.

2.118 The authors also suggest that their analysis supports the full-scale introduction of resource taxes (which China is experimenting with in several locations, see paras. 2.127-2.128) and effluent charges, policies which would have economic as well as environmental advantages. In this regard, the economic advantages of a reorientation in China's industrial structure were analyzed in the World Bank's most recent economic report:48/

"Through a combination of a more neutral policy regime and guidance by market signals, China might shift the emphasis away from expansion (as distinct from the technological upgrading) of heavy machinery, metallurgical and traditional engineering industries towards manufacturing sectors richer in linkages as well as in technological possibilities, for example, transport and electronics. Service industries might also receive more attention because they contribute importantly to overall growth, employment and industrial productivity."

Thus, for the future, both economic growth and environmental improvement call for new thinking about industrial policy in China.

Energy Efficiency and Conservation

2.119 China's energy conservation policies during the 1980s have tended to promote improved energy management and technical renovation projects through a combination of administrative pressure on enterprises and targeted, in-plan investments. The successful realization of the Government's goals for the 1990s and beyond, however, is likely to require a wider approach, including greater attention to the role of indirect policy tools.

2.120 Some of the types of macroeconomic and structural policies that are expected to play an important role in shaping energy demand trends in the future include policies affecting relative sector growth (especially between industry and services) and trade, the degree of emphasis on local self-reliance and other policies affecting the development of township and village industries, and strategies for acquiring and disseminating technologies. Clearly, energy efficiency is but one concern among many in determining these policies and some measures to improve energy efficiency can at times run counter to overall economic efficiency. It is important, however, for the government to carefully analyze policies and economic incentives and disincentives that will have a particularly strong bearing on the development of energy efficiency.

2.121 For the more narrowly focused energy conservation policies, a key issue is how to achieve the best blend of promotion techniques and institutional elements already in place with more indirect measures built upon the

growing importance of the market. Market development and price and enterprise reforms will strengthen and help rationalize the framework of enterprise incentives for efficient use of energy. Accordingly, however, the strength and usefulness of many of the administrative measures which have been heavily relied on to date will greatly diminish. Although they will be important in the 1990s, the issues and options surrounding these adjustments in China's conservation policies do not appear to have been given adequate attention in the Chinese energy conservation community recently.

2.122 A final set of policy-related issues concerns setting strategic priorities for energy conservation. Typically, priorities are being established on a sectoral or subsectoral basis, with a fairly narrow perspective of the available options. There is a need to review relative priorities across sectors, and to some extent across fuels. There also is a need to review the prospective roles of different generic measures to improve industrial energy efficiency, defined in a broad sense. This includes efforts to (a) increase output (both physical output and/or the value of output) with the same given level of energy input; (b) adopt more efficient process technologies; (c) replace existing inefficient energy-using equipment with new, more modern equipment; and (d) improve the efficiency of the new equipment being produced for domestic use. Finally, in regard to fuel diversification, at present China does not have large scope for substituting cleaner fuels for coal in either industrial or residential applications; however, there are still some resources (natural and coal-based gas) which are not being fully exploited because of low prices and insufficient capital commitments.

Improving the Design of Incentives for Pollution Control

Adjustments to the Pollution Levy System

2.123 The level of the pollution levy should be increased in stages over a period of years to approach the marginal cost of pollution control for each primary pollutant in the various waste streams. Evidence suggests that a higher fee that is part of an improved levy system could significantly reduce pollution by encouraging better maintenance and operating practices, even without investments in new pollution control equipment. For example, officials in the Ministry of Chemical Industry estimate that pollution reductions of 30-40 percent could be obtained from improved operation and maintenance.49/ The Ministry of Light Industry estimates that better operation and maintenance could reduce pollution 30 percent, and the Ministry of Textiles estimates a reduction of about 20 percent. These improvements would be achieved at very low cost and would represent, by far, the most cost-effective options available to all enterprises.

2.124 A number of other modifications to the levy system could reduce pollution at a lower cost. The National Environmental Protection Agency has

49/ However, the chemical industry would need an estimated Y 100-million investment in testing, process monitoring, and analysis equipment to be able to deliver this kind of improvement, which is a small amount of investment in relation to the pollution reductions that would be achieved.
already modified and is planning to further modify this system to improve its cost effectiveness. Some modifications already being implemented include converting all effluent and emission standards to a mass basis (instead of concentration), and phasing out grants, which will be replaced with a competitive process to select recipients for loans from the pollution levy fund. In general, the objective of the competitive process is to separate entirely those paying levies from those receiving subsidized loans. The interest rate subsidy for these loans should also be reduced over time to approach the commercial rate. Several pilot projects are being set up to involve banks in administering the levy funds, especially in evaluating the financial qualifications of enterprises applying for such funds. An appraisal scheme has been developed by World Bank industry experts, together with the Beijing municipal government, for the Beijing Branch of the China Investment Bank (CIB) under the proposed Beijing Environmental Project.50/ This scheme could be adapted for more widespread use under the pollution levy fund.

2.125 Theoretical considerations and limited international experience suggest that a number of additional improvements could make the pollution levy system work more efficiently. First, the fees should be paid on all primary pollutants, not just the largest, and the levy should cover all waste streams. Second, until enterprise reform in China progresses further and the "soft" budget constraints become "hard" constraints, the government could require that the fee be paid out of retained profits and not be passed on to consumers as price increases (either as administered prices or above-quota market prices).51/ To reduce the enterprises' opposition to this change in the levy system, the Government could simultaneously raise the percentage of retained profits so as to leave the amount of retained profits unchanged in the first year of the revised levy system. The fee is used to encourage compliance, but

50/ Under the plan agreed upon by the Bank and the municipal government of Beijing, the Municipal Planning Commission and the Beijing Environmental Protection Bureau will screen proposed industrial pollution control projects to ensure that they address the most serious pollution problems facing the city. The Beijing Branch of the China Investment Bank will assist in this evaluation and will carry out a financial analysis to ensure that the enterprise benefiting from the project will remain financially sound after the project is completed. Once the project is under way, the CIB will act as financial agent for the municipal government, collecting and disbursing funds. The basic criterion for evaluating the projects will be cost-effectiveness (i.e., the least-cost method) in meeting environmental standards, based on economic prices and a suggested discount factor of 10 percent. Pollution control approaches would include modification of the manufacturing process, relocation of the plant, end-of-pipe effluent treatment, and total or partial closure of a plant.

51/ Currently, those enterprises that existed before the first environmental law on pollution levies went into effect in 1979 are "grandfathered" to permit the deduction of fees as costs, rather than from retained profits, for tax purposes. For all other enterprises, fees are deducted from retained profits. Fines are deducted from retained profits for all enterprises.
compliance requires abatement costs. While the fee should be taken out of retained profits to encourage enterprises to act, the abatement costs should be taken out of gross profits because abatement costs are a cost of doing business, just like any other cost. Abatement costs (but not fees) should be shared among (a) profits or remittances to the State, (b) retained profits to the enterprise, and (c) increased costs of products. Otherwise, the right signals will not be passed along to the consumers of highly polluting products. The precise allocation of abatement costs among (a), (b), and (c) above is a different matter. In the private sector, it would depend upon competition. In the public sector, allocation formulae would need to be developed (e.g., as they are for public utilities in the United States).

2.126 In the medium to long term, in order to create incentives to do more than simply comply with the standard, the noncompliance penalty could be transformed into a traditional emissions fee system, in which fees are paid on emissions both above and below the standard. Of course, enterprises will strongly oppose this approach because of the large increase in levies that they initially would pay. To reduce such opposition, a grace period could be instituted that would give enterprises several years to reduce emissions and thereby avoid the large increases. This "announcement" feature was built into the German system and resulted in substantial reductions in effluents before the new effluent fee system came into operation (see Annex 4). Another alternative would be to phase in this concept with the adjustment of the levy to a level approaching the marginal cost of pollution control for each constituent in the waste stream.

Indirect Policy Instruments

2.127 Problems with monitoring and enforcement, especially in the case of atmospheric emissions, suggest that indirect policy instruments could be used also to internalize pollution costs. These instruments may carry with them some inefficiency but they are easy to enforce and do not require much monitoring. Such policy instruments include raising taxes on polluting inputs to production processes or on polluting outputs. An example is a tax on the sulfur content of fuels. A more complex variation on this theme for solid wastes is a deposit-refund system (e.g., for glass bottles).

2.128 Sichuan Province is now establishing a regulation to assess fees on the basis of polluting inputs, such as coal used by industry, rather than emissions, in order to ease the enforcement burden while still obtaining reductions in emissions. This tax will provide an incentive to conserve energy, and to use higher quality coal with less sulfur and less ash. While it will provide obvious environmental benefits, it will not provide any incentive to install pollution control equipment or to maintain it. Not only should the tax be assessed on the basis of quantity, but also on the quality of coal in order to increase the demand for better quality coal (i.e., to improve end-use efficiency). It is expected that the Sichuan authorities will

have to continue plant inspections and use monitoring and enforcement in cases where effective pollution control measures are not being implemented.

2.129 An additional question arises about the use of the collected tax, which should be transferred to the pollution levy fund. Some of the funds generated by this tax should be allocated for production of improved quality coal (including screening and washing) and for manufacturing more efficient equipment for energy conversion (e.g., boilers, electric motors, etc.) The results of this experiment should be closely monitored by the Government to determine if it should be applied more widely.

Greater Enterprise Autonomy and Taxation

2.130 An early phasing in of key enterprise and fiscal reforms is essential to complement the expansion of economic policy instruments for pollution control. Important elements of this reform include: making enterprise management accountable for profits and losses, as well as for production targets; allowing them to retain profits; changing to a standardized rule-based taxation system for all types of enterprises, including such incentives as accelerated depreciation for tax deductions for investment in energy efficiency and pollution control; revaluation of assets to allow for inflation, etc. Otherwise, the cost-effective measures which economic incentive instruments promote will not be adopted to any significant extent by the polluting enterprises. Inefficient, uneconomic industries consuming large quantities of materials and energy, and supported by soft allocations from constrained government budgets, will continue to be a drain on the economy and a source of heavy pollution.

2.131 Fiscal reform will have an important impact on some of the economic and financial incentives which would be available for environmental protection. Currently, tax incentives are given to enterprises which use or recycle waste materials as input to their processes or which use waste material as a secondary product which is then sold. However, the most important revenue resource is for township and village-level governments is the township and village enterprise. Therefore, until the fiscal and tax structure of the national, provincial and township-level governments is reformed, the use of fiscal and tax incentives will remain problematic.

2.132 Another reform which would facilitate the management of municipalities and the provision of urban public goods and services, including environmental protection, would be to remove the ownership and management of municipal enterprises that provide private goods and services from the direct control of the municipal authorities. As an interim measure, one or several special holding companies could be created. They would be controlled by the municipality, but distinct from it, and would oversee enterprises the way investment banks do in many countries, leaving the enterprises a fair degree of freedom in their day-to-day management. The main task of the municipality, as in most other countries, would be to provide urban public services, and it would be organized to do this more efficiently.
Increasing the Availability of Investment Funds for Pollution Control

Pollution Levy Fund

2.133 The adjustments needed to manage this fund more effectively and efficiently through the commercial banking system are discussed above. However, it is important to consider the range of activities and priorities for the use of these funds and to build these adjustments into the new approval process. The pollution investment needed in China far exceeds the currently available and anticipated funds, even after the pollution levy is increased, as recommended above.

2.134 Since its inception, the pollution levy fund has focused on financing end-of-pipe technologies, which do not improve process efficiencies and, which in fact, are an additional operational burden and cost to the enterprise. As a result, many such installations are not adequately operated and maintained and are frequently shut down to save operating costs. One survey in China has shown that less than half of such facilities are kept in continuous working order. A shift in the targeted use of the levy funds is urgently needed to focus on such cost-effective pollution control measures as: plant renovation, introduction of low-waste generating technologies, waste minimization, comprehensive waste use, energy efficiency, upgrading of coal quality, production of more efficient energy conversion equipment, etc. Priorities also should be established to focus on the larger polluters in the first instance, as well as on pollution control investments that can collectively address pollution in a number of enterprises (e.g., upgrading coal quality, upgrading the manufacture of boilers to improve combustion efficiency, central combined wastewater treatment facilities, etc.).

2.135 Until economic reforms are operating efficiently, the Government may also find it necessary, as an interim measure, to allocate credit funds, even at market interest rates, to supplement the pollution levy fund. The blend of subsidized pollution levy funds with credit funds at market interest rates would be a sufficient incentive for firms to invest in the cost-effective pollution control measures recommended for support under this scheme.

Funds for Urban Public Services

2.136 There are at least four possible options that would have the most significant impact on the availability of funds for urban public services and pollution-control investments, namely: increasing tax retention rates for local governments, improving local taxation, allowing municipal borrowing, and increasing user fees. Other less significant sources of funds are also discussed. Currently, expenditures by the central government on environmental investments are small in relation to total expenditures for this purpose. It could be argued that another option for solving the problem of funds for pollution-control investments would be to establish a more rational balance between the local share and the national share of revenue for pollution control. Specifically, a larger share could be allocated to the national level, to be redistributed for transboundary problems or other specifically designated environmental purposes. This type of transfer of funds from the central government to provincial and local governments for designated environmental investments, often on a matching basis with local funds, has been done in many
developed countries. However, the current tax system in China, with its bot-
tom-up, local-to-central government retention scheme, precludes any substan-
tial funds remaining at the central level for major transfers or redistribu-
tion back to the provincial and local governments for designated environmental
protection investments (see para. 2.104).

2.137 In dense urban areas, such as China, it is often the case that the
most cost-effective way to deal with urban and industrial pollution problems
is through large-scale investments in consumer public service facilities such as:
interceptor sewers and combined municipal and industrial sewage treatment
plants, district heating schemes, gas supply networks, etc. While it would be
appropriate to use some of the pollution levy funds for these purposes, the
amount available is small in relation to the large investments needed. For
rural communities, investment in safe drinking water supplies may be the first
priority.

2.138 In order to make such investments, local authorities require a sta-
ble revenue base, not one that is frequently subject to negotiation and
change, as in the current arrangement for tax sharing. One step that would
overcome this uncertainty would be to develop automatic formulas for calculat-
ing tax retention rates that are based on identified needs and availability of
resources, not negotiated on an ad hoc basis. Those cities with a greater
need for public service investments and operation and maintenance funds to
maintain them would be assessed on the basis of this requirement.

2.139 Cities should also be given the flexibility and freedom to raise
local taxes as in other countries, either through rate adjustments or through
new untapped tax bases. Rate-setting gives local officials the possibility of
making real choices: either higher taxes, together with higher levels of
urban public services, or lower taxes associated with lower levels of public
services. Having to make such choices increases their awareness and account-
ability as well as efficiency, because local officials are usually more aware
of the most appropriate investments for their city than are higher levels of
government. Local taxes could also be established on capital, on labor, and
on land. Such taxes would not only raise local revenues, but would also pro-
vide an incentive for more efficient use of production factors and encourage
productivity increases.

2.140 All of the urban public service investments for least-cost pollution
control require large-scale, long-lasting infrastructures. There is no reason
why they should be financed out of current income, or out of accumulated sav-
lings. They are, on the contrary, natural targets for long-term borrowing.
Since such a facility is not available to cities in China, a program needs to
be initiated that will cover this gap. At the same time, municipal accounts
and procedures need to be standardized and made transparent. Long-term bor-
rowing conditions should require development of long-term, least-cost, master
plans for urban pollution control as a precondition for phasing investments
and developing investment schedules.

2.141 User fees for public services are set too low in China and result in
overuse: good examples are water and sewer charges, and district heat and
gas. There are, therefore, considerable opportunities to conserve scarce
resources, reduce pollution and increase local revenues through increases in the user fees.

2.142 Other sources of funds which cities could more effectively tap to support pollution control investments include: the 7 percent setaside for pollution control in new investment projects (although this setaside needs to be reviewed in light of the need to identify the most cost-effective investments, which often involve more than end-of-pipe treatment); and provision for allocation of funds or "funds in kind" from the sale of land-use rights in inner city areas to relocate and renovate polluting enterprises, etc.

2.143 A number of the urban fiscal reforms discussed above should be tested in a comprehensive way in one or more cities, as a model for other cities in China. Such an opportunity may be provided in Changzhou during the preparation of the World Bank-supported Southern Jiangsu Environment Project; this would be an ideal mechanism for developing and implementing a comprehensive approach to urban environmental management and financing. In addition, one of the principal recommendations in Chapter V for follow-up environmental sector studies by the World Bank is a study of urban and provincial environmental management that would focus on urbanization trends in China and the environmental implications, and would include a more in-depth examination of the issues and recommendations discussed above (paras. 5.5 and 5.13).

Improving Regulatory and Administrative Instruments for Pollution Control

2.144 The environmental and economic responsibility systems were devised as a "stopgap" measure during the transitional phase of enterprise and fiscal reform, in an attempt to improve the performance of enterprises and local governments in these two critical areas. They have achieved some results and will continue to be used until the major elements of the reforms are in place. A major deficiency in the current system is that there is no link between attainment of objectives and efficiency in regard to pollution control. Some suggested improvements at the enterprise level could include:

(a) tying the reward to performance on reducing emissions, not to construction of projects, and increasing the reward for better performance;

(b) specifying that the unit receiving the reward will be the unit incurring the abatement or prevention cost (to internalize any external costs to the enterprise within the unit); and

(c) introducing rewards for low-cost attainment of contract goals (by establishing target costs and rewarding the enterprise when these targets are reached or exceeded).

2.145 In the Chinese system, the environmental responsibility contracts have a multitude of target objectives in terms of factors, percentages, indices, concentrations, etc. (see Table 2.4), but no assessment is made to determine: (a) how much the controls will cost; (b) the most cost-effective overall approach; and (c) whether the objectives are compatible, or even achievable, etc. It would be more effective to develop long-term, least-cost master plans and phased investment plans for environmental management, with
clear priorities established for attaining environmental objectives and committing funds to achieve these objectives. This would provide a more sound basis for an environmental responsibility system than the comprehensive, non-prioritized, ad hoc objectives and targets which are currently in effect. For some rural jurisdictions, the objectives may be quite clear, namely, securing a safe supply of drinking water.

2.146 Other high-priority regulatory actions required for pollution control are:

(a) draft and enact laws and regulations to manage and control hazardous waste;

(b) draft instruments to control withdrawals from underground aquifers so as not to exceed the long-term sustainable supply;

(c) draft codes and standards for construction and maintenance of recharge zones over critical underground aquifers;

(d) enforce insulation standards in existing building codes;

(e) draft energy efficiency standards for new, small industrial boilers, electric motors, etc.;

(f) establish coal quality standards for specific users;

(g) develop least-cost strategies for controlling sulfur dioxide and nitrogen oxide emissions, and draft regulations to this effect;

(h) develop least-cost strategies for controlling greenhouse gases and draft regulations to this effect; and

(i) draft legislation for a phaseout of chlorofluorocarbons according to the requirements of the Montreal Protocol.

Improving Institutional Arrangements for Pollution Control

Develop Cost-Effective Environmental Master Plans

2.147 China can avoid the mistake made by most developed countries of considering every environmental problem a priority, or readjusting priorities with the winds of public opinion. Wealthy countries have not followed priorities rigorously because they can count on much government funding and they can call upon industry to act on many environmental fronts at once, knowing that associated costs will be low relative to GNP. Developing countries such as China do not have this luxury and must identify those areas where improvements are most cost-effective. Most environmental plans in China do not analyze alternative strategies to ensure that the environmental target will be achieved at least cost, nor do they adequately estimate the costs of the investments required to ensure that the controls are affordable. The choice of a correct environmental strategy can produce substantial cost savings, a consideration which is important in sustaining environmental improvement efforts. Experience in other countries has shown that the total cost of meet-
ing ambient air and water quality standards by less efficient strategies can be several times greater than that of a least-cost strategy. While some of this least-cost planning has been and is being implemented in selected areas (e.g., the least-cost, long-range master plans for water, air and solid waste management being formulated under the forthcoming Beijing Environmental Project--see Annex 6), it needs to be used more widely by local authorities throughout China.

2.148 Professionals trained in economic analysis are needed to carry out cost-effectiveness analyses as well as to design environmental policies that act through economic incentives. There are far too few economists in China working in the environmental area and few, if any, are in policy-making or involved in decisions over the distribution of research funds. While neither the available data nor the number of available academicians is sufficient to support a major push now for cost-effectiveness analysis, work in developing these techniques should begin on an urgent basis. The requisite tools, techniques, and underlying theory applicable to such an analysis is available in developed countries and should be an area of primary focus for international assistance. Promoting these techniques at the provincial and municipal level may be the only practical approach to long-term strategies and investment planning for air, water and solid waste management in a country as large and increasingly decentralized as China. Coordination of investment planning among the various organizations involved can be more efficiently and cost-effectively managed at the subnational level in China. Furthermore, most pollution problems are best tackled at the municipal and regional level because individual sources of pollutants and, therefore, appropriate solutions, will vary.

Improve the Performance of EPBs

2.149 The State Planning Commission and NEPA both should promote the introduction of such least-cost pollution control analyses in major cities as early as possible, then replicate them in medium-size cities. Developing the methodologies of cost-benefit and cost-effectiveness analysis will provide important tools for evaluating investment options. At the national level, these agencies should fund generic reviews of different investment options and technologies to provide greater technology guidance based on economic criteria and consideration of broader energy and industrial tradeoffs nationwide. This will mean coordinating more closely at the national level with the Ministry of Energy, the various industrial ministries, the State Science and Technology Commission, and other appropriate institutions on issues of energy and technology development affecting opportunities for mitigating environmental effects.

2.150 Another priority should be to strengthen the enforcement capability of the EPBs, as well as their performance in collecting levies. This may involve reorganizing these bureaus to a higher level within the government hierarchy to give them greater administrative authority. This is particularly important at the county level and below, but also at the municipal level in some provinces. One suggestion that has been made is to set up within the NEPA/EPB system an independent inspectorate or an equivalent that monitors and evaluates the performance of agencies at the next level down (i.e., the NEPA inspectorate would monitor the performance of provincial EPBs, the provincial
inspectors would monitor the municipal level, etc.), using performance indicators appropriate to that level.

**Coordinate Pollution Control Strategies at the National Level**

2.151 Various government agencies are active in developing policies and strategies for pollution control at the national level. There is much scope for closer cooperation, however, in developing public policies and strategies, and encouraging investments for resource conservation and pollution mitigation over the next 10-20 years. The recently established Environment and Economic Policy Research Center, under the auspices of NEPA, should be strengthened to help provide this strategic perspective for environmental policies and programs, especially in regard to the interface between environmental management and economic policies. Particularly important areas include: encouraging larger, more efficient plants; renovating plants to improve efficiency; improving coal quality through washing and screening; research on the technological alternatives and economic policies to address future problems from vehicular pollution, etc. Stronger collaboration would recognize the close interdependency of environmental, energy, and industrial policies and strategies. Environmental policy-making initiatives (in addition to technical proposals) should also be encouraged from all ministries with environmental responsibilities for pollution control.

2.152 Consideration should be given to establishing subcommissions under the SEPC with the task of reviewing the sectoral policies of other environmentally important ministries, in order to recommend changes to the SEPC or State Council (para. 1.11).

2.153 A task force should be appointed to review monitoring and other environmentally relevant data collected by NEPA and other agencies to eliminate duplication and promote consistent data networks and information sharing.

**Role of NEPA and EPBs**

2.154 To date, NEPA and the EPBs have principally focused on technological issues relating to industrial pollution control through monitoring and enforcement of effluent and emission levels, and the levy system. However, this narrow focus now needs to be expanded to deal with pollution control in a more comprehensive, system-wide manner. This should include not only industrial pollution, but also urban wastes, agricultural practices, ecological concerns, water resources as well as water pollution control, energy supply in addition to emissions from energy use, urban central heating systems, gas supply systems, alternative fuels, etc.

**Development of the Environmental Products and Services Industry**

2.155 As of 1989, some 2,500 enterprises were involved in the environmental products and services industry. This represents rapid and impressive development within the industry, but there are reports of uneven quality and a lack of standardization. The formation of industry associations for raising product standards and facilitating standardization should be encouraged, along with measures to minimize possible negative effects on market functions. A recycling or scrap materials association also should be established to promote
the development of this important industry. Further measures probably will be necessary to strengthen the domestic environmental services and products industry, and to address the issues of uneven quality and lack of recourse in the event of problems. To foster public trust in the industry, NEPA, the industry associations, and possibly the People’s Insurance Company of China should be encouraged to provide performance bonding or a surety system.

**Suggested Policy and Technical Options for Air, Water, and TVIEs**

2.156 Economic and financial incentives should reinforce environmental policies. As an example, an effective, environmentally beneficial strategy for air, water, and TVIE pollution control in China might contain the following elements.

**Air Pollution and Coal**

2.157 The strategy should include a mixture of price incentives, mandatory standards, and financial resources focused primarily on improving the quality of the coal supply and efficiency of coal use. Fine and ultrafine particulates (as opposed to TSP) are considered most dangerous to health; therefore, they should be of highest priority in regard to air pollution abatement. This suggests that environmental authorities should give priority to investments that reduce ambient concentrations of fine particulates. That means: identifying low-level sources of pollutants, improving the quality of coal and targeting different types or forms of coal to specific users, improving energy combustion or industrial processes, and/or installing more effective control equipment. Precombustion solutions may be less costly than postcombustion control (especially if they can improve energy efficiency as well). Better scale of boilers and plants should help improve energy efficiency (a precombustion solution) and also make it easier to afford control equipment (a postcombustion solution). Also, indoor air pollution, while not studied in this exercise, appears to be very serious; obtaining a better understanding of its effects and taking immediate measures to reduce it are also priorities. The major indoor activity is household cooking; in winter, there is heating also. These are small-scale uses of coal. One of the challenges is how to improve energy supplies to such small-scale users.

2.158 The above recommendations and following measures for the short to medium term in regard to coal use are discussed in detail in the World Bank report, "Efficiency and Environmental Impact of Coal Use in China":53/

(a) gradually deregulate the allocated coal market, ending the present dual market over a specific time frame, for example five years;

(b) increase allocated prices of coal in the short term to about 80 percent of estimated long-run marginal economic costs (LRMC) of supply (washed coking coal of export quality and certain blending coking coals would be priced with reference to border prices);

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53/ World Bank, "Efficiency and Environmental Impact."
(c) introduce a wide range for reference prices used in negotiating for differences in quality and location;

(d) continue enterprise and fiscal reforms while expanding investment in infrastructure to reduce transport constraints;

(e) institute measures to offset the adverse financial impact of price increases on major users, while still encouraging efficiency adjustments;

(f) immediately use economic prices for planning investments in the state coal sector and the energy sector generally (e.g., central heating systems);

(g) phase in stronger controls on the quality of coal going to various users in dense urban areas and to urban and rural households; in parallel with this, invest in coal preparation and blending facilities to raise the quality of coal supplied to household stoves and industrial boilers or furnaces;

(h) improve the supply of anthracite briquettes and sized, washed anthracite to households; also improve the heat controls of small coal stoves and support the manufacture of more versatile, efficient appliances;

(i) use improved efficiency ratings to improve the operation of existing boilers, and manufacture of industrial and utility boilers and associated pollution control equipment;

(j) continue with investments in large-scale thermal and hydro power development and in transport infrastructure;

(k) improve asset efficiency and energy recovery in large plants, and upgrade and improve scale in small plants;

(l) use available industrial energy (waste heat and gas);

(m) invest in insulation and metering in the housing stock and revamp the tariff system for heat charges in central heating systems;

(n) encourage technical and managerial innovations in order to more rapidly introduce new energy-efficient technologies in areas ranging from boiler technology to lighting and refrigeration; and

(o) improve air quality monitoring to include fine particulates and acid aerosols (measured by proxies such as sulfates and nitrates), and to better evaluate the effects of indoor air pollution on health.

**Water**

2.159 In the water sector, priority short- to medium-term measures should include:
(a) adjusting water prices over the short to medium term to make them closer to the estimated long-run marginal cost of supply;

(b) increasing sewer charges to cover the operation and maintenance costs of collection and treatment, as well as a portion of the capital costs for new investments;

(c) instituting a nationwide program to upgrade rural water supplies;

(d) developing sewage collection and treatment master plans based on least-cost strategies for urban areas using economic prices and including surveys of future industrial investment plans and likely waste loads;

(e) increasing mobilization of financial resources, including diversification of financing sources, such as developing nationwide policies for funding public water supply and sewage treatment;

(f) testing and introducing a new low-cost lime treatment technology for sewage sludges, which produces a recyclable material for use in agriculture;

(g) setting up industrial parks with central waste treatment facilities, including domestic wastes, in rapidly developing communities;

(h) setting up mechanisms, at the urban level (or at a river basin level), for integrated planning and management of water resources and water quality, especially in regard to municipal sewage discharges and industrial wastewater discharges. This should include surface as well as ground waters;

(i) introducing more efficient technologies for water use in agriculture, which is the main source of water demand but which has a much lower net economic benefit than industrial and domestic use;

(j) introducing more efficient processes in industry to reduce water demand and water pollution loads;

(k) improving operation and maintenance in industries to reduce water demand and pollution loads;

(l) increasing the water pollution levies to a level that provides an economic incentive to conserve water and reduce pollution;

(m) improving monitoring, enforcement, and collection of the pollution levy;

(n) encouraging and supporting waste minimization in industries;

(o) providing extra funding to support the above initiatives;

(p) developing and implementing water conservation programs for urban communities; and
(q) developing a comprehensive nationwide strategy for water resources and water quality management.

TVIEs

2.160 The TVIEs are another priority for pollution control. Some suggested initiatives to improve environmental management and performance of the TVIEs include:

(a) setting up a special agency to promote and support the needs of this small- to medium-scale industrial sector (examples of such agencies can be found in Korea, Japan, and India);

(b) opening up the commercial credit markets to the TVIEs to give them access to funds to improve their efficiency and performance;

(c) opening up more opportunities for experienced engineering and technical personnel to upgrade these capabilities in the TVIEs, which are generally at a very low level, even in the most technically demanding subsectors such as chemicals and dyestuffs;

(d) facilitating the involvement of experienced Chinese design institutes as consultants in preparing engineering designs and supervising construction and startup of TVIEs in order to upgrade design and construction of these facilities;

(e) selecting priority subsectors such as: chemicals and dyestuffs, tanneries, pulp and paper, building materials, textile finishing, and beverages and alcohol distilleries, etc., for enforcing the effluent and emission standards, the pollution levy system, and the EIA process;

(f) upgrading the capability of municipalities and county governments to carry out physical planning in rural as well as urban areas, and setting aside industrial development zones and industrial estates for TVIEs as well as state industries where it will be possible to collectively treat industrial wastes (and, if possible, urban wastes);

(g) promoting through special research and design institutes the concept of waste management; improving operation and maintenance, comprehensive waste use, and energy efficiency, etc., to improve the performance of the TVIEs;

(h) shutting down, relocating, and restructuring highly polluting TVIEs on a systematic basis;
(i) identifying groupings of TVIEs to determine if centralized waste treatment systems can treat their wastes at least cost, and developing the institutional and investment arrangements to bring these into effect; and

(j) selecting areas (i.e., a county or municipality and its counties) where these reforms can be tested and evaluated.
III. AGRICULTURE

A. Introduction

3.1 About 60 percent of China's people depend directly on the agriculture sector, which accounts for 30 percent of the GDP. Yet only 10 percent of the land area is arable. The prime agricultural lands south of Beijing and from Gansu and Sichuan eastward have been intensively cultivated for centuries. Grains—rice, wheat, and millet—have always been the mainstay of farming systems.

"Traditional Chinese crop yields... compared with yields obtained in Europe before the introduction of modern rotations and chemical fertilizers, were really impressive.... Since hardly any land or grain was required for feeding livestock, a given area of land could support a far greater density of population than its equivalent in Europe.... By (the 17th or 18th century) farmers in the Canton area habitually grew three crops a year... and many northern farmers commonly grew three crops in two years."¹/

Traditional farming systems were sustainable because the land was suitable for cultivation, organic matter was returned to the soil as fertilizer, and crop rotations traditionally included soil-enriching crops such as legumes.

3.2 In most of China's prime farming areas today, the expansion of irrigation and the use of improved plant varieties and chemical fertilizers have greatly increased production. However, the excessive use of water, and inappropriate use of fertilizers and pesticides in some areas, has begun to create environmental problems. These may worsen as population growth makes it necessary to further boost production on prime lands. In particular, the increasing and often conflicting demand for water for irrigation, industrial, and municipal uses has created a pressing environmental issue.

3.3 As early as 1000 AD, overpopulation drove farm families out of the prime farmland in the river valleys to try to cultivate marshy, hilly and mountainous lands. The process has continued ever since and reached a peak during the 1960s and 1970s. Large areas of marginal land have been brought under cultivation, and in other areas, cropping has been intensified to levels that are unsustainable under current practices. The productive returns of these marginal lands are often too low to induce farmers to invest in conservation measures, and eventually the land may have to be abandoned. While the conversion process has slowed, and may even be undergoing reversal, cultivation and grazing have severely degraded large areas. The most important of these areas are the red soils, the loess plateau, the northern grasslands and the northeast plains. Although these areas have different farming systems and natural characteristics, they all have soils that erode and retain water

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poorly when the natural vegetation is removed from the slopes. Moreover, they have dry windy winters and summers in which much of the rain falls in heavy storms—a pattern that exacerbates erosion by wind and water.

3.4 The Chinese Government recognizes that agricultural practices have created environmental problems. To tackle them, it has established institutions and promulgated regulations, invested in infrastructure and research, and started monitoring a variety of indicators. These interventions, however, are still outside the mainstream of agricultural planning, which remains heavily oriented to boosting production to meet quantitative targets. Moreover, some of the broader policies and economic environment create incentives for environmentally unsound practices.

3.5 The environmentally sound development of prime irrigated lands has to include technological improvements, investments in water conservation, and changes in the financial incentives affecting cropping. On marginal lands, future strategy has to include cultivation techniques that improve soil and water conservation, investments both on- and off-farm, and possibly resettlement of people living in unsalvageable areas. Research on these topics, and the extension of findings to farmers, needs to be intensified.

B. Environmental Issues

3.6 The environmental issues facing Chinese agriculture are grouped under the following headings for this discussion, although many are common to more than one area.

(a) Farming practices on prime agricultural land.

(b) Water use and conservation.

(c) Land degradation in marginal areas.

(d) Fuelwood and other energy sources for rural areas.

(e) Marine fisheries.

(f) Forestry practices.

3.7 About half of China's farmland is on relatively flat, productive land, of which half, in turn, is irrigated. The intensive farming techniques used on these irrigated lands enable them to produce two thirds of China's food. It is inevitable that farmland will continue to be converted to residential and industrial use; thus, the remaining prime farmland will need to generate ever greater production, especially if the conversion of marginal lands to agriculture is to be slowed or stopped. Three aspects of this type of intensive agriculture can generate environmental problems: fertilization, pest management, and water use. Water use is discussed in the section on irrigation.
Farming Practices on Prime Agricultural Land

Fertilization

Chemical Fertilizers

3.8 The rapidly increasing use of chemical fertilizers in China has drawn attention to the environmental aspects of fertilization practices. It is important to distinguish among the several components of this issue.

3.9 In the 1950s, virtually all of China's agricultural nutrient supply came from organic manure; today the share is less than 40 percent. Between 1978 and 1988, the total consumption of chemical fertilizer tripled, and the average amount used per hectare of cropped area increased from 59 kg of nutrient to 149 kg. This increased use of chemical fertilizer has played an extremely important role in the spectacular growth of agricultural production. It is responsible for about half of the 100-million-ton increase in grain production over that decade, and a significant proportion of the increases in cash and high-value crops.

3.10 At present, China's application rate is less than half that of Japan and the Republic of Korea. The Government, in its drive to increase grain production, has given high priority both to increasing the total use of fertilizer and to improving the balance and efficacy of its application. While nitrogen is still the main nutrient being supplied, the share of phosphorus and potassium has been increasing as the needs for balance have become increasingly understood. There is also a shift toward the use of compound fertilizers.

3.11 The main environmental problem associated with the use of chemical fertilizer--notably nitrogen--is the leaching of nitrates into groundwater and runoff into streams and other surface water. Nitrate pollution of groundwater has already been detected in some high-use areas, but there has been no general assessment of its prevalence or seriousness. The more nutrient taken up by the plant, the less is lost off-site. Thus, by applying only the quantity that the plant can use, and applying it correctly and at the right time, the farmer can limit waste, reduce pollution and save money. However, the farmer's incentive to reduce wasteful application is reduced to the degree that the cost of fertilizer is subsidized (see para. 3.13).

3.12 Basic agronomic trials to determine fertilizer response curves, as well as improved soil and foliar analysis, are the tools for refining fertilizer recommendations. At the same time, groundwater and surface water needs to be monitored more widely, and for a wider range of chemicals. A secondary, but not yet serious, problem is volatilization into the atmosphere. Ammonium bicarbonate, which is a very common form of nitrogenous fertilizer in China, is particularly apt to do this. China is beginning to upgrade manufacturing and packaging practices to reduce volatilization.

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3.13 The Government's policies on the supply and distribution of fertilizers may be discouraging their environmentally sound use, although the importance of this has not been assessed. Since the supply of fertilizer through official channels is directly linked to production of certain crops, its marginal product is not necessarily being maximized, except insofar as fertilizer may be illicitly shifted to other crops. The overall level of subsidies on fertilizer, along with price distortions among different forms of the same nutrient, almost certainly induces inefficient use. Moreover, supplies of high-quality fertilizers, which are mostly imported, are inadequate, while domestically produced low-grade fertilizers, which have more potential to create environmental side effects, are more plentiful. The issue of fertilizer is an important element of the Bank's dialogue on rationalizing Chinese agriculture. Environmental benefits can be expected to result from reforms that are motivated mainly by economic efficiency.

Organic Fertilizers

3.14 The increased use of chemical fertilizer has been accompanied by a leveling off in the use of organic fertilizers. This can be a problem because the continuous intensive cropping of land without addition or return of sufficient organic matter eventually depletes the soil and leads to a deterioration of soil structure. The plant's ability to use nutrients efficiently is reduced and crop yields decline. Organic matter can be in the form of human, animal or plant waste, or of nitrogen-fixing crops that are plowed under, known as green manure. Because much organic manure is generated and used within the same farm, data on its use are sketchy and unreliable. It appears that the absolute quantity of organic manure used increased during the 1960s and 1970s but has leveled off or declined since 1980. Its share of total nutrients has decreased to less than half. This is mainly because these manures require a lot of labor to collect, transport and apply. One study estimates that it takes 35 to 45 days of work to collect and apply 100 kg worth of nitrogen.

3.15 As for green manure crops, their area is declining mainly because of the high cost of using land for crops that do not produce income or food and, in some areas, the incentives or compulsion applied by governments to grow higher priority crops. Organic manures have much lower nutrient value per unit volume than chemical fertilizers, although in some soils they have certain chemical advantages. Thus, the incentive to use them depends critically on the relative prices of labor, chemical fertilizer, animal feed and animal products, as well as how effectively they fertilize the crop and soil in question.

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2/ Ibid., p. 53.


3.16 In some areas, the total quantity of organic matter available (as distinct from the incentive to use it) is inadequate. The number of animals, which determines the available quantity of animal manure and used stable bedding, may be limited by the amount of fodder and other feed available. Moreover, in many areas virtually all crop residues are burned as household fuel because there is not enough fuelwood. In fuel-scarce areas of southern China, families may recycle 10 percent or less of their rice straw because they must burn the remainder for cooking. A UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) study in a fuel-scarce area of Jiangxi Province found that three quarters of farmers return virtually no straw to the field even though they recognize its benefit as fertilizer. In northern China, too, where families need fuel for both cooking and heating, the proportion of straw and stalks used as fuel has steadily increased, to as much as 80 percent of the total fuel volume each year.

The government exhorts farmers to use more organic manure, and has a target of doubling its use. However, it is clear that the production and use of organic manure depends upon the whole pattern of incentives and production, not only of crops, but also of livestock, fuelwood and other sources of fuel.

Crop Rotation

3.17 Different crop rotations can enhance or harm soil fertility and structure. There has been a general trend toward continuous cropping and away from crop rotations that sustain nutrient levels and limit pest and diseases.

"For example, in some local regions of Heilongjiang province, the area planted to continuous soybeans accounts for 40-60 percent of the total crop area. Also in the middle region of Jilin province, continuous corn planting accounts for 40-70 percent of the total planted area."7/

Continuous cropping of soybeans results in increases in nitrogen and deficits in phosphorus and potassium in the soil, while promoting the incidence of nematodes, root rot and other pests and diseases. "Clearly, it would be beneficial to increase corn production in Heilongjiang and to increase soybean production in Jilin. If this were done and sound management practices adopted, then appropriate crop rotations would be possible in both provinces."8/

The intensification of rice production may in some areas require harmfully high quantities of fertilizers because of multiple rice crops within a year.9/

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8/ Ibid., p. 302.

9/ Bruce Stone, "Chinese Fertilizer Application."
3.18 An important reason for this specialization is the Government’s designation of certain areas as "bases" for grain or other crops, to achieve national production targets. Administrative units, and the farmers within them, have to meet their quotas and cannot vary their crop rotations to include, for instance, a legume crop as green manure. A departure from this trend, though, may emerge from the Bank’s forthcoming Tarim Basin Project in Xinjiang Region. Provincial authorities have agreed to reduce grain production targets to permit farmers to grow more cotton. This would increase farmers’ revenues and permit them to introduce a green manure crop—which is not lucrative but is essential to maintain soil fertility—into their rotations.

Effects of Fertilization

3.19 What is the impact of these changing practices on soil productivity? National average figures are not meaningful because each soil type and cropping pattern is different. A number of studies have demonstrated a decline in soil organic content in many locations. For example, "since the black soil of Northeast China has been cultivated, soil organic matter and total N [nitrogen] in the topsoil have been reduced from 11 percent and 0.6 percent to 2.3 percent and 0.2 percent respectively." However, the overall extent and impact on production and erosion is difficult to assess. While it is indisputable that the productivity of agricultural soil is often related to its content of organic matter, the minimum desirable amount depends on the soil type, cropping pattern and use of other fertilizers. Where the basic soil structure is good, recommendations vary as to how much crop residue must be recycled to maintain a minimum level of organic matter. In sandy or degraded soils, organic matter levels must be enhanced before or as soon as cultivation is begun. This illustrates how important it is for research agencies and state farms to determine the need for both organic and inorganic fertilizers on a local basis. Often, a soil analysis has been done but not fed back into the design of fertilizer trials and recommendations. In other cases, soil and plant leaves must be analyzed to refine recommendations, which now often do not differentiate among soil types within a region.

Pest Management

3.20 The use of high-yielding varieties and large-scale monocropping, while necessary to attain significant production increases, makes crops more vulnerable to pest damage. Pesticides are the main means of pest control throughout the country. About 90 percent of the agricultural pesticides used in China are insecticides, and these are used mainly on rice, cotton, oilseeds and horticultural crops. Pesticide use has increased manyfold since the 1960s but the increase in tonnage is not a meaningful indicator because concentrations of active ingredients have increased over time. The 1982 Regulations for Pesticide Registration, which are generally in accordance with Food and Agriculture Organization guidelines, govern the sale and use of all products. According to a 1985 study by the World Resources Institute, the retail price of pesticides in China was subsidized directly or indirectly to about 19 per-

It would be useful to update this figure to determine whether subsidies for pesticides, as for fertilizers, may be affecting their efficient use. Conventional economic reasoning suggests that, far from being subsidized, pesticides should actually be taxed to cover the external costs they impose on persons other than the users. Removal of any subsidy might have the further benefit of encouraging farmers to use integrated pest management (IPM) techniques.

3.21 China is one of the world’s leaders in research on integrated pest management, including the use of economic threshold levels and biological controls, and the technique appears to be applied more widely than in most developing countries. There is a national pest surveillance and monitoring system that is used to determine threshold treatment levels. Despite the research achievements, these techniques are only beginning to be applied on a wide scale, mainly because the links between the research and extension systems are weak. Research institutes have difficulty obtaining large cropped areas on which to demonstrate IPM techniques.

Effects of Pesticides

3.22 Three kinds of environmental problems can arise from the use of pesticides: toxicity to humans; residues in the water, soil and food; and resistance of pests to pesticides. The regulations contain satisfactory provisions for testing and labeling products as to their human toxicity, and highly hazardous items have restrictions on their use on food crops. However,

"Owing to the limited number of ... personnel serving the vast agricultural area, and the large numbers of local pesticide manufacturing plants, pesticide distributors, and farmers using pesticides, enforcement of pesticide regulation and pesticide quality control is difficult, if not impossible."

Although extension services do provide training for farmers on safe handling and application of pesticides, it is difficult to provide training and safety equipment to the large numbers involved.

3.23 As for pesticide residues and runoff, the Government in 1983 banned the use of organochlorine products, such as DDT, that persist in the environment for long periods. Nonetheless they continue to be manufactured and used, albeit in limited quantities, indicating that enforcement and monitoring are weak.

"Although the Government is concerned about pesticide residues in the food and the environment, staff and facilities to conduct the necessary monitoring programs are not

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yet available. In addition, the country has not yet established legal limits for residues and depends on FAO ... limits that are not proposed for all crops and major pesticides used in the country."[13/

This is a priority area for intensified work by the Government as part of the recommended general improvement in monitoring agrochemical residues. Recently, some work has begun on experimental projects to produce residue-free, organically grown "green" crops and some facilities have been set up to conduct pilot monitoring programs and expand the range of crops and pesticides for which legal limits for residues are set.

3.24 As in all countries, pests have developed resistance to a number of products, and the average number of applications needed to maintain control is increasing, especially on cotton. Chemicals are alternated to combat resistance, but a more systematic approach is needed within the framework of an IPM system.

Water Use and Conservation

3.25 China ranks sixth in the world in surface water resources (behind Brazil, USSR, Canada, United States, and Indonesia) and its average water resources per capita (2,840 m³) are one fourth of the world average. China's total long-term average water resources are estimated at 2,812 billion cubic meters (Bcm) of surface water and 829 Bcm of groundwater. These resources are unevenly distributed: the area south of the Yangtze River has about 7.5 times as much water per square kilometer of land as the north. The north has 20 percent of the water resources but 64 percent of the prime farming land. The northern plains, though poor in surface water, have significant groundwater supplies.

3.26 Nearly half of China's cropped land is irrigated, and the productivity of irrigated land is about double that of rainfed land. A major achievement of the Chinese Government since 1949 has been the rapid expansion of irrigated land—from 20 million ha in 1952 to some 45 million ha today. About 82 percent of this area is fed by surface water—rivers and lakes—and the rest by groundwater. This massive development of water resources has been a major contributor to China's self-sufficiency in grain production.

3.27 Much of the development of irrigation infrastructure in recent years has taken place in northern China, especially the North China Plain. The rapidity of the development, combined with the scarcity of water resources and the heavy reliance on groundwater, has led to three kinds of environmental problems: waterlogging and salinization caused by inadequate drainage; over-exploitation of groundwater, and pollution of irrigation water.

Salinization

3.28 Almost 7 million ha of irrigated farmland are affected by salinization and alkalinization as a result of indiscriminate irrigation without ade-

[13/ Ibid., p. 127.]
quate drainage. Of these, about 2.7 million ha are in the North China Plain where, in the basins of the Hai, Huai and Yellow rivers, 12 to 15 percent of the cultivated area is affected. Even the mild to moderate levels of salt found in these areas reduce the yields of rice, corn, soybeans and wheat by 10 to 25 percent. Even cotton, a salt-tolerant crop, loses 10 percent of its yield under these conditions. Inner Mongolia and Ningxia also have significant areas of irrigation-related salinity, amounting to 0.5 million ha. Salinization of irrigated land has two causes that are roughly equally prevalent in China: inadequate drainage and inadequate water application. The massive investment in irrigation facilities during the 1960s and 1970s was financed largely by the central and provincial governments. The accompanying infrastructure of minor and tertiary drains was supposed to be financed by local authorities, but in many areas they were never built due to lack of funds or organization. Irrigation also causes salinization when not enough water is applied to flush salts down through the soil and into the drainage system. This problem generally happens where the total water supply is simply inadequate.

3.29 Because of the potential to rapidly increase crop yields by reducing salinity, the Government already has an extensive program to install drainage networks, introduce conjunctive use of surface and groundwater, and improve crops' salt tolerance through plant breeding. Over the long term, the proposed south-north water transfer project and other irrigation investments will be the only remedy for the water shortages that cause inadequate water application.

**Groundwater Exploitation**

3.30 The number of tubewells for irrigation grew from 600,000 in 1971 to 2.4 million by 1985. The uncontrolled and rapid development of groundwater for both irrigation and municipal use has led to excessive extraction and a consequent drop in the water table and subsidence of the land, especially in the North China Plain. The drawdown has rendered many tubewells inoperative or substantially lowered their yields. The water table has been reported to drop by 1 to 3 m annually and in some severe cases as much as 6 m. In the coastal areas of Hebei and Shandong, the excessive drop of groundwater level has led to intrusion of saline water into the freshwater aquifers, rendering them useless.

3.31 In urban areas, where the demand for water is very high, or where shallow groundwater is of poor quality, wells are sunk to tap the deep aquifer, which is only partially recharged by precipitation. The removal of water from the aquifer eventually leads to depressed water tables, which cause consolidation of the soils and subsidence of the land. The area of subsidence around Beijing is reported to be 1,000 km² and that in Tianjin more than 500 km². In addition, intensive exploitation of a deep aquifer for irrigation and municipal use will eventually exceed its recharge rate and the resource will run out. Further, a deep aquifer is not always completely isolated from shallow ones: eventually, heavy drawdown of a deep aquifer can affect the water table of a shallow aquifer, which in turn can deplete surface water in the area.
3.32 Ensuring that groundwater extraction is maintained at sustainable levels will require better assessments of water resources and their rates of recharge; better administrative controls on the sinking of new tubewells, and, in water-short areas, the use of water-saving pipe systems. It has not been possible to assess the effectiveness of existing programs, and this is a subject that could be covered by the proposed irrigation sector study. In the meantime, several Bank projects have provided for such improvements within their project areas, but a province-wide approach is needed. In the Henan Agricultural Development Project, the provincial government has, for the first time, agreed to do a provincial water resource assessment and plan for sustainable development.

On-farm Water Use

3.33 It is possible to apply more irrigation water to a crop than can be used by the plant. This wastes scarce water and can create unnecessary shortages for downstream farmers. Excessive water use can also cause salinization of the soil if drainage is inadequate. There is some evidence that this is happening in China's irrigated areas. For example, a survey of 11 waterworks in Jiangxi Province showed that the actual amount of water used for farmland is as high as 1,297 m$^3$ per mu (1 mu = 0.0667 ha); in some irrigation areas it is as high as 1,925 m$^3$ per mu, greatly exceeding the standard of 600 m$^3$ set by the province.\textsuperscript{14/} Excessive use of water is encouraged by water charges that are too low in absolute terms. The Government recently estimated that nationwide, agricultural water charges covered only 40 percent of prescribed standards.\textsuperscript{15/} A study in Jiangxi found that collected water rates are only 25 percent of the cost of supply. Moreover, water charges are not applied at the farm level, but for large command areas. Farmers therefore effectively pay a flat rate per unit area, and there is no disincentive for overuse. Since it is expensive to install the pipes and meters needed to charge individual farmers for the water they consume, it would be unrealistic to recommend wide-scale charges for irrigation water based on volume. It is somewhat more practical to introduce volume-based charges at the group or village level, and this is being done in some areas. As the need for more funds for operation and maintenance becomes increasingly acute, local authorities are already increasing the level of water charges and the collection rate. In any case, excessive water use at the farm level appears to be a less significant cause of salinization and waterlogging than inadequate drainage infrastructure and insufficient application of water.

Effects on Water Quality

3.34 Water pollution can be traced to point and nonpoint sources. Chapter II discusses point source pollution from industries and urban centers. Nonpoint source pollution is caused mainly by the use of agricultural fertilizers and pesticides. As described in paras. 3.9 and 3.20, the use of these

\textsuperscript{14/} Anonymous unpublished paper, "Survey and Analysis of Irrigation Water Rates" (Beijing, 1986).

Chemicals is increasing rapidly. There is fragmentary evidence of excessive concentrations of nitrates in certain rural areas, but most Chinese and Bank experts believe that this is still a rare phenomenon, although one that warrants close monitoring in the future. Although there have been some surveys of groundwater quality in urban areas, monitoring in rural areas is very limited and it is difficult to assess the extent of contamination. Several Bank irrigation projects are taking steps to upgrade groundwater monitoring in project areas, but here again, there has been no overall assessment of the adequacy of monitoring systems and enforcement of standards.

3.35 The Chinese regard wastewater—both urban sewage and industrial effluent—as a good source of irrigation water. Some 1.4 million ha are irrigated by untreated wastewater, of which about 80 percent is urban sewage. Acids and toxic heavy metals in much of this water impair the soil chemistry and render it useless for agriculture. Where agriculture is carried on using this water, the crops will contain some level of toxic residue. For example, an eight-year investigation by the Agriculture Environment Protection Institute in Tianjin found that 8.4 percent of the wastewater-irrigated farmland surveyed produced crops containing pollutant levels exceeding safe standards. Pollutants included heavy metals, petroleum substances, suspended solids, salts, etc.16/ An additional 9.7 percent of the land surveyed produced grains or vegetables containing more pollutants than those produced with clean water. In yet other areas, prolonged use of sewage water for irrigation has contributed to the formation of an impervious hardpan in the subsoil, inevitably decreasing crop yields. This deliberate use of polluted water for irrigation, combined with the uncontrolled leaching of polluted industrial runoff onto agricultural soils, has destroyed some 2.6 million ha of farmland nationwide. It is not clear whether these findings indicate that the existing water quality laws are inadequate, whether the funding and probably the quality of wastewater treatment is insufficient, or whether the enforcement mechanism is absent. Because the problem is partly agricultural and partly one of water treatment, it requires further investigation by NEPA.

Land Degradation on "Marginal" or Erodible Lands

3.36 Probably the most visible environmental problem that agriculture has created in China is soil and water loss caused by the cultivation of semiarid or sloping lands. Some such lands have long been cultivated, but large areas have been deforested or brought under cultivation since 1949. Chapter IV discusses the effect of this process on natural ecosystems. The following paragraphs discuss its effect on soil and water conservation.

Effects of Runoff and Erosion

3.37 About 65 percent of China's land area is mountain, hill or plateau. When sloping or fragile lands are not protected with ground cover, or are cultivated without defensive measures, accelerated surface runoff and soil erosion are inevitable. The extent and significance of these depends on topography, soil types, rainfall patterns, and the management practices used.

3.38 Both the eroded land itself ("on-site" effects) and downstream ("off-site" effects) areas are affected by increases in surface runoff and soil erosion. The off-site effects include increased sedimentation of rivers and lakes, flooding, and decreased stream flows in the dry season.

3.39 The main on-site effect is a decline in crop yields. The causes for this differ among soil types, ecological environments, climatic conditions and crops. The actual area of arable land may decrease as gullies form or as coarse eroded matter buries good soil. However, the most significant causes of yield declines are changes in three soil characteristics: plant-available soil moisture, plant-available soil nutrients, and the interplay of these two with organic matter. Inevitably, erosion decreases the productivity of the site. The yield decline is less pronounced on soils with favorable subsoil characteristics--such as loess soils--than those with unfavorable characteristics, such as the red soils. In general, 1 mm of soil loss per year can cause yield declines of 5 percent, and 8 mm will cause declines of 10 to 25 percent, other things being equal.

3.40 The national guidelines for land use are as follows:

(a) less than 30 percent slope: annual crops

(b) 30 to 50 percent slope: "integrated" hillside development with emphasis on tree crops

(c) greater than 50 percent slope: forested or permanent grass.

Areas Affected

3.41 The Chinese Government classifies almost 17 percent of the total land area, or 1.5 million km², as more than slightly eroded. Within this total, there are four particular zones where agricultural activities cause widespread and severe losses of soil and water: the northwest loess plateau, the red soils hilly area south of the Yangtze River, the northeast plains and the grasslands of the northwest.

Loess Plateau

3.42 The loess plateau comprises 530,000 km² in the middle reaches of the Yellow River. The soil is as much as 150 m deep, largely undifferentiated, and one of the most highly erodible in the world. Rainfall is less than 400 mm and most of it falls in a few torrential storms during the short wet season. The original vegetation was probably grasses and forest, but the area has been cultivated continuously since the neolithic period, some 7,000 years ago.
"The severe erosion under natural conditions is worsened by the fact that over hundreds of years people have removed the natural vegetation...to cultivate the plateau top, steep slopes and alluvial flats. One of the more hazardous crops is winter wheat which is harvested in June, thus leaving the soil bare and open for erosion during the rainy season."17/

Even in the uncultivated areas, the local people dig up turf to use as fuel, because coal is expensive and hard to get, and crop residues are inadequate. Erosion seems to have been a serious problem ever since the beginning of its settlement, but has worsened dramatically since the 1960s, because the population on the plateau has doubled since 1949. The erosion problem is usually illustrated by the silt load in the Yellow River and its tributaries. Scholars estimate that the average annual silt discharge 3,000 years ago was about 1 billion tonnes, where today it is about 1.6 billion tonnes, indicating the contribution of human activity to erosion.18/ In addition to these off-site effects, erosion has two important on-site effects. First, the deep gullies, which make up 30 to 50 percent of the plateau's land area, cannot be cultivated. Second, the heavy runoff reduces soil moisture and washes away nutrients. The impact of these effects on crop production has helped make this area one of the poorest in China.

3.43 Extensive efforts have already been made to control soil erosion and its effects in the Yellow River Basin: over 300 organizations are doing research and demonstration projects there.19/ Engineering works to control the effects of siltation and prevent flooding have been, and will continue to be, essential, but they must be complemented by much better use of on-site measures. These include agroforestry, minimum tillage techniques that leave crop residues on the surface, use of vegetative barriers on slopes, restoration and improvement of grassland for pasture, etc. The benefits of these techniques have already been demonstrated in limited areas, but the potential for and constraints on their widespread adoption are not clear. In addition, the Government's plans for further development of the area need to be investigated. Further expansion of dryland cultivation is not advisable; if any more investment is done, it should involve expansion of irrigation, which actually stabilizes the soils.

Red Soils Area

3.44 This area comprises 2 million km²—21 percent of China's area—in the warm, humid zone south of the Yangtze River. It is an area of hills and


low alluvial valleys. The lowlands are under irrigated rice cultivation that appears to be environmentally sustainable, but the uplands are a zone of serious degradation and low productivity. Once forested, they are now either under low-intensity cultivation or abandoned because they are eroded. About one quarter of the area has been heavily eroded. The erosion problem is particularly severe in Guangxi Province, where siltation has reduced the irrigation system to 30 percent of its capacity. Throughout the area, soil loss, gully and poor moisture retention greatly restrict agricultural production.

3.45 The soils in the uplands are shallow, acid, and have low water-holding capacity. They are deficient in most nutrients. Nonetheless, with an annual rainfall of more than 1,500 mm, this area has high potential for increased agricultural productivity, provided that fertility can be restored to the degraded soils. The prevailing practice for development of these soils is to stabilize the land by terracing, to apply huge quantities of manure and other organic matter, and to introduce irrigation wherever possible, even at high cost.

3.46 A recent Bank mission found that these practices are probably not sustainable over the long term. First, terracing has proved to be costly, often ineffective and unstable. Structures are usually laid out with lateral or outward slopes, with no control of runoff and with no cover crop. Unacceptable rates of soil loss can continue even from terraced slopes, and unless terraces are maintained—an expensive operation—they eventually degrade and disappear. Stabilization using selected plants such as Vetiveria zizanoides (vetiver grass) is a better method, accompanied by improved terracing techniques for the places where terraces are still suitable.

3.47 Second, to obtain enough organic matter to develop new areas, the farming system will have to include more animals, and hence more fodder and more plant residues. Since these items are already lacking, there will need to be significant diversification of the farming system within the farm or locality. The choice of crops should not be determined solely by local production or export targets, but also by the long-term potential and the requirements of the land and soil. Finally, there is potential for increasing the productivity of rainfed cultivation by improving the soil's ability to conserve moisture through contour planting and other techniques. This could reduce the perceived need for high-cost irrigation on this difficult terrain.

3.48 The Bank and the Government are now planning a project in five provinces that will promote these concepts. A major contribution of the project would be to introduce the watershed as the basic unit of land use planning and development. Rather than ad hoc reclamation of particular areas for production of particular crops, this approach uses forestry, cropping and livestock production to optimize the use of land and moisture at all points, from ridge-top to valley bottom.

The Northeast China Plain

3.49 This 117,000 km² area in Heilongjiang, Jilin, and Liaoning provinces and the eastern part of Inner Mongolia is one of the world's three largest black soil areas. Because of its rich soils, its lowlands have been an important grain production area for more than a century. In recent decades, how-
ever, more and more forested land and grassland in the area's hills has been converted to crop land. At the same time, some effective traditional soil conservation techniques—such as the use of organic fertilizer and sound crop rotations—have been abandoned. There is now serious soil erosion in about 13.3 million ha of the mountain and rolling hills. About 0.5 cm of soil is lost annually. "After 60-70 years of cultivation, the black topsoil layer on the slope area has been reduced from 60-70 cm thick to 20-30 cm thick."

3.50 Recent agricultural research efforts point to a variety of possible remedies. These include intercropping corn with sweet clover that can be used as green manure or animal feed, and minimum tillage techniques to reduce erosion and use of inputs. Both economic and environmental benefits would be generated by using crop residues and green manures to raise livestock and then effectively manage the animal manures as crop fertilizers.

Grasslands in Inner Mongolia, Xinjiang and Gansu

3.51 Land degradation in the grasslands has two aspects (see also Chapter IV, paras. 4.13-4.18): the conversion of grassland to crop cultivation, and the increase of grazing intensity to unsustainable levels. Over the past 30 years, total herd size on the grassland has increased from 30 million to 100 million head, with the average grassland per animal reduced from 1.5 mu to 0.34 mu. In addition, more than 100 million mu of grasslands have been brought under cultivation. Overall, it is estimated that grass supply in China in the 1980s was 30 to 50 percent less than it was in the 1960s.

3.52 Conversion of Grassland. Grassland is still being brought under cultivation on a large scale—the rate of 20,000 ha per year is frequently quoted. As noted in para. 4.19, the Eighth Five-Year Plan includes proposals for conversion of 145,000 ha in Inner Mongolia and Xinjiang. At the same time, some cultivated area is being turned back to grassland. The government states that on balance more area is being converted back to grassland than is being converted to cultivation, although data on the extent of the reconversion are lacking. In the northeast, where cropping activities have increased soil alkalinity to high levels, areas are being put back into pasture on a limited scale, using highly tolerant species in a rotation system with crop production. In central and south China, some efforts are being made, with the assistance of the Ministry of Agriculture, to convert terraced agricultural land to production of forage crops to sustain livestock development activities. In these areas, there is a high potential for reconversion to benefit both animal husbandry and land stabilization. No information was obtained about what efforts are being made to regenerate good quality grassland through seeding or other measures. The relative quality of the land being converted is also unknown. It is likely, certainly in the north, that lower quality cropland reverts to grass, and better quality grassland is converted to crop. A long-term strategy for revegetation of depleted grasslands will require reliable seed supplies and research on the acceptability and persistence of various forage species.

3.53 **Overgrazing.** The problem of overgrazing in many, but not all instances, is closely linked to land tenure arrangements. Under the old commune system, with communal ownership of both land and animals, there was little incentive to intensify production, and therefore little overgrazing. When the individual responsibility system was introduced, households were assigned their own animals but not their own land. This provided an incentive to overgraze. Most recently, at least in some areas, individual households have been given responsibility for their own areas of land.

3.54 In Heilongjiang, 35 percent of the total grassland has been contracted to farmers, and the contract system for grazing is also used in Jilin, Qinghai, Shanxi and Inner Mongolia. The contract periods are from 5 to 15 years, and the contracts include numerous rules designed to restrict overgrazing and other damage to the grassland. This has produced in some regions a dramatic difference between contracted plots, in which overgrazing is rare, and areas still under control of the State Farm, where conditions are much worse. However, in Inner Mongolia, other factors may have counteracted the generally positive impact of the contract system. In Inner Mongolia, where leases to household management units under the responsibility system were being implemented, problems of "scale" created by dividing up the land effectively overrode any benefits achieved by the change in land tenure arrangements. If the grazing land was overstocked before the land was divided into small units managed by individual households, it was certainly overstocked when the household tried to maintain the same number of livestock on the land allocated to it. In most instances, the degradation was increased because of the increased concentration of animals. Instead of one relatively large "sacrifice area," many small sacrifice areas were created. With or without changes in land tenure, the need is to bring about a balance between stocking rate and grazing capacity. Although there are fines for overstocking and misuse of grazing land, there has been no evaluation of adequacy of enforcement. Lack of funds for fencing also inhibits better management.

3.55 The MOA would like to develop grazing management guidelines specific to more localized conditions. However, developing guidelines and enforcing regulation of grazing will require the creation of an infrastructure that does not exist at present and that is highly unlikely to be developed in the near future. Efforts should be made to support activities to determine land use capabilities, standardization of grassland investigative techniques, extension of appropriate farming and grazing methods throughout agriculture, and research at the plant-animal interface.

**Further Development and Conversion of Land**

3.56 National data and projections concerning the conversion of land into and out of agricultural use are often cited by Chinese and foreign observers to illustrate the environmental effects of Chinese agriculture. Large areas of prime land are said to be taken out of cultivation each year, requiring the conversion of ever-larger natural areas to agriculture. This is not a useful way to determine the scope and extent of present or future land use problems. First, the data on cultivated areas are not reliable because farmers often underreport the area to reduce their tax or quota obligations. Local governments have sometimes collaborated in this process to reduce their crop delivery obligations. Moreover, of the gross area taken out of cultivation in
recent years, about 40 percent has been converted to forest or grassland, and
the rest to housing and other construction. It is claimed that the area con-
verted from cultivation to natural vegetation roughly equals the area con-
verted the other way; only a detailed qualitative assessment could determine
whether the newly cultivated land is less or more suitable to agriculture than
that abandoned. In other words, a focus on the conversion of land per se does
not provide a clear prescription for action. One needs to assess on a case-
by-case basis what kinds of land are being developed for farming and whether
sustainable farming systems can be, and are being, introduced.

3.57 Chinese authorities have recently emphasized the need to halt or
slow down the conversion of prime agricultural land to residential and indu-
trial use. Provinces impose heavy taxes on those wishing to convert agricul-
tural lands, and use the revenues to develop farmland. While this may be a
suitable mechanism to create appropriate incentives in particular cases, it
cannot substitute for a comprehensive land-use strategy that, among other
things, tries to gu'de, rather than halt, industrialization and urbanization.
In the longer run, there is no substitute for creating clear ownership of and
title to all land--rural or urban--and value in land through the marketability
of titles. Of course, if farmers were free to sell and land values were ade-
quate, this might hasten conversion in the short term; however, conversion
could be offset by limited demand if the full rent (or price) were paid.

3.58 The Government officially plans eventually to extend and intensify
cropping in all the above-mentioned marginal areas even though its development
plans for the 1980s remain largely unfulfilled. Depending on the nature of
the planned development, the environmental implications could be good or bad.
Similarly, the intensification of production on land already intensively
farmed--another Government priority--can forestall the conversion of natural
ecosystems, as well as creating direct environmental benefits; if it is
improperly done, however, it can also create environmental problems. Overrid-
ing these uncertainties is the fact that the Government's plans are based on
production targets and self-sufficiency objectives that, as a World Bank
study 21/ and others have shown, are not necessarily efficient from an eco-
nomic standpoint. Since the rate of growth in grain consumption has leveled
off to roughly the rate of population growth, there is actually little eco-
nomic rationale for converting large areas to agriculture. The focus should
instead be on improving the management of land already under cultivation, both
to increase yields and to mitigate environmental effects.

Forestry and Fuelwood

3.59 About 75 percent of China's forest area consists of naturally occur-
rning stands, and the remainder has been planted for a variety of purposes.
Chapter IV describes the consequences of overharvesting the natural forests;
this chapter describes the environmental aspects of human-made forests.

3.60 From the 1960s onward, the Chinese Government and local authorities
have encouraged and financed tree planting to limit soil erosion by wind and

21/ World Bank, "China: Managing an Agricultural Transformation"
water. The practice of planting trees around villages, canals and roads has been widely adopted and its impact on local wind and water erosion has been demonstrated. China is in the forefront of agroforestry technology, and has developed several successful methods for interplanting trees with crops. In some cases, tree-planting campaigns have failed because of inappropriate technologies, lack of incentives and absence of follow-up. In general, though, the Chinese have a creditable record in "environmental" forestry and are planning to intensify existing programs in vulnerable areas such as the upper reaches of the Yangtze River and in Gansu Province, and to extend the shelterbelt system in coastal areas.

3.61 Less success has been achieved in establishing sustainable supplies of fuelwood. Biomass fuel—wood, brush, crop residues and grass—accounts for about 80 percent of China's total rural household fuel use. Since the early part of the century, available fuelwood resources have declined, following declines in accessible forest resources overall. In areas where fuelwood is still available from forests, it usually consists of prunings, lopped branches or logging residues. Much of the fuelwood consumed is actually low-quality brush and weeds collected from already deforested hills. This practice denudes accessible hillsides of any sizable biomass growth, contributing to the kind of soil and water losses described in paras. 3.38 and 3.42. To compensate for diminishing supplies of wood, rural people increasingly use crop residues as fuel, with the deleterious effects on soil that were described in para. 3.16.

3.62 The loess plateau and the red soils region—described earlier—are two areas critically affected by natural vulnerability to erosion, which is exacerbated by cultivation and fuel gathering. An increase in the area of fuelwood plantations is needed to improve the rural energy situation. The incentives to maintain such plantations, however, depend on local land tenure practices, relative fuel prices in the locality, and the costs of growing wood rather than other crops on hillside land. Ideally, fuelwood production should be part of an integrated watershed development program in which forestry is combined with crops and pasture on appropriate soils and slopes to maximize conservation of soil and moisture.

3.63 Wood for building materials, paper and other industrial uses is in chronically short supply in China, and the Government has an ambitious program—already under way—to establish forest plantations for timber. Some of these are operated by State farms, but most are established and run by local authorities and semicommercial entities. Since most plantations are located on formerly barren hillsides or grazing land with low productivity, they can generate major environmental benefits if properly designed. The Ministry of Forestry has recently established environmental guidelines for plantations. The guidelines limit the size of blocks of a single species (in order to reduce the potential for pest and fire damage), prescribe planting along the contour and require appropriate pest and fire control measures to be in place.
Marine Fisheries

Overexploitation

3.64 Overexploitation of China's inshore and offshore marine fishery is emerging as a serious economic and environmental problem. The problem involves both simple overfishing of commercial species at unsustainable rates, and the incidental harvesting of noncommercial species. Although since 1980 the Government has promoted fish production by aquaculture, half of China's fish production still comes from capture fishery in the Yellow, Bohai, East China, and South China seas. The Ministry of Agriculture's Bureau of Fisheries Management is responsible for enforcing fisheries regulations and protecting the fisheries environment.

3.65 Before 1980, the marine fishery expanded rapidly without planning and regulatory measures. The Government introduced fishing vessels haphazardly and encouraged uncontrolled fishing to increase production. Owing to the lack of technology and funds, the initial investments were for the construction of small- and medium-sized boats, which resulted in a large number of fishing boats in the coastal and near-offshore areas along the entire coastline.

Protection Efforts

3.66 In the mid-1980s the Government decided to protect the resources and rationalize the fishing effort. The Fishery Law of June 1986 controls the growth of the coastal fishing fleet and trawler operations through a licensing system and establishment of fishing zones. The fishing areas are divided into the coastal zone (depth less than 40 m), the offshore area (40 to 80 m) and the deep-sea zone (80 to 200 m). Management measures include: strict enforcement of licensing and inspection of vessels, protection of spawning and breeding areas, protection of fry, limits on production, open and closed seasons for shrimp trawling, etc. Provinces and counties are responsible for allocating and enforcing the central Government's limits on vessels and production, and for developing a unified plan for waters under their administration.

3.67 In many areas, however, it has proven impossible to enforce the Fisheries Law because the authorities lack the boats, communication equipment and staff they need to patrol the waters. Overfishing continues, with drastic results on the annual catch and estimated stocks. For example, the annual catch of large yellow croakers in the East China sea has plummeted from 200,000 to 2,000 tons. Although newly hatched hairtail (East China Sea) are protected by law, in 1990 state and collectively owned boats caught some 20,000 tons, and the total catch of hairtail declined by 13 percent between 1989 and 1990. In the South China Sea, the number of fishing vessels increased by 75 percent between 1979 and 1988, and many people have moved into fishing as an occupation. Most of the fishing vessels and 80 percent of the catch are concentrated inshore, creating an imbalance with deep-sea fishing output. Poison, explosives and electric devices are used illegally but widely.
China's monitoring and protection activities for ocean fish deal almost exclusively with commercial species, which constitute only a few dozen of the 2,000 or more species found in the South China Sea. Many of the other species are rare and can easily be destroyed by commercial fishing practices. The monitoring system should be expanded to cover the less abundant noncommercial species. An assessment of their ecological importance, combined with monitoring data, would reveal whether important species are at risk, and appropriate measures could then be designed.

C. Policies and Actions of the Chinese Government

Laws and Regulations

Annex 7 lists some of the major laws and regulations that apply to agricultural activities, namely the Environment Protection Law (1979 and 1989), the Forestry Law (1979-84), the Grassland Law (1985), the Wildlife Protection Law (1989), and the Marine Environmental Protection Law (1983). In addition, the following sets of regulations have been established:

(a) regulations regarding water and soil conservation for farmland;
(b) pesticide regulations;
(c) water conservancy regulations;
(d) water quality standards for farmland irrigation (1979);
(e) water quality standards for fishery (1989); and
(f) forest pest-control regulations.

It has not been possible to assess whether the present regulatory framework is adequate, but it appears to cover the priority subjects. It is the enforcement of the regulations that is likely to be somewhat weak. In addition to these national regulations, there are regulations, incentives and other controls imposed by provincial and county governments, but no comprehensive compilation and assessment could be made of these.

Institutions

The National Environmental Protection Agency and its provincial and local offices concentrate their efforts on problems of pollution, leaving ecological and land use problems as the responsibility of the Ministries of Agriculture, Water Resources and Forestry. Each of these ministries has established one or more units with responsibility for environmental matters. These units are generally small and underbudgeted in relation to the main operational departments of their ministries.

The Ministry of Agriculture's (MOA) Bureau of Environment Protection and Rural Energy was established in 1985. It has promulgated regulations and standards on several subjects, including the safe application of pesticides and the quality of irrigation water, and is preparing others. With a staff of only seven people, though (in a ministry of over 1,200 at the national level),
its scope of work and impact are necessarily very limited. A much larger number of staff are employed in the provincial and local agriculture environmental units and research institutes under MOA. The MOA's State Farms Bureau is responsible for conversion of new land to agricultural use, and its Bureau of Fisheries has jurisdiction over regulation and enforcement of marine fisheries. The State Oceanographic Administration (SOA) does planning and research on marine resources.

3.73 The Ministry of Water Resources (MWR) is responsible for development, utilization, management and conservation of water resources across the country. Its Water Resources Department is responsible for long-term water supply planning, cross-river water transfer planning and water resource protection. Its Hydrology Department also monitors and investigates surface water and groundwater conditions. Its Department of Rural Water Conservancy and Soil Conservation has been designating counties and watersheds for intensive erosion control measures since 1983. The MWR also oversees and finances seven river basin commissions and their provincial and county-level counterparts, which are responsible for monitoring and planning surface water development in the major river basins. As for groundwater, the Ministry of Mines and Groundwater is primarily responsible for monitoring and planning its exploitation, but county governments have virtually complete control over exploitation of groundwater. This fragmentation of responsibility for groundwater exploitation, along with its dissociation from surface water management, is an important reason for the problems described in paras. 3.30 and 3.31.

3.74 The Ministry of Forestry (MFO) is responsible for the protection of forest resources and forest ecosystems, including endangered animal and plant species. The ministry has a small Department of Wildlife and Forest Plant Protection that is responsible mainly for forest reserves and other protected areas. It is a new department and is still defining its role and relationship to other parts of the ministry. Management of the natural forests is under the control of forestry bureaus, and it is not clear to what extent they explicitly analyze and mitigate the environmental consequences of their harvesting activities. As for forest plantations, the ministry's afforestation department has recently developed environmental guidelines for plantation design and management. This may prove to be an example of successful integration of environmental considerations into mainstream operations.

3.75 Ministries of the central Government play an important role in establishing policies, guidelines and investment programs, but they do not have direct control over the implementation of policies at the field level. This is the responsibility of provincial, prefecture and county governments. In agriculture, these lower levels of government control matters such as promulgation and enforcement of regulations and standards, implementation of development projects, the terms of production contracts with households and firms, groundwater use, operational research and extension, etc. A complete assessment of the scope and effectiveness of their work is essential in order to understand the environmental aspects of Chinese agriculture. Case studies of several counties might be carried out to observe how centrally designed policies are adapted, adopted, or evaded at the local level.
Environmental Impact Assessment

3.76 The Environmental Protection Law, first promulgated in 1979, calls for environmental impact assessments to be done for most development projects, and for all projects receiving external financing. The enterprise or institution responsible for the project commissions the EIA, and NEPA or its provincial arm must approve it in order for the project to proceed. Most assessments are carried out by research institutes, universities or other technical agencies.

3.77 The EIA process has been used mainly to assess the pollution impacts of industrial projects; it is only in the past two years that it has been applied to agricultural projects. The EIAs completed so far typically cover pollution from agroprocessing plants and from agricultural chemicals, the implications of large-scale water transfers, protection of historic sites, and similar issues. Those submitted for Bank-financed agricultural projects have accurately identified the major potential problems and described how various indicators, such as water quality, should be monitored. They have been less effective in proposing solutions to the potential problems. It is frequently unclear what action will be taken if standards are not met. To date, EIAs have not been used to assess conversion of land to agricultural use, soil erosion and structure, deforestation and afforestation and other topics. The EIA has considerable potential as a way to improve the design of agricultural projects, particularly if done at an early stage, and the Government should continually assess its effectiveness, expand the scope of application, and make improvements where appropriate. Since the responsibility lies primarily with provincial agriculture bureaus and research institutes, attention should be paid to strengthening their capacities to do EIAs.

Environmental Monitoring and Research

3.78 Except for some investments in water conservation and land reclamation, government programs in the area of environment and agriculture consist mostly of data-gathering and monitoring, research and demonstration activities. The scope of these activities is very limited: central government expenditure on agricultural environmental protection has averaged only ¥2 million per year over the past five years—a fraction of NEPA's already minimal annual budget. Out of this amount, one quarter goes to the MOA's Agro-Environmental Research Institute in Tianjin for its research, primarily on ecological farming. The budget allocations of provincial and county governments are believed to be insignificant. The MOA's Agricultural Environment Monitoring General Station and its three environmental stations, focusing on fishery, wasteland reclamation and grasslands, form a nationwide network to monitor soil, atmosphere, irrigation water, fishery water and agricultural and fishery products, as well as carrying out research. It has not been possible to assess the quality or usefulness of the data gathered, or the measures taken when the system identifies problems.

3.79 Since the late 1970s, the MOA, with assistance from NEPA, has set up more than 400 trial sites for "ecological agriculture" all over China (there are an estimated 2,000 ecological sites in total in China) and MOA plans to expand the scope of these during the Eighth Five-Year Plan period. According to MOA data, these average more than 5,000 ha each and together cover 1.7 per-
cent of the nation's cropland. They appear to be model rural communities in which the design of crop, livestock and fish production and the use of human and animal wastes and crop by-products result in a self-contained, sustainable system. Production of biogas as fuel, and heavy or exclusive use of organic fertilizers, appear to be main features. Proponents claim that yields and revenues on these sites are significantly higher than averages in other areas. However, it is not clear what inducements or incentives the sponsors provide to villagers to adopt these systems, or whether these systems are financially attractive in the long run. Moreover, it is unclear how the findings and techniques are to be extended to the rural population at large. It would clearly be worthwhile to further investigate this ambitious program and the conclusions emerging from it. At the same time, it must be recognized that the impact of demonstration projects is weak at best compared with the incentives created by the relative prices of crops, fertilizers and fuel sources.

Incentives and Sanctions

3.80 A major factor influencing the adoption of sustainable agriculture practices at all levels is that economic and social attitudes and goals, at least currently and probably indefinitely, will take precedence over ecological goals. Only when it is obvious that benefits from ecologically sustainable use will be of equal or greater benefit will that approach to use of resources be taken. Therefore, regulations alone will not ensure the proper and effective use of resources. As indicated, enforcement coupled with economic incentives will work to some degree as long as other economic interests do not override the benefits to be obtained from following regulations. For example, a considerable effort has been made in China by MOA to develop systems that integrate ecological principles governing use of agricultural land with the economic principles governing the production system. The Center for Integrated Agricultural Development at Beijing Agricultural University is trying to develop farming systems that lead to sustainable use. The grassland division of the MOA is doing experimental work and has demonstration areas for integrated management of grazing land. However, no effective extension system exists for moving this work beyond the experimental stage into mainstream operations because of (a) an apparent inherent distrust by line managers of research or educational institutions; (b) any attempt to decrease short-term production to bring about balanced use of resources is regarded as unfeasible; and (c) there are no funds or infrastructure for extending results.

3.81 On the other hand, there is some evidence that the contract responsibility system is being used to create incentives and sanctions for farmers to follow sound environmental practices. For example, in counties where the MWR has started special erosion control programs,

"Increased output from newly constructed and renovated fields will be exempted from additional quota obligations; procurement and taxes can be reduced for sloping lands that have been converted into grassland or forest;"

22/ Zhang Renwu and Sun Hong Liang, "Current Situation and Prospects of Sustainable Agriculture in China," unpublished.
and the tax of specific products is allowed to be reduced or exempted for production of cash trees such as fruit trees."23/

In grassland areas, households who contract to grow hay have to follow certain environmental guidelines or their payments may be reduced. Counties and households who contract to establish commercial timber plantations are also obliged to follow environmental guidelines, and their compliance is verified before they receive payment. The extent and effectiveness of this type of practice has not been assessed, but it is a subject of high priority for further investigation because it permits environmental considerations to be fully integrated into existing production arrangements. This and other economic and social issues that affect the adoption of sustainable agriculture practices should be a priority area on which to focus the efforts of the newly created Environment and Economic Policy Research Center (see para. 2.151).

D. Recommendations and Proposed Strategy

3.82 The documents reviewed in preparing this chapter suggest that Chinese officials and researchers are aware of environmental problems in the agriculture sector. Some problems, such as sedimentation caused by soil erosion and declining organic content of soil, are well documented. Interesting and alarming extrapolations are frequently made from present trends in deforestation, soil erosion, water pollution and other problems. However, the diagnosis of the reasons for these problems tends to focus on China's large population, its mountainous terrain, the bad policies of the 1960s and 1970s and farmers' failure to follow correct practices. Since none of these factors can be changed, the analysis rarely leads to concrete strategies for improvement. The strategies proposed generally rely on exhortation and education to change agricultural practices. They only rarely consider the incentives and disincentives of adopting desirable practices.

3.83 Almost every imaginable agricultural practice that is environmentally sound was either widely used in traditional Chinese agriculture, or has been successfully demonstrated by contemporary Chinese researchers. Examples include the use of organic fertilizers and crop residues, the nonchemical control of pests, the use of trees to combat wind erosion, low-tillage cultivation for weed control, vegetative barriers to inhibit soil erosion on slopes, and many others. Yet the failure to widely use these known techniques generates many of the environmental problems described above. An environmental strategy for agriculture should therefore identify and remove the barriers to adopting known techniques. Such a strategy should cover four main areas:

(a) economic policies and incentives,

(b) investment priorities in the agriculture sector,

(c) research and extension of better techniques, and

(d) regulations and enforcement.

3.84 The following section contains recommendations about the wide range of environmental problems stemming from agriculture that this chapter has described. Of these, four stand out as worthy of the Government's most concentrated attention:

(a) As irrigated cropping is further intensified, the use of fertilizers, pesticides and irrigation water (especially groundwater) will inevitably increase. Both local and central governments should design and install systems and procedures to monitor the quality and quantity of water. They should also have long-term plans to prevent the quality and rate of exploitation from reaching unacceptable levels (see also paras. 3.91 and 3.97).

(b) The use of crop production targets set by central government and the linkage of targets to input supply should be phased out (see also paras. 3.85-3.87).

(c) On marginal lands already under cultivation, comprehensive rehabilitation programs should be implemented that involve changes in cropping patterns, changes in land tenure arrangements, control of soil erosion, and improved extension of known techniques (see also paras. 3.43, 3.46, 3.47 and 3.62).

(d) The general policy on further conversion of marginal lands to cropping should be reviewed and strict environmental guidelines established. The policies and practices of state farms, county governments and other local entities should be reviewed in this context (see paras. 3.57 and 3.58).

Economic Policies and Incentives

Grain Production and Distribution

3.85 National policies on grain production and distribution have a big impact on how agriculture affects the environment. The Government has set a target of producing 500 million tonnes of grain by the year 2000 in order to achieve self-sufficiency. Within the overall target, the Government intends particularly to increase the production of rice despite the fact that demand for it has leveled off. Achieving this target would almost certainly require the continued conversion of marginal land into cropland or intensification of cropping on marginal land. As described in Chapter IV, the Eighth Five-Year Plan in fact includes proposals for such conversions on a large scale. The financial and environmental cost of doing this would be very high. The Bank's recent China agriculture sector report 24/ shows that if market forces were allowed to operate, the population would likely demand only about 470-475 million tonnes of grain per year by the year 2000, with about 10 million of that being supplied as imports. This would imply less need to convert land

24/ World Bank, "China: Managing an Agricultural Transformation."
and to intensify cultivation, and would permit an increase in crop specialization by region.

3.86 The central Government has established quotas for the obligatory delivery of grain by each province. The provincial authorities then establish quotas for individual counties. The central Government also promotes provincial self-sufficiency in grain production, rather than encouraging specialization in crops of regional or geographical comparative advantage. These policies encourage the conversion of unsuitable land to cropping and discourage the use of alternative, potentially regenerative cropping patterns.

3.87 Government policies should be designed to provide incentives to adjust and improve the cropping systems to maintain a sustainable agriculture. Given that large portions of China's agricultural areas experience severe spring drought, summer flooding, late autumn drought and/or salinization, the crop production mix should consider these various situations. Further, investments to control flooding and better irrigate and drain the agricultural areas should be encouraged. Wheat is a moderately drought-tolerant crop, sown in the autumn and harvested in the summer, and can provide high and stable yields. However, when an autumn drought is followed by a spring drought, wheat will seriously deplete residual soil moisture and reduce yields. Therefore, a more diverse cropping pattern is recommended and should be encouraged:

(a) Maize, a summer crop, cannot withstand either drought or excess water, resulting in unstable yields when these conditions occur. Alternatively, soybeans are more drought-tolerant and add a modest amount of nitrogen to the soil. Hence, soybeans might replace a portion of the maize area if there were adequate financial incentives (prices);

(b) Sorghum, also a summer crop, is quite drought- and salinity-tolerant and also can tolerate wetter soils than maize. Where drought and flooding combine with saline conditions, sorghum production should be promoted. Similarly, millet, which is an even less-demanding crop, could be promoted on land which is even more saline;

(c) Where green manure crops fit well into crop rotations, they should be encouraged. The adoption of green manure rotations will depend upon both the dissemination of information and the provision of financial incentives to farmers. However, more important, to maintain soil structure and increase the organic content of soil, crop residues should be chopped or shredded and plowed back into the soil.

3.88 Grain policy is an important subject in the Bank's dialogue with Chinese authorities about both the design of projects and findings of sector studies. The Bank is recommending, among other things, that the use of quota procurement gradually be replaced by the creation of buffer stocks of grain; that projections not be used as the basis for imposing production targets, and that current restrictions on international and domestic trade in grains be relaxed. If implemented, these reforms could be expected to have a favorable environmental impact by reducing artificial pressure to intensify grain cultivation and to meet nationally set targets, irrespective of local conditions.
Pricing and Distribution of Agricultural Inputs

3.89 The Government links the distribution of some farm inputs, especially fertilizer, to the production of specified crops in certain areas. That is, inputs are allocated by administrative rather than market means, at prices that are directly or indirectly highly subsidized. The stated reason for this is to give farmers an incentive to use more fertilizer; it also has the effect of compensating them for distorted crop prices. As described in para. 3.13, this probably leads to the allocation and use of fertilizer on crops and in areas where its marginal product is not optimized. The elimination of direct allocation and subsidization of fertilizer will have to be linked to reforms in the pricing and marketing of crops. The Government directly and indirectly supports the survival of small, inefficient plants that produce low-grade fertilizer. This results in disproportionate use of low-grade products, which have the environmental disadvantages described in para. 3.11. As in the case of grain policy, the reforms that the Bank is recommending for reasons of economic efficiency can also be expected to have desirable environmental effects.

3.90 As for pesticides, the only analysis available, which is several years out of date, suggests they are subsidized to some degree. Subsidization is inappropriate both because the Government wishes to promote their selective use within an integrated pest management program, and because there are external costs to their excessive use. An updated analysis of pesticide pricing and distribution is therefore a high priority.

3.91 Two related problems in water use for irrigation can be partly addressed through pricing. First, overapplication of water by farmers, which is leading to waterlogging and salinization of soil in some areas (see para. 3.28), is encouraged by water charges that are uniform irrespective of the quantity used. It would be impractical to recommend the introduction of universal volume-related water charges at the farm level, but a volume-based charge for groups of farmers served by a minor canal has been introduced in some areas. In water-scarce areas, there should already be a strong motivation to use such charges to allocate water in an economically efficient way. These motives would simply be reinforced by environmental considerations. Thus, where volume-based charges have been tried, the Government should evaluate whether they have had the desired effect on water use and soil salinization, and determine the most cost-effective method of measuring water use. Second, the excessive drawdown of groundwater, described in paras. 3.30-3.31, calls for a combination of tighter regulation of pumping rights and improved pricing methods. At present, groundwater charges to farmers cover only the costs of pumping and distribution; there is no charge for the water itself. That is, although the water is a valuable resource that is partly fixed in quantity, there is no rational means of allocating it. Also, since charges for surface water are usually higher than groundwater pumping costs, farmers have an incentive to sink tubewells even when surface water is available. The introduction of charges for groundwater, as done in Indonesia and Israel, would not only limit its total use, but also help authorities to introduce conjunctive use of surface and groundwater.
Land Tenure and Land Use Patterns

3.92 The security and duration of farmers' tenure of their land affect their decisions about exploiting and enhancing its potential. For example, assigning control of grazing lands in Gansu Province to individual households appears to have resulted in a more sustainable level of grazing. In fuelwood forestry, where revenues are not earned until several years after planting, the land tenure and contracting arrangements are obviously a crucial element in the incentive to plant trees. On the other hand, it has been alleged that the introduction of the household responsibility system for crop production has disrupted traditional, sustainable cropping patterns in favor of techniques with rapid but unsustainable payoff. As pointed out above, this complex topic is best examined in the context of local geographical and agricultural conditions.

3.93 In regard to grazing lands, Chinese agricultural administrators generally believe that development means more intensive use in crop production rather than secondary production through grazing animals harvesting native forages. Even where marginal environmental conditions are acknowledged to be too limiting for cropping, the development goal is to introduce higher producing forage species, usually as an attempt to meet the demand of the excessive numbers of livestock already present. It is a scientifically doubtful premise that introduced forage species will raise the productivity of grazing land if growing conditions are already limiting for native species. The attempt to grow crops on marginally productive land increases the stocking rate on the remaining, more marginal grazing land, which is least able to maintain a sustainable ecological condition under the increased grazing pressure.

3.94 However, if the grazing land with the highest potential productivity were converted to perennial forage crops adapted to growing conditions, not only would soils be protected, but the increased productivity could potentially provide for increases in livestock while reducing grazing pressure on the marginal land. It is this situation that has the highest potential to increase forage and fodder availability by introducing species from other areas. The main point is not that all development activities are necessarily harmful to the grazing land environment, but that development activities are being undertaken without an awareness or clear understanding of environmental limitations (e.g., forcing development of rainfed farming in an area ideally suited to extensively managed animal husbandry).

3.95 Although Chinese authorities have established many regulations governing the use of different types of land, they have only occasionally tried to use the tax system to encourage the desired use patterns. In many cases, existing taxes on agricultural products, incomes and profits directly affect the quantity and composition of agricultural output and, indirectly, decisions about developing and using land and resources. For example, the very high rate of taxation on timber compared with that on field crops may act as a disincentive to establish tree plantations for fuelwood. An analysis of these effects is complex and was unfortunately outside the scope of this study. It should be a priority topic for future study.
Overall Investment Priorities

3.96 Government investment in agriculture has been strongly influenced by the need to meet grain production targets. Since a given amount of investment in conversion of new land often generates more crop production--in the short term--than investment in improvements to already cultivated land, investment programs have tended to concentrate on the former. In selecting and preparing investment projects, all levels of government should take a more systematic account of environmental costs and the prospects for sustainability. Environmental aspects of development should not be solely the concern of small, marginal "environment departments," but should be integrated into mainstream operations.

Water Conservation

3.97 Despite extensive investment in irrigation and drainage civil works, problems of drought, waterlogging and salinization persist. Water conservation projects should be based on comprehensive plans that incorporate drainage, conjunctive use of surface and groundwater, and improved management and control procedures. The following measures should be considered:

(a) Integrate regulations and control of surface and subsurface water, and design operating rules for drainage, irrigation, storage, and recharge. Irrigation and drainage should be integrated, with primary emphasis on drainage, so that excess water can be drained and drought-stricken land can be properly irrigated.

(b) Develop conjunctive use of ground and surface water by developing a network of well irrigation systems. In light of the different hydrogeological conditions in each locality, pump wells should be placed so that there is both extraction and replenishment of groundwater and so that the wells ensure groundwater is used during drought periods while river waters replenish the groundwater sources during periods of surplus.

(c) Strengthen irrigation management by training personnel, improving the system of irrigation and using water scientifically. Irrigation should be done at the right time, in keeping with local conditions and according to differing crop water requirements.

(d) In the North China Plain, divert the water from the Yellow River and other rivers to irrigate areas along these rivers. There should be strict control, however, over the quantity, frequency and timing of water diverted. The area to be irrigated, quantity of water, time periods and management personnel should be fixed ahead of time to prevent indiscriminate water diversion, which leads to secondary salinization.
Support Services

3.98 There are many farming practices whose environmental advantages have been demonstrated but which most farmers do not use. These include integrated pest management methods, contour planting, recycling of crop residues, agro-forestry, and others mentioned above. On a larger geographic scale, too, concepts of integrated watershed management and other farming system approaches have been studied for some time. While Chinese authorities have established numerous research projects and demonstration sites for "ecological agriculture," it remains unclear what the potential and obstacles are for widespread adoption of these techniques. It is also not evident what lessons from these "model" communities can be applied to the typical farming system under the existing structure of prices and incentives. The Government should therefore analyze more closely the extent to which improved extension services, access to technical assistance and training, civil works and equipment, and other investments could contribute to wider dissemination of known techniques.

Fuelwood and Rural Energy

3.99 In order to arrest the degradation of natural forests, high-yielding fuelwood plantations have to be established, alternative forms of energy such as biogas need to be developed, and energy conservation measures increased. It has been difficult to establish successful fuelwood stands through regulations or compulsion alone. People have little incentive to invest in establishing and maintaining plantations, and to convert cropping or grazing land to trees, as long as crop residues and other wood is available "free." Moreover, unless the whole community feels responsible for the plantation’s success, some people will illicitly take wood for their own use. Not only does the overall pattern of land use have to be considered, but also relative prices and incentives for alternative rural energy sources.

Research and Extension

3.100 This chapter has identified several priorities for basic research and better adaptation and extension of known results. Priorities for new research include:

- Crops and cropping systems suitable for steeply sloped, nutrient-poor or otherwise difficult sites (see para. 3.43).
- Further plant breeding for pest resistance and drought and salinity tolerance (see para. 3.29).
- Identification of multipurpose plantation regimes (e.g., plantings for a combination of fuel, timber, protection, cash crops, etc.) that can be financially attractive to farmers (see para. 3.62).
- Basic research and monitoring of marine fish stocks of all species, with a view to developing effective guidelines and regulations that can be monitored (see para. 3.68).
Priorities for improved extension include:

- Detailed soil analysis (including organic matter content) to establish the nutrient status of soil for cultivation of a given crop.
- Treatments for green and animal manure to make them easier to handle and transport.
- Training for farmers in pesticide handling.
- Extension of IPM measures.
- Contour planting, vegetative barriers and other on-farm erosion control techniques.

The Chinese and provincial research and extension services should reassess the importance given to such topics in their overall programs.

Regulations

3.101 Because of China's dense network of institutions and its tradition of administrative control over individuals and firms, it may be more ready and able than other developing countries to use regulations to induce desirable environmental practices on its farms. One area where the regulatory framework appears entirely inadequate is groundwater exploitation. At present, the only requirement for sinking a well is money to finance the drilling and the pump. Better local regulation of groundwater use, combined perhaps with a pricing mechanism as described in para. 3.91 is an urgent priority. More generally, though, regulations already exist to govern most major aspects of agriculture, including land use, soil and water conservation, pesticide use, marine fishing, etc. However, the problems cited in this chapter indicate that these regulations are not always enforced. Local authorities charged with enforcement may find it prudent to put the achievement of production objectives, for which they may also be responsible, ahead of enforcement of environmental rules. A careful review is needed (but was outside the scope of this paper) of both the resources devoted to enforcement and the institutional forces that may weaken enforcement.
IV. LOSS AND DEGRADATION OF NATURAL ECOSYSTEMS

A. Introduction

4.1 In virtually every country in Asia, the major environmental problems are similar. Pressure on a limited natural resource base to feed, house, clothe, and provide the energy needs of an expanding population leads to degradation of land, destruction of natural habitats, pollution of land and water (from urban and industrial sources), and pollution of the atmosphere (mainly from energy generation). China is no exception.

4.2 If present trends continue, within the next few decades China will lose almost all wildlands outside its nature reserves—a loss that will be irreversible. Not only will valuable plants and animals be lost, but many of the various ecosystem "services," such as the regulation of water discharge and the absorption and breakdown of pollutants, will also disappear. The diverse gene pool crucial to maintaining or increasing agricultural productivity will be lost or severely diminished. Wildlands already under protection but insufficiently managed could also disappear. The loss and degradation of ecosystems on this scale is a matter of immediate urgency and concern. However, China, like many developing countries, gives low priority to preserving its wildlands, in part because their importance to economic activity is not well appreciated at many centers of decision-making.

General Trends

4.3 The precise rate and magnitude of the loss of natural ecosystems is difficult to ascertain, given the patchiness of data and the lack of reliable time-series data. However, based on Chinese reports, observations, and interviews, the rate of loss seems to have accelerated after World War II, primarily as a result of pressure from population increases and accelerated economic development.

4.4 The rate at which specific natural ecosystems are disappearing in China varies according to the type of ecosystem and the value that government and society attach to it. For instance, the environmental impacts from loss of forest cover have been well described worldwide, and a growing awareness within China of these effects, and their economic consequences, has helped slow the trend of deforestation. Forests in upper catchment areas are now recognized as crucial in reducing silt content, regulating water flow, and ensuring a water supply to farmland at the foothills. In the arid Northwest, the forests of euphratica and tamarisk trees are now far more valued for protection against desert encroachment than for fuel.

4.5 Since attention to forests in China has increased and slowed the trend to destruction, the two natural ecosystems the most threatened today are

1/ The term "natural ecosystem" will be used throughout this chapter to refer to wildlands (or wilderness areas), wetlands, grasslands and forests, even though some of these ecosystems are substantially modified by people.
wetlands and, to a lesser extent, grasslands. These two ecosystems are viewed by the Chinese as "wastelands" and therefore lands that should be "improved" or converted to more productive uses. Yet both ecosystems provide important economic as well as ecological benefits.

4.6 For example, wetlands are areas of great natural productivity, hydrological utility, and biological diversity. They provide natural flood control, improve water quality, recharge aquifers, stabilize the flow of streams and rivers, and provide habitat for fish and wildlife. Similarly, grasslands are a natural buffer against encroaching deserts and thus protect farmland; they are a self-renewing resource, requiring little or no outlay of energy to produce meat, milk, wool, and so forth. They are, as well, valuable ecologically, being rich in diverse plant and animal species. However, China is expected to include in its forthcoming Eighth Five-Year Plan the further conversion of large areas of grassland to agriculture, in places such as Inner Mongolia, and similar conversion of wetlands in Sanjiang Plain in Heilongjiang Province.

4.7 Coastal salt marshes could be the first natural ecosystem in China to disappear totally, as they are rapidly being converted to rice fields and fish and shrimp ponds in the interest of economic development. Ironically, the only constraint to this rapid conversion of coastal salt marshes is the shortage of investment funds.

4.8 This chapter examines the loss of China's natural ecosystems through deforestation, degradation and conversion of grasslands and wetlands, siltation of major inland lakes, and marine pollution. Table 4.1 summarizes the status of the major ecosystems. (See also para. 4.53 for a discussion of the significance of China's per capita share of natural resources.) The chapter discusses the major consequences and causes of this loss, and assesses Chinese responses. It also identifies key areas for attention, examines institutional arrangements and makes recommendations for change. Chapter III discussed environmental problems associated with agricultural development.

B. The Status of Natural Ecosystems in China

Forest Ecosystems

Deforestation

4.9 Deforestation resulting from conversion to farmland, state-run commercial logging, illegal private cutting, and fires has long been identified as a major environmental issue in China. The problem was exacerbated in the years from 1950 to 1970, during the periods of the Great Leap Forward and the Cultural Revolution, when illegal felling of trees for lumber and fuel became rampant and the conversion of forests to cropland was extensive. Natural tropical forest in Hainan dropped from 25 percent (of total area) in 1956, to 19 percent in 1964, to 8.5 percent in 1981.2/ This massive deforestation

### Table 4.1: COMPARISON OF MAJOR ECOSYSTEMS

<table>
<thead>
<tr>
<th>Country / Region</th>
<th>Land Area (000 ha)</th>
<th>Croplands</th>
<th>Forests</th>
<th>Rangelands ( ^a )</th>
<th>Wetlands ( ^b )</th>
<th>Wilderness</th>
<th>Other Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>China (1)</td>
<td>932,641</td>
<td>100,890</td>
<td>134,532</td>
<td>340,000 ( ^c )</td>
<td>25,000</td>
<td>182,247</td>
<td>174,972</td>
</tr>
<tr>
<td>India (1)</td>
<td>297,319</td>
<td>168,550</td>
<td>67,327</td>
<td>11,900</td>
<td>17,296 ( ^d )</td>
<td>1,538</td>
<td>48,004</td>
</tr>
<tr>
<td>Asia (1)</td>
<td>2,678,653</td>
<td>451,030</td>
<td>539,890</td>
<td>678,546</td>
<td>n.a. ( ^e )</td>
<td>372,454</td>
<td>636,733</td>
</tr>
<tr>
<td>World (1)</td>
<td>14,626,624</td>
<td>1,473,059</td>
<td>4,074,427</td>
<td>3,215,463</td>
<td>n.a. ( ^e )</td>
<td>5,088,731</td>
<td>775,144</td>
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<table>
<thead>
<tr>
<th>Percentage of Total Land Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
</tr>
<tr>
<td>India</td>
</tr>
<tr>
<td>Asia</td>
</tr>
<tr>
<td>World</td>
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</table>

<table>
<thead>
<tr>
<th>Per Capita Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country / Region</td>
</tr>
<tr>
<td>1,135.5</td>
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<tr>
<td>853.4</td>
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</tbody>
</table>

/\( ^a \) Rangelands, as defined by the World Resources Institute (1988), include arctic tundras, temperate grasslands, annual desert grasslands, semiarid shrublands, grazing areas carved from monsoon forests, and even swamplands. Figures given are by the Food and Agricultural Organization for permanent pasture, which underestimates total size of rangeland.

/\( ^b \) Wetlands may be included with other types of land cover, therefore, they are not factored into summary statistics, percentages of total land area, or per capita distribution of land cover.

/\( ^c \) Includes permanent pasture and other types of rangeland. (World Resources 1988-89, p. 79).

/\( ^d \) Excluding rivers; paddy cultivation in croplands.

/\( ^e \) n.a. = data not available

Sources:
(2) World Resources Institute, World Resources 1990-91 (New York: Oxford University Press, 1990)
(3) D. Scott, A Directory of Asian Wetlands (Gland, Switzerland: IUCN, 1989).

increased soil erosion and siltation of rivers, and resulted in catastrophic floods. Such direct negative economic effects led to government intervention to control random felling and to establish large-scale plantations to meet demands for timber. Table 4.2 summarizes recent Ministry of Forestry (MFO) data on forest cover that may indicate significant progress from these efforts.

**Information Available**

4.10 There is better information for forest ecosystems than for any other ecosystem type in China because of the national forest inventory program that began in the 1950s. Systematic information is now collected from 255,000 permanent forest plots at least every five years. According to the 1989 govern-
Table 4.2: CHINA'S FOREST COVER  
(Heilongjiang, Yunnan, Guangdong and Hainan Provinces)  
(000 ha)

<table>
<thead>
<tr>
<th></th>
<th>1973-76</th>
<th>1977-81</th>
<th>1984-88</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land area</td>
<td>960,272</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural forest</td>
<td>98,170</td>
<td>87,466</td>
<td>86,354</td>
</tr>
<tr>
<td>Plantations</td>
<td>23,690</td>
<td>27,812</td>
<td>38,299</td>
</tr>
<tr>
<td>Forest cover (%)</td>
<td>12.7</td>
<td>12.0</td>
<td>12.98</td>
</tr>
<tr>
<td><strong>Heilongjiang Province</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total land area</td>
<td>72,280</td>
<td>45,461</td>
<td>45,461</td>
</tr>
<tr>
<td>Natural forest</td>
<td>24,320</td>
<td>13,552</td>
<td>12,383</td>
</tr>
<tr>
<td>Plantations</td>
<td>880</td>
<td>1,742</td>
<td>3,233</td>
</tr>
<tr>
<td>Forest cover (%)</td>
<td>35</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td><strong>Yunnan Province</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total land area</td>
<td>38,340</td>
<td>38,264</td>
<td>38,264</td>
</tr>
<tr>
<td>Natural forest</td>
<td>9,220</td>
<td>8,380</td>
<td>8,146</td>
</tr>
<tr>
<td>Plantations</td>
<td>340</td>
<td>817</td>
<td>1,180</td>
</tr>
<tr>
<td>Forest cover (%)</td>
<td>25</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td><strong>Guangdong Province</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total land area</td>
<td>22,090</td>
<td>21,201</td>
<td>17,790</td>
</tr>
<tr>
<td>Natural forest</td>
<td>3,920</td>
<td>3,306</td>
<td>2,290</td>
</tr>
<tr>
<td>Plantations</td>
<td>3,570</td>
<td>2,573</td>
<td>2,575</td>
</tr>
<tr>
<td>Forest cover (%)</td>
<td>34</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td><strong>Hainan Province</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total land area</td>
<td>n.a.</td>
<td>n.a.</td>
<td>3,410</td>
</tr>
<tr>
<td>Natural forest</td>
<td>-</td>
<td>-</td>
<td>557</td>
</tr>
<tr>
<td>Plantations</td>
<td>-</td>
<td>-</td>
<td>309</td>
</tr>
<tr>
<td>Forest cover (%)</td>
<td>-</td>
<td>-</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: China Ministry of Forestry (September 1990).

ment statistics from the latest five-year forest inventory,\(^3\) the total forest cover (natural and plantations combined) has increased slightly from 12 percent some ten years ago to 13 percent today.\(^4\) Much of the increase in forest cover is the result of large-scale afforestation, changes in manage-

\(^3\) From the Ministry of Forestry, Department of Forest Resources and Forest Policy, July 1990, which aggregated data from the provinces.

\(^4\) Some skeptics suggest that the actual forest cover is around 10.5-11 percent and is expected to decrease to 8.3 percent by the year 2000 (K. Forestier, "The Degreening of China," New Scientist, July 1, 1989).
ment practices (e.g., the establishment of forest responsibility systems to plant and maintain trees), reforms in timber pricing policy, and public education campaigns. Tree cover is expected to continue to increase, albeit slowly, as a result of the government's ambitious program to establish and rehabilitate up to 57.2 million ha of plantations by the year 2000.

Although past afforestation efforts have had problems with tree survivorship (which is reported as low as 30 percent), an effort is now being made to improve performance by introducing more effective forestry management practices and by providing a variety of incentives to promote their use and to encourage the planting of better quality trees.

Fuelwood

4.11 It is unclear whether current measures are meeting the heavy demand for fuelwood by the rural poor. Fuelwood ranks number one among all energy resources used by rural households and its collection has been a major cause of deforestation in China. The Ministry of Forestry estimates that of the approximately 344 million m$^3$ of timber consumed in China each year, one third is consumed for fuel. In 1987, the total supply of fuelwood from all types of forestry was 1.4 million tons—about half of the estimated consumption of rural households. This implies that the other half is met by uncontrolled felling and collection from natural forests as well as plantations, although much of the fuel used is probably in the form of brush and crop residues. This challenges the present forestry initiatives that give fuelwood supply a lower priority than commercial plantations or those designed for protection (i.e., shelter belts). (A more detailed discussion of the environmental implications of rural energy supply and demand is covered in the preceding chapter, paras. 3.61-3.63 and 3.99.)

Trends

4.12 In spite of the recent stability of areas under tree cover, the degradation and loss of natural forests is a matter of continuing concern. The latest inventory shows that forest cover has increased in the south as a result of the expansion of plantations, but has decreased in the northeast and Inner Mongolia because of unsustainable harvesting. Currently, the large areas of remaining natural forests in the northeast, southwest, and on Hainan Island are being selectively logged for commercially valuable species until

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6/ China Daily (October 1990) reported approval from the State Council to afforest, by year 2000, some 57.2 million ha of land, of which 16 million ha will be timber forests, 12 million ha environmental protection forests, 4 million ha for fuel, 6 million ha for fruit and nut trees.

they are no longer commercially valuable. At that time, the land is generally cleared and the trees replaced with monoculture plantations that have a higher commercial value (e.g., larch in the northeast or rubber on Hainan Island). Natural forests will continue to be overexploited until plantations can be developed to reduce the current annual shortfall of some 28-30 million m³ of timber.

Grassland Ecosystems

4.13 Northern and western China contain the world's most extensive grasslands, which occupy over one third of the country. Most of China's grasslands are concentrated in Inner Mongolia, Xinjiang, Tibet, and the adjacent provinces, which are sparsely populated, but which contain millions of sheep, goats, cattle, horses, and camels. Although the Chinese consider grassland degradation and its loss a major environmental problem, China's major concern for its grasslands is economic. Large numbers of ethnic minorities depend on the grasslands for their livelihood. Increased demands and open trade for meat, wool, hides, and other animal products (e.g., China's textile industry has outstripped the supply of wool, driving up imports to $900 million in 1988) has accentuated the economic potential of these ecosystems.

4.14 Grassland ecosystems in China have been grazed for thousands of years and have generally evolved under grazing pressure. The point is that: (a) grazing by livestock as well as wild herbivores is a natural part of this system; (b) grassland ecosystems can stand relatively high grazing pressure; (c) the grassland ecosystems in the north of China are relatively resilient and unless the degradation process caused by overgrazing is allowed to proceed beyond a point of no return, progressive succession is an important characteristic of these ecosystems. These grassland ecosystems have been grazed and probably should be grazed to maintain them in high ecological condition. The salient point, however, is that the scale and rate of degradation that is occurring today is the result of an imbalance between livestock and the amount of grazing land available, and the conversion of the most productive grazing land (in terms of producing forage for livestock) to marginal, rainfed cropland. The grassland ecosystem is being pushed to the point of no resilience; degradation is so extreme and occurring over such a wide area that even if the negative factors were removed immediately, the extent of soil problems, emergence of poisonous plants and desertification, etc., have greatly reduced the productive capabilities of the grassland ecosystems.

Reclamation and Conversion

4.15 China has a long history of reclaiming grasslands for crop production. Reclamation of the north and northwestern areas intensified after World War II, resulting in heavy losses of natural grasslands to cropland and in degradation caused by overstocking the range. This combination of conversion and intensified use has accelerated desertification by eliminating the vegetative cover, the natural buffer against desert encroachment. Conversion of grassland to rainfed cropland may also result in excessive soil erosion.

addition, overgrazing disrupts the food chain, resulting in outbreaks of pests and reduced productivity of the grassland. For example, pests such as rats and insects are adapted to feed on less nutritious and more noxious herb and grass species, and are creating a problem of increasing concern. In Qinghai Province, 26 million ha are estimated to be affected by rats, causing an estimated loss of some 3 billion kg of forage grass per year.9/

4.16 While the scale of land conversion is certainly a major problem, the type of conversion is also important from the standpoint of what is practical, given the large population living on grazing lands. The conversion to annual rather than perennial crops is a major destabilizing factor in the grassland ecosystem. In the relatively harsh environment of North China or even in the humid subtropics, annual cropping predisposes the land to erosion by wind and/or water. Planting perennial fodder crops would have the benefit of (a) providing fodder for livestock to reduce the pressure on the remaining natural grazing lands, and (b) provide a year-long vegetative cover to reduce the amount of erosion.

4.17 The issue of land conversion involves not just converting land from a natural state to an agronomic condition, but trying to do so under the marginal environmental conditions characterizing semiarid and arid grazing lands. Under these conditions, the long-term instability introduced into the system outweighs benefits from the short-term increases in productivity. Expensive inputs in terms of fertilizer, irrigation, etc. are required to maintain the higher productivity. For example, crops can be grown under rainfed conditions in Inner Mongolia but their productivity will be low without fertilizer and irrigation. The areas suffering the greatest degradation from current attempts to convert grazing land to cropland lie in the zone between areas that are obviously too marginal in rainfall and temperature for cropping (i.e., cold and dry) and the more humid areas in which cropping is more practical in terms of the input/output ratio.

**Trends**

4.18 Degraded vegetation, large-scale erosion by water and wind, and poor physical condition of grazing animals indicate that the carrying capacity of grasslands is being exceeded.10/ From 1950 to the 1970s, an area of approximately 334,000 km² became desertified, expanding at a rate of 1,560 km² per year. Degraded grassland increased from 15 percent of the 250,000 ha of usable grassland in the 1970s to more than 30 percent in the middle 1980s.11/ Currently, the area of degraded grassland is up to 86.6 million

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10/ D. Sheehy, personal communication Texas A&M University, Lubbock, TX, 1991.

11/ Data from briefing notes provided by the Chinese Academy of Science.
ha and is increasing at a rate of 1.3 million ha a year.12/ The predicted trend is that grassland ecosystems will continue to be lost and modified, not only by continued conversion and overstocking, but also as a result of the pasture improvement programs that favor selected species and thus simplify the ecosystem, creating more favorable conditions for rodents and insects.

4.19 The major difference between earlier cycles of desertification and the current cycle is their relative scale. Modern tools and advanced technologies allow increasingly marginal grassland to be converted to cropland that soon becomes economically unproductive and eventually agriculturally unsustainably. Continuing planned conversion increases the threat. For instance, in the proposed Eighth Five-Year Plan, the State Farm and Land Reclamation Bureau proposes to convert 125,000 ha in Inner Mongolia and 20,000 ha in Xinjiang.

River, Lake, and Marine Ecosystems

4.20 China has numerous rivers and lakes. There are some 1,500 rivers with drainage areas of more than 1,000 km² each, and 50,000 others with drainage areas of more than 100 km².13/ Most of the rivers are located in the southeast outflow region and flow toward the China sea. The five major lake areas are the eastern plains, Qinghai-Tibet Plateau, Inner Mongolia, Yunnan-Guizhou, and the northeast region. Within these areas are 13 lakes that cover more than 1,000 km² each, and more than 2,600 smaller ones that are larger than 1 km².

Causes of Loss

Cultivation of Lakefront Land

4.21 Although sediment loading (due mainly to upstream deforestation) and new dams (which divert water from lake areas) have been important factors in reducing lake size in China, the major cause of the disappearance of lakes has been the cultivation of lakefront land. This practice, which began as early as 3,000 BC, has accelerated in the past 30 years, particularly in the east, where population has increased more than 2.5-fold. Reclamation and cultivation decrease the capacity of the land to absorb water and release it slowly, causing flooding, silting and drying in the lower reaches of some rivers, and resulting in great losses of aquatic resources and fish catch. On the Jianghan Plain, the number of lakes with an area of more than 50 ha dropped by almost half from the 1950s to the 1980s. Two large lakes, Dongting and Poyang, have lost 170,000 ha and 80,000 ha, respectively. The reduction in the capacity of Poyang Lake is believed to have caused floods on the Poyang Plain six times in the past 30 years. Taihu Lake, which was originally connected to three rivers flowing to the sea, now links only with the Huangpu River.


13/ From China Natural Conservation Strategy.
Pollution

4.22 As indicated in Chapter II, China's water resources have been facing an even more destructive threat from pollution, mostly as a result of dumping raw sewage and other wastes into rivers, but also as a result of aquaculture activities. Since 1980, the amount of industrial wastes dumped into rivers and lakes has increased with the growth in industry generally, but more important, it has increased with growth in numbers of enterprises located along water bodies. Unfortunately, efforts to reduce urban pollution by moving industry out of heavily populated areas added to the rapid growth in rural town and village industrial enterprises. The increase in rural populations also has produced increased household wastes and agricultural runoff that drain into the waterways and lakes, degrading them further and hastening the accumulation of nutrients and reduction of oxygen supply (eutrophication). Often, this process is even further intensified by adding organic fertilizers to lakes to increase fish production.

4.23 These land-based effluent discharges are also threatening coastal and marine ecosystems. Some 85,000 factories and more than 9 million TVIEs and collective enterprises along the coast discharge some 5-7 billion tons of effluent per year into estuaries and coastal waters. Such discharges have had more impact on near-shore coastal environments than on far-shore marine ones, because the strong ocean currents flush and dilute the wastes. However, the potential for ocean pollution is a global concern of importance to the Chinese.

4.24 Industrial and urban wastewater discharges have increased eutrophication of some coastal sea areas and are believed to be the cause of the increasing frequency of red tides. In 1989, a red tide occurred in the coastal waters near Huanghua City, causing damage to 1,635 shrimp areas, an economic loss of Y 25 million. The Bureau of Fishery and Fishing Port Supervision of the Ministry of Agriculture estimated that the average annual direct loss of fish yield due to pollution is 140,000 tons, or about Y 240 million.

Trends

4.25 Polluted rivers and lakes affect public health since most people living next to these water bodies use them for drinking water. It is estimated that 150 million Chinese are drinking polluted water (see Chapter II). In Zhejiang Province, surface water is so contaminated in some areas that drinking water must be piped in. In 1986, red tides in Dongshan, Fujian Province, poisoned 136 residents. In 1988, an outbreak of hepatitis caused by polluted shellfish infected approximately 300,000 people in Shanghai. The trend is expected to get worse since population in the coastal areas of

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14/ From briefing notes provided by the State Oceanographic Administration, July 1990.

15/ Marine plankton bloom in a density fatal to many forms of marine life because of large amounts of toxic by-products produced at high densities.

16/ Data provided by the State Oceanographic Administration, July 1990.
China is estimated to reach 500 million by the year 2000, with a concomitant doubling or tripling of industrial and urban wastes.

Wetland Ecosystems

4.26 Wetlands include coastal salt marshes or mudflats, and inland marshes. A marsh is a tract of lowland that is usually seasonally waterlogged. A mudflat is low, muddy land that is sometimes called salt marsh. China has a great variety of wetlands, including some of the most important wildlife habitats in the world. Although wetlands in China comprise only one fourteenth of the total land area, they contain some 400 species of wildlife (one fifth of all land vertebrates in China), of which 36 species are classified as rare and endangered.17/

Coastal Wetlands

4.27 Coastal wetlands are under the most immediate threat—from land reclamation and from contamination by domestic, industrial, and agricultural effluents. Some 40,000 ha of mudflats in Jiangsu, Zhejiang, Fujian, Guangdong, and Liaoning have been reclaimed for grain, cotton, and sugarcane since 1949. On the coast of Guangdong, large tracts of mangrove forests have been cut to make room for farmland. Of the 8,000 ha of mangrove forest on Hainan Island until recently, only 2,000 ha now remain and very little is left of the groves along the Fujian coast.18/

4.28 However, there is also a natural process of land building due to high silt and sediment loads in many rivers. These sediments are deposited on the mudflats of river deltas, producing new land. This process often creates wetland habitat favorable for shorebirds and other wildlife. The major issue is whether more wetlands are being destroyed by development than are being created by natural and man-made causes, and the quality (e.g., ability to sustain equivalent numbers of species, or the potential for biological diversity; functional value such as storm buffer, etc.) of these newly created habitats compared with the mangroves, mudflats, and marshes they have replaced.

Trends

4.29 Most of China's 3.1 million ha of coastal marshes and mudflats are located in the Hangzhou Bay area; around the estuary of the Yellow River in Bohai Gulf; and in the estuarine system of the Shuangtaizi, Liao and Hun rivers in Liaoning Province. Most of the rivers flowing into the Yellow Sea carry large amounts of sediment, resulting in rapid growth of deltas and continuous creation of new wetlands. Each year, the rivers dump about 2 billion tons of silt into the sea, forming 26,000 to 33,000 ha of land. To the south of Hangzhou Bay, extensive wetlands occur only at the mouths of larger rivers,


18/ Ibid., pp. 129-260.
such as the deltas of the Pearl River and Min River. Scattered stands of mangroves cover a total area of 67,000 ha, much of which is extremely degraded. Some of the best remaining stands are to be found on Hainan Island, for example, in Dongzaigang Nature Reserve. These coastal wetlands are very important as storm protection and for fisheries.

4.30 Without policy changes, it is likely that most coastal wetlands will disappear within the next 10 to 20 years, particularly in East China (Shanghai, Zhejiang, Jiangsu, and Shandong) as a result of population and economic pressures. Nearly 100 million people live in or near the coastal zone, exerting heavy pressure on the land and resources. At present, the coastal areas produce 50 percent of the gross national product. The opening of 14 coastal cities and four special economic zones to international trade has increased development activities.

4.31 At the national level, the State Oceanographic Administration conducted a coastal zone investigation from 1979 to 1986 which concluded that the coastal zone has been underexploited. Consequently, SOA is drafting a coastal zone development plan, particularly to promote increased development of shrimp and fish farms. Coastal provinces are also drafting plans for the conversion of their coastal wetlands. Liaoning Province, with the second largest contiguous salt marsh in the world, has already converted one third of its marsh to agricultural fields and has recently developed a ten-year plan for further rapid conversion.

Inland Marshes

4.32 Most of China's inland marshes are located in Sanjiang Plain, the Greater and Lesser Hinggan Mountain ranges, the Changbai Mountains in the northeast, and the Qinghai-Tibet Plateau. Total estimated marsh area is 11 million ha. The largest freshwater marshes in China are situated in the northeastern provinces of Heilongjiang, Jilin and Liaoning, and in northeastern Inner Mongolia. The Sanjiang Plain covers some 1.1 million ha of shallow freshwater lakes, reed marshes, and peat bogs in the lowlands. The wetlands in this area are extremely important as breeding habitat for waterfowl, notably the endangered red-crowned crane (Grus japonensis), and are also very important for their fisheries and reed production. Reed is an important raw material for pulp and paper and accounts for 26 percent of China's total pulp output. Unfortunately, these marshes have been under rapid development since the mid-1950s. The forthcoming Eighth Five-Year Plan proposes further development of some 266,000 ha of marshes in Heilongjiang for agriculture.

4.33 The other large contiguous area of freshwater marshes is found in the Ruoergai Highland in northwestern Sichuan (300,000 ha). This area contains the fifth largest peat reserve in the world. Fortunately, there is no immediate danger of large-scale reclamation (owing to a shortage of funds), although the area is being used at present for dumping industrial wastes. However, the Sichuan provincial government is exploring with foreign companies the extraction of peat from this area.

19/ Personal communication with wetlands experts at East China Normal University, Shanghai, China, July 1990.
Quantifying Value

4.34 In general, the Chinese view wetlands as "wastelands"—as not providing in their natural state the high economic returns they would if they were converted to agricultural or industrial production. For this reason, quantifying the value of natural wetlands in China would seem to be an important step toward developing a more rational use strategy. The importance of the ecological services provided by wetlands is now acknowledged worldwide, but quantification of these services is still in its infancy. However, there are examples of ways to calculate the commercial value of wetlands. The U.S. Army Corps of Engineers, for instance, estimated that the loss of 8,422 acres of wetland within the Charles River Basin, Massachusetts, would produce an average annual flood damage of over $17 million. Similarly, the market value of an acre of Louisiana coastal wetlands is about $500; but the real economic value lies between $2,500 and $17,000 per acre when one adds commercial fishing ($317-$846 per acre), trapping ($151-$401), recreation ($46-$181), and storm protection ($1,915-$7,549).20/

C. Consequences and Causes of Loss and Degradation of Natural Ecosystems

Consequences

4.35 The major environmental consequences of loss of natural ecosystems are generally accepted. Deforestation and loss of vegetative cover is linked with massive soil erosion, greater frequency of floods and droughts, advancing desertification and the loss of diversity of biological resources (see Table 4.3 for summary). The economic consequences of loss of natural ecosystems are less well appreciated, as is the interrelationship between the economic value and intrinsic value of natural resources. If the intrinsic value of an ecosystem is so little appreciated as to be severely degraded or lost, it frequently becomes of immediate economic value when the services it has been performing must be replaced.

4.36 Although the natural environment and its conversion for agricultural and other uses has played a central role in China's historical development, there is a growing recognition that conversion of natural ecosystems runs counter to efforts to improve the environment. For example, uncontrolled conversion of land is both the cause and the consequence of land degradation, intensified natural catastrophes and loss of soil productivity. The severity of this vicious cycle varies with region, natural conditions (fragility of the land), and population density, among other factors.

Soil Erosion and Natural Disasters

4.37 Soil erosion is very serious in China. Since the late 1940s, the eroded area has increased 38 percent, and areas subject to erosion now include one sixth of the total land area. For instance, only 4 percent of the total area in Jiangxi Province in the 1950s was affected by erosion, but the figure

Table 4.3: SUMMARY OF MAJOR CAUSES AND CONSEQUENCES OF ECOSYSTEM CHANGE

<table>
<thead>
<tr>
<th>Ecosystem/Resource</th>
<th>Causes</th>
<th>Consequences</th>
<th>Relevant Action Proposed in Eighth Five-Year Plan(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forests</td>
<td>- Increasing population</td>
<td>- Increasing fuelwood consumption</td>
<td>- n.s.</td>
</tr>
<tr>
<td></td>
<td>- Conversion to farmland</td>
<td>- Erosion, flooding, silting</td>
<td>- Conversion of 123,000 ha in Inner Mongolia and</td>
</tr>
<tr>
<td></td>
<td>- Conversion to higher yield monoculture</td>
<td>- Loss of biodiversity</td>
<td>20,000 ha in Xinjiang Province (a total of</td>
</tr>
<tr>
<td>Grasslands/Rangelands</td>
<td>- Conversion to farmland</td>
<td>- Increasing desertification</td>
<td>670,000 ha wetlands and grasslands in China)</td>
</tr>
<tr>
<td></td>
<td>- Overgrazing</td>
<td>- Degradation</td>
<td></td>
</tr>
<tr>
<td>Rivers/Lakes/Marine</td>
<td>- Dumping industrial wastes</td>
<td>- Pollution</td>
<td>- Conversion of 670,000 ha of wetlands and grasslands in China</td>
</tr>
<tr>
<td></td>
<td>- Growth of TVIEs</td>
<td>- Eutrophication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Increase in agricultural runoff</td>
<td>- (Possibly) red tide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Deforestation</td>
<td>- Decreasing fish production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Erosion for disease control</td>
<td>- Increased flooding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Conversion to fish ponds</td>
<td>- Decreased water quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Drained and filled for industrial use</td>
<td>- Loss of fisheries and wildlife resources</td>
<td></td>
</tr>
<tr>
<td>Coastal Marsh Wetlands</td>
<td>- Low value as “wastelands”</td>
<td>- Marshes may disappear totally by the year 2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Drainage for disease control</td>
<td>- Erosion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Conversion to fish ponds</td>
<td>- Increased flooding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Drained and filled for industrial use</td>
<td>- Increased wetland quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Pollution</td>
<td>- Loss of fisheries</td>
<td></td>
</tr>
<tr>
<td>Nature Reserves/Wilderness</td>
<td>- Nature reserves are “paper” parks, low in priority and not managed well</td>
<td>- Conversion to production forests, agricultural use</td>
<td>- Add 100 new nature reserves (to protect giant</td>
</tr>
<tr>
<td></td>
<td>- Lack of data on flora and fauna</td>
<td>- Poaching (fish, wildlife, timber, reed, pest, etc.)</td>
<td>ponds, marine, reserves, etc.)</td>
</tr>
<tr>
<td>Loss of Biodiversity</td>
<td>- Loss or pollution of habitats</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

21/ The Eighth Five-Year Plan had not been accepted at the time this report was prepared; plans reported may no longer be current.

rose to 10 percent in the 1960s, 13 percent in the 1970s, and 23 percent in the 1980s.21/

4.38 Although some of the erosion is either natural or caused by inappropriate practices on agricultural land, much is caused by the loss of vegetative cover through deforestation and clearing for agriculture, particularly in erosion-prone areas such as the loess plateau. Soil erosion in that area has raised the bed of the Yellow River in the lower reaches 10 cm a year and increased the cost of flood-control measures.22/ The economic cost of increased siltation is tremendous. For example, to the 100 million people living in the flood-prone areas, there are the costs (estimated at Y 1 billion) of raising the dike a fourth time and the costs associated with decreased reservoir storage capacity and reduced river transport.

4.39 Over the past 30 years, the number of disasters such as floods and landslides has increased, a trend that many Chinese experts attribute directly to the loss of vegetative cover. While it is not clear how much of the increase in disasters is attributable to natural phenomena or to man-made damage, the Chinese are greatly concerned by the trend in frequency of occurrence. For instance, 46 counties in the central Sichuan Basin are experiencing a 15-20 percent decrease in their annual average rainfall, and they have

21/ From China Natural Conservation Strategy.

22/ Data from briefing notes from the Ministry of Water Resources.
seen an increase in the incidence and duration of drought, from one 15-20-day drought every three years in the 1950s to one 40-50-day drought every year at present.

Desertification

4.40 Another major consequence of overuse or inappropriate use of natural ecosystems, particularly in arid and semiarid areas, is desertification. In general, desertification occurs when natural vegetative protection is removed and fertile soil is exposed to wind, which eventually wears the soil away, leaving only sand desert. Although deserts and desertified land account for 15.5 percent of the total land area in China, it is estimated that only 5.5 percent of that area can be attributed to a natural process of desertification. Most of the 3.3 million ha of deserts formed each year are caused by excessive conversion of marginal grassland to cropland and overstocking. Though the result--increasing desertification--is the same, the process of degradation caused by conversion and overgrazing is different.

4.41 Inner Mongolia is a representative and important example of the problem of desertification in China. The Inner Mongolian Autonomous Region of China is the major (range) livestock production base. The total area is 114 million ha, 86 million ha of which are considered usable for grazing. Pressure to increase production by overstocking or converting lands to agriculture for forage has placed the area under threat of desertification. As stated earlier in this chapter, one of the economic benefits of grasslands is that they are a naturally renewing resource that requires little or no supplementation. However, if the ecosystem is pressured to function unnaturally, a substantial exertion in cost and effort will be needed to maintain its productive capabilities or else it will eventually be degraded.

4.42 Inner Mongolia has been arid since the Cretaceous Age. The soil is sandy clay or sandy texture. Sandy clay is typically a shallow upper layer over a claypan. Either overstocking or conversion to rainfed crop production can cause erosion as surface soils become more exposed to wind and water. (Deep gullies are often formed and runoff from rangelands at a higher elevation creates further problems by degrading cropland at lower levels.) The restoration of highly eroded soils is often impossible or is very costly and requires mechanical intervention.

4.43 Sandy-textured soils, generally, are stabilized sand dunes--a thin layer of fertile soil over sand, low in fertility and extremely vulnerable to wind erosion. Soil fertility is limited to the topmost portion and a vegetative cover must be maintained to prevent desertification. Conversion of such soils to rainfed crops has not proved successful over a period of years, and has resulted in loss of previously productive grassland to desert. Landsat imagery of rangelands in Zhelimu and Zhaowunda leagues in Inner Mongolia confirms desertification from (a) conversion of highly productive rangeland to farmland near rivers and villages; (b) overgrazing of rangeland by livestock near villages and along rivers; (c) intensive cultivation of formerly stabi-

lized sand dunes; and (d) conversion of loss croplands to rainfed farming.24/

**Causes**

4.44 Two major practices of overstocking that have led to desertification in Inner Mongolia are the increase in total numbers of stock and the introduction of imported breeds. Overstocking can occur from sheer numbers and from the timing of grazing that does not allow for a seasonal rest of pasture to maximize the growth of desirable forage species. Because of the limited growing season in Inner Mongolia, maximum forage is available during July through September. Native Mongolian livestock were suited to the climate by their ability to store maximum body fat during the short season, and to survive the rest of the year on poor-quality roughage left in the pastures. The introduction of imported breeds that require high-quality forage year-round has put pressure on the pasture during the spring and early summer when new growth is not yet well established. Grazing during those months denudes the pastures of good forage plants, which are replaced by less palatable plants. In areas near villages that are typically the most overgrazed, good forage plants are replaced by poisonous invader plants, or suffer ecologic deterioration to bare soils and desertification.25/

**Remedial Efforts**

4.45 China has developed effective procedures for stabilizing sand dunes—for example, leveling and stabilizing the dune by planting trees on the leeward side and low-growing plants on the windward side, allowing the topmost portion to be blown away—but it is impossible to restore the land to its former richness and functioning. Clearly, it is urgent that desertification be slowed as much as possible or stopped.

**Loss of Biological Diversity**

4.46 China is recognized as one of the dozen "megadiversity" countries, which harbor 60-70 percent of the world's biodiversity (Table 4.4). However, as ecosystems are being lost or degraded, so is the diversity of species living there. China's rich biological diversity has intrinsic value, and also potential economic value. Biological diversity is necessary to sustain and improve agriculture, to provide opportunities for medical discoveries and even some industrial innovation,26/ and to preserve choices for addressing the unpredictable problems of future generations. The actual and potential eco-

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25/ Ibid.

26/ For example, polar bear hairs are tiny hollow tubes that funnel ultraviolet light inward to warm the body, and this feature has been incorporated into cold-weather clothing to produce a more efficient thermal garment; it could eventually be the pattern for solar-energy light, and pipe collectors for heating homes and offices.
nomic productivity of the world's diverse biological endowment, in uses ranging from subsistence foraging to genetic engineering, can hardly be overstated. Closely related are essential ecosystem services, which include moderating climate; concentrating, fixing, and recycling nutrients; producing and preserving soils; controlling pests and diseases; and aesthetic and ethical considerations. This endowment is in danger from the loss and degradation of natural ecosystems.

Table 4.4: CHINA'S "MEGADIVERSITY" STATUS

<table>
<thead>
<tr>
<th>Group</th>
<th>Mammals</th>
<th>Birds</th>
<th>Amphibians</th>
<th>Flowering Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of species</td>
<td>394</td>
<td>1,195</td>
<td>265</td>
<td>27,000</td>
</tr>
<tr>
<td>Rank worldwide</td>
<td>5th</td>
<td>10th</td>
<td>6th</td>
<td>3rd</td>
</tr>
</tbody>
</table>

4.47 China straddles the Palearctic and Indomalayan biogeographical regions and, benefiting from both regions, is very rich in biodiversity. Besides the diversity of ecosystem types, China contains 10 percent of the world's plants (or 30,000 vascular species) and 10 percent (or over 2,100 species) of total mammals, birds, reptiles, and amphibians. The grasslands of China alone contain some 4,000 species of grasses. Some 150,000 species of insects are believed to exist, of which only 35,000 species have been described thus far. Each year 400 new species of insects are identified. Some 200 genera of plants are native and many of the flora and fauna are unique to China.

4.48 Many of the species are also valuable. Of the 8,000 species of trees and shrubs, some 2,000 are timber species. Some 70 species of animals provide fur and leather. In the natural steppes in Inner Mongolia, there are more than 150 kinds of excellent forage grasses, as well as medicinal, fiber and dyestuff plants. Most traditional medicines exist in their wild form, including ginseng. China is also home to important wild relatives of cultivated plants. Hainan Island has some 380 different types of wild rice.

Causes

4.49 The major cause of species endangerment and extinction is loss of habitats (or ecosystems). However, in China, overhunting (for meat and skin) and collecting (for medicinal purposes and as valuable specimens) have also devastated some populations.

27/ From China Natural Conservation Strategy.

28/ Personal communication with the Institute of Zoology, Chinese Academy of Sciences, July 1990.

29/ From China Natural Conservation Strategy.
China is already experiencing the effects of the loss or reduction of ecosystem services because of its forest management practices. The simplification of more complex natural forest ecosystems as well as the increase in the area of monoculture plantations has produced an increase in pest and disease outbreaks. Stands of single species are more prone to attacks by insects and diseases than stands of mixed species. Each year some 1 million ha (mostly plantations) are infested, resulting in an economic loss of approximately 10 million m$^3$ of timber per year, a loss that China can ill afford. The incidence of insect and disease outbreaks is expected to increase as more plantations are established. The seriousness of the situation is reflected by the priority the Chinese Academy of Forestry Science places on pest research in the forthcoming Eighth Five-Year Plan. Also at risk are the diverse plant and animal species living in these complex forests that are valuable to local people for food and medicine, and that could also have commercial value.

**Trends**

Although records on extinctions in China are patchy, there is some evidence showing that the number of extinct species and endangered species have increased over the past 30 years. For instance, some 200 plant species are believed to be extinct, with an estimated 5,000 species becoming endangered in recent years as a result of deforestation, particularly in Hainan, Xishuangbanna, and southeast Tibet, which are areas rich in plant species. Between the years 1600 and 1800, 25 species of birds became extinct. From 1800 to 1950, 78 species disappeared. It is estimated that two species of birds will become extinct every three years, and by the year 2000, one species will disappear each year.\(^{30}\)

The irreversible loss of plant and animal species cannot be ignored and should be assessed. Reduced diversity of species could mean loss of resources necessary to improve the quality of life; or at worst, it could mean loss of resources necessary to meet future human needs or to maintain key ecological processes upon which the Chinese depend.

**Causes of Degradation and Loss**

**High Population and Fragile Natural Resource Base**

Chinese experts readily identify high population pressure as the cause of losses of natural areas and the associated ecological problems, and there is little doubt that China's long-term survival will depend on the success of its efforts to curb rapid population growth. By the year 2000, the population in China will exceed 1.3 billion, and by the year 2020, 1.5 billion. The average per capita share of various natural resources in China is already small compared with the world average (see Table 4.1), placing tremendous pressure on the resource base to provide immediate needs for food, fuel, and fodder. Farmland per capita has decreased from 0.18 ha (about 2,000 m$^2$) in 1952 to 0.12 ha in 1970, and to 0.09 ha in 1987.\(^{31}\) It is expected that


\(^{31}\) Chinese Academy of Sciences, *Ecological Deficit.*
per capita farmland will shrink to 0.07 ha (about 674 m²) by the year 2000.32/

**Economic Policies**

4.54 Problems related to high demand and low supply of natural resources are exacerbated in China by such economic policies as emphasis on heavy industrial growth and self-sufficiency in grain production. Economic policies, particularly in agriculture (see Chapter III, especially paras. 3.85-3.95), have been the main driving force behind destruction of natural areas. China has long considered agricultural strength, particularly grain production, to be the backbone of economic health. Agricultural strength, in turn, is thought to produce social stability. The government, therefore, places high priority on the production of grain to maintain the nation's agricultural strength. In the 1960s, the grain production plan was developed without considering whether the proposed practices would be sustainable, given the natural capability of the land. Cultivation of marginal land (grasslands, forestlands, wetlands) destroyed many millions of hectares of natural ecosystems--and the marginal land could not be sustained and soon became useless for agriculture.

4.55 Current economic conditions and the emphasis on grain self-sufficiency once again put natural systems at risk. The current agricultural development plan targets development of four underexploited regions--the Sanjiang River plain, the red soils region of south and southwestern China, the Huang-Huai-Hai River plain, and the loess plateau of the northern Yellow River region. The loess plateau is viewed as the most technically difficult area and will be the last to be developed. During the next five years, it is expected that substantial investments will be funneled into the development of the Huang-Huai-Hai area, which is also the area that has suffered the most severe droughts, according to the National Meteorological Administration. Under the forthcoming Eighth Five-Year Plan, some 670,000 ha (mostly wetlands and grasslands) are proposed for conversion to farmland.

**Institutional Factors**

4.56 Decentralization of authority and an already strong tradition of local autonomy have inhibited cooperation among administrative units. Central agencies have difficulty enforcing rules that infringe on the narrow economic interests of local producers. The planned economy has often reinforced localism by insisting on local self-reliance and production quotas while inhibiting market activities that could lead to more appropriate use of resources (such as land), based on regional comparative advantage.

4.57 Likewise, the lack of cooperation among institutions has hindered efforts to effectively conserve remaining natural ecosystems. Environmental protection is multidisciplinary and requires multisectoral cooperation, but such cooperation appears to be especially difficult to achieve in China. For example, both the State Council and its ministries, and the provinces and autonomous regions can designate nature reserves. As a result, the adminis-
tration of the reserves is divided between various ministries such as the Ministry of Forestry, NEPA, the provincial forest authorities, and various scientific and educational institutions such as the Chinese Academy of Sciences (CAS). This situation fosters a tendency to designate more nature reserves, to expand an institution's power base, and possibly to obtain more funds from the central budget, rather than a focus on effective management and protection of existing reserves. Under these circumstances, priorities are unclear and expenditures are not channeled to priority areas.

Attitudes

4.58 Another underlying cause of loss of natural areas is the Chinese cultural attitude toward nature that reflects a blend of traditional and twentieth-century China. Present views seem to reflect the traditional Confucian attitude that natural forces should be made to "behave properly." There is a desire to "harness" nature, irrespective of cost, and to force nature into a model formed by human rationality, that is, economic development and engineering science. This attitude promotes attempts to squeeze more out of the natural system at any cost. At the macroeconomic level, this is manifest through large-scale irrigation works and land conversion, and through fertilizer and energy (e.g., diesel fuel) subsidies to farmers. There is a belief that engineering technologies will solve the problems regardless of the capital cost and sustainability of inputs.

4.59 Such attitudes make it difficult to implement the modern Chinese environmental protection principle of "prevention first, who develops must protect, who uses must conserve or compensate, and who damages must pay or reclaim." Instead, unsustainable development is allowed to occur and the public bears the direct and indirect costs of longer term ecological damage.

D. Chinese Actions to Arrest and Reverse Ecosystem Degradation

4.60 Owing to the seriousness of ecological deterioration and the dependence of the population on the resource base, the Chinese have responded to these problems through (a) the establishment of a legal and institutional framework that includes laws and regulations (see also Chapter I), and the development of incentives and "responsibility" systems to enforce policies; (b) the development and implementation of specific measures to protect critical ecosystems of economic importance, including rational use of resources and restoration of degraded lands; (c) measures to protect wildlands, such as the establishment of parks and nature reserves; and (d) the establishment of monitoring systems to evaluate changes in the environment.

Legal and Institutional Framework

Laws and Regulations

4.61 Major laws and regulations to protect environmental and natural resources have been formulated over the past 20 years and provide a good framework for action (see Annex 7). With a soil and water conservation law recently enacted, the main remaining gaps seem to be in the area of conservation and management of coastal zones, including wetlands. Further refinement of existing regulations is expected to continue, especially in regard to
nature reserves. In addition to national-level laws and regulations, individual provinces and counties are drafting their own regulations, for example, the Jiangsu Provincial Regulation for Coastal Zone Management.

Institutions

4.62 The vertical institutional structures for implementing natural resource laws and regulations are in place and well developed (see Annex 8 for major institutions dealing with resource protection). Environmental and resource protection units, supportive research facilities, and planning and design units exist—from the national to the county levels. However, ecology and natural ecosystem issues (unlike pollution, for example), are addressed by line ministries rather than the environmental protection agencies. The environmental protection units within the ministries are understaffed, underbudgeted, and often ignored by the production side of the ministry. For example, the Bureau of Fisheries of MOA has identified overharvesting as the major reason for a decline in fish catch, yet this bureau is relatively powerless to do anything if the Fish Production Corporation of the same ministry is promoting increased fish catches. Although the Bureau of Fisheries has the authority (and an inspection system) to prevent overfishing, it does not have the necessary equipment (e.g., boats and communication equipment) to patrol the waters and catch violators.

4.63 Another obstacle to effective administration, as mentioned earlier, is the fragmentation of responsibility among institutions. The lack of coordination between line ministries and environmental agencies has led to duplication of effort and inefficiencies. For example, each ministry has an extensive monitoring network that collects very specific data. However, without a system to share information across ministries and to synthesize the data, a comprehensive view of the status of China’s natural ecosystems is difficult to obtain. Several institutions conduct research on ecological farming, independent (and unaware) of what the others are doing. Furthermore, centuries-old patterns in institutional behavior inhibit collaborative efforts in research methodology or results (see the section on recommendations).

Enforcement

4.64 Enforcement of the laws and regulations has been understandably difficult given the vastness of the country and the number of people. Laws provide the broad framework but they need to be reinforced with detailed regulations that outline incentives (e.g., land tenure rights) and disincentives (e.g., fines and levies), and promote the development of systems that foster economically sound patterns of behavior. Some creative responsibility systems have been developed in China during the past few years (similar to the agriculture responsibility systems) that have increased institutional or personal incentives to manage or protect natural resources.

4.65 For example, individuals are now held personally responsible for the protection of certain resources in exchange for cash, the use of the land, and technical assistance and materials. In 1984, the Ministry of Forestry started experimenting with a responsibility system under which individual households (farmers or herders) are given responsibility for managing and protecting certain forest lands in exchange for wood or a percentage of the harvest. The
specifics of the responsibility system (e.g., duration of land tenure, types of assistance and incentives) vary considerably from region to region. Therefore, although the responsibility system seems to have led to overall improvement, the degree of success is highly variable, depending in part on other incentives or disincentives. In some areas, for added incentive, when a farmer turns in a person poaching wood on his land, he will also receive a percentage of the fine paid by the poacher. Another approach, privatization of common property resources, has helped to slow down the destruction of euphratica poplar forests and to increase tree cover for oases in southern Xinjiang.

4.66 On the other hand, despite the implementation of a responsibility system in Inner Mongolia, incentives to increase production have led to overstocking that deteriorates grassland and to conversion of land for cash crops (see also paras. 3.51-3.54 and 3.92-3.93). Such practices are encouraged and approved by the sumu (or county). More recently, a cadre responsibility system has been implemented in some areas where, for example, a county establishes tree planting and tree coverage targets. If the target is met, the cadre receives a bonus; if it is not met, then the cadre loses a percentage of the yearly bonus.

4.67 However, the responsibility system has limited utility for nature reserves and other types of protected areas. In some regions, individual households have been allocated responsibility for land along the periphery of the park where some human activity could take place. In the core area of the nature reserve, there are no alternatives to prohibiting or severely restricting human activities. However, making resources available to hire and maintain park guards to enforce those restrictions is not a high priority in China.

4.68 On the other hand, the need to strengthen enforcement regarding rational use is recognized by the Chinese government. For instance, in 1989, the MFO established a system to inspect forest harvests based on sustainable yield or allowable cuts of timber. Inspectors, from the provincial through the county levels, conduct regular inspections. The MFO plans to appoint township-level inspectors for even more thorough control.

Measures to Protect Critical Ecosystems of Economic Importance

Rational Use of Resources

4.69 China’s main ecological strategy to protect critical ecosystems has been to promote sustainable development. Although this strategy does little to prevent conversion of natural areas, it does attempt to ensure that conversion and its new use is based on the inherent capability of the land or water resources.

33/ See "Energy Use in Three Poor Counties in China: Interim Findings of ESMAP/China Household Energy Survey" (a draft report September 1990), for examples of variations in responsibility systems for woodlot management.
4.70 Sustainable development proponents in China advocate the development of resource use plans and demonstration trials such as those for agroecological systems. The central ministries, since they have little jurisdiction over on-the-ground management, focus their efforts on such planning tools as resource use plans; however, these plans take a long time to develop in China and are often ignored by local governments. Much effort is spent on large-scale investigations that take 5-10 years to complete, by which time the data may be obsolete. Several more years are then spent developing the plans, which may never be implemented because central government agencies, in general, lack jurisdiction over actions of local governments.

4.71 When resource plans are developed by the production units of ministries, the likelihood of such plans being implemented is higher since these plans promote economic development. For instance, it is expected that the coastal zone development plan being drafted by the Department of Islands and Coastal Zones (the production arm of SO& which advocates more rapid exploitation of coastal resources), will be well received by local governments. When plans are developed by the environmental units, however, these plans are often ignored because they seek to balance economic development and environmental protection. The latter is still seen by many as a block to development. For example, the Department of Marine Environmental Management and Monitoring, the environmental arm of SOA, has developed a plan for the Bohai Sea that delineates marine areas into five use (including conservation) zones. This exercise, however, is unlikely to have much impact since the department has no jurisdiction to enforce the plans.

4.72 A small number of Chinese officials in the MOA, the CAS and provincial institutions are focusing on developing agroecological systems that promote long-term sustainability of agricultural land while maintaining production. Over 20 years of effort have been invested in developing such systems on an experimental basis and the results are promising. What is needed now is an increase in farmers’ awareness of the potential of such practices; this can be promoted through more demonstration sites and extension (see para. 3.80).

Restoration

4.73 Another strategy the government has undertaken is the restoration of damaged sites. Ministries prefer to treat the consequences of inappropriate land conversion through restoration or "ecoengineering," such as large-scale revegetation of critical watersheds and terracing, rather than preventing inappropriate land conversion. It may be beyond the reach of any one ministry to suggest the macrolevel policy changes necessary to address the underlying causes. In the meantime, restoration is necessary because vast areas have been degraded. Restoration also may benefit the natural ecosystems by reducing pressure on them (e.g., to convert marginal lands) as the degraded areas become productive. Similarly, the current large-scale effort to reforest degraded land should eventually reduce the pressure to overcut natural forests.

4.74 Nonetheless, efforts to treat the symptoms often are very costly, too small to have widespread impact, and too late. For instance, in the MOF’s program to reforest the middle and upper reaches of the Yangtze River, it will cost an estimated Y 4 billion (not including labor cost) to replant 6.7 mil-
lion ha (by the year 2000). The goal is a total of 20 million ha, costing many more billion yuan. The apparent lack of cost-benefit analysis in decision-making means that short-term gains from land conversion continue regardless of the cost of later restoration efforts. (See Chapter II on use of cost-benefit approaches in environmental management.)

Measures to Protect Wildlands

Nature Reserves

4.75 The primary Chinese response to loss of important natural habitats is to establish nature reserves, the first having been created in the 1950s by the Chinese Academy of Sciences. The system of nature reserves stagnated during the period from 1966 to the early 1970s because of civil strife and, unfortunately, some of the already established areas were devastated during those years. In Xishuangbanna Nature Reserve, the original conserved area was 57,000 ha; by 1972, 11,000 ha of forest had been felled. One section was so totally destroyed that it has little value for future conservation. Since 1979, however, designation of nature reserves has increased rapidly. There were some 33 nature reserves in 1978, 43 in 1979, and by 1983 there were 134. Today, there are 606 nature reserves, excluding urban parks and scenic spots, covering 40 million ha or 2.7 percent of the total land area of China.

4.76 The total number of reserves is expected to increase since various ministries and provincial governments propose to continue designating more areas as nature reserves (Table 4.5 lists current responsibilities). For instance, as part of the proposed Eighth Five-Year Plan, the Ministry of Forestry proposes to establish 14 more wildlife reserves as part of a nature reserve development plan to protect the giant panda, and the State Oceanographic Administration proposes to establish 6 marine reserves. At the provincial level, the Sichuan Province government, for instance, plans to establish 32 natural reserves of provincial or national significance with a total area of 1.58 million ha comprising 2.7 percent of the provincial land area. Seventeen have already been set up, with an area of 470,000 ha making up 0.84 percent of the land. Overall, some 100 nature reserves are proposed for the Protected Areas Developing Plan of the Eighth Five-Year Plan.

4.77 As in many other developing countries, however, China's nature reserves are mostly "paper" parks. Because these reserves do not yield economic returns, they are low on the government's priority and are not allocated the budget necessary for effective management and protection. The situation is further exacerbated by the lack of expertise in nature conservation in the institutions responsible for these areas. For instance, the NEPA system, while strong in environmental protection and pollution control, does not have the expertise to manage the system of 100 or so nature reserves under its jurisdiction (Table 4.5). Likewise, the Ministry of Agriculture is not equipped to manage endangered aquatic animals, nor does the State Oceanographic Administration have expertise in the management of coastal and marine reserves.

Table 4.5: NATURE RESERVES IN CHINA

<table>
<thead>
<tr>
<th>Administrative Responsibility</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Environmental Protection Agency</td>
<td>100</td>
</tr>
<tr>
<td>Ministry of Agriculture</td>
<td>50</td>
</tr>
<tr>
<td>Ministry of Forestry</td>
<td>385</td>
</tr>
<tr>
<td>Ministry of Geology and Minerals</td>
<td>50</td>
</tr>
<tr>
<td>Ministry of Water Resources</td>
<td>11</td>
</tr>
<tr>
<td>State Oceanographic Administration</td>
<td>10</td>
</tr>
<tr>
<td>TOTAL</td>
<td>606</td>
</tr>
</tbody>
</table>

Source: NEPA, Department of Natural Conservation, July 1990.

4.78 Another hindrance to the effective management of China's nature reserves is the lack of baseline data on flora and fauna. There are few funds available for basic ecological research and even simple surveys for baseline data. Some 10 years ago, the Chinese Academy of Sciences was directed to become more self-supporting and to contribute directly to the economic growth of the country—in short, to be more oriented toward applied research. The Academy therefore has had to rely on direct economically oriented activities for its existence. As a consequence, the direction of research has shifted to applied (e.g., agroecological) research at the expense of basic ecological research.

4.79 Furthermore, although there are guidelines for selecting nature reserves, some areas under current designation are probably too small in size to be effective, some ecosystems are underrepresented, and some are overrepresented. Compounding all of these inadequacies in management is a fragmented jurisdiction over the reserves that makes identifying comprehensive solutions very problematic (see discussion of legal and institutional framework in paras. 4.61-4.68).

Monitoring

4.80 China's system of environmental monitoring provides a similar challenge to coordinating the various efforts under way. There are many important monitoring systems in place, particularly for environmental pollution (industrial, air and water), and they are very useful where they have been developed for enforcement purposes, for example, excessive cutting of timber. In general, however, monitoring in China has become an end in itself, rather than a means to an end, and efficiency is greatly reduced by duplication of effort as institutions compete to develop their own monitoring systems.
Moreover, it is apparent that little ecological monitoring is taking place in China; certainly none of the existing systems of the natural resource ministries monitors the ecological environment comprehensively. The limited amount of ecological data being collected is very specific and detailed, and not often used to identify or solve a specific problem of that ministry, much less to provide a much-needed overall picture of the status of China's ecological environment. This is owing partly to the difficulty of monitoring ecological change over the long term, but also to the lack of priority the Chinese place on such tasks. The dearth of accurate, time-series data on the extent and degree of ecological deterioration is a major constraint to raising the awareness of decisionmakers and the public to the seriousness of ecological environmental problems in China.

Even where good monitoring data exist, they are not often integrated into decision-making processes. For example, a vast amount of information has been collected in China about grazing land resources, but the problem of processing and applying the results becomes the limiting factor. Generally, scientists and researchers are dedicated and technically proficient. The studies carried out, given the limited resources, are well done. Lack of research into causes and functions of degradation of grazing land or the development of approaches to sustainable use of the land are not limiting factors. What is limiting is the inability to use this information in the decision-making process for agricultural development and use of grazing land ecosystems. This is an area in which new technology being developed around information systems can be useful in addressing environmental problems. For example, the use of decision support systems in managing grazing lands can provide a format for collecting critical information, allow access to the information, provide a base for adding to the information, provide a focus for educating managers about requirements for sustainable use, and assist in decision-making about rational and sustainable use of grazing land resources.

The SOA, which measures changes in the marine environment, monitors mostly chemical and physical, not biological or ecological, parameters. The Ministry of Forestry is concerned mainly with the health of commercial forests; hence, its monitoring is heavily focused on commercial timber species and not on nontimber forest plant and animal resources. Similarly, the MOA monitors on-farm environmental problems such as soil and water erosion, soil degradation, fishery resources, and sometimes atmospheric and water pollution, only as they affect agricultural production. Recently, the CAS and MFO established experimental stations for ecological monitoring, but they are site-specific, research-oriented projects and thus not very useful in providing a national assessment of the state of the ecological environment.

Of these various deficiencies discussed, however, the primary hindrance is that no single institution has a clear responsibility for monitoring the overall status and rate of land conversion. Since no institution has the responsibility or the funding to oversee the natural ecological environment, none have been motivated to include such a comprehensive program in their budgets. Even if ecological data were available from the monitoring systems of the various institutions, sharing them would be difficult, for reasons of technology (different collection methodology, definitions, etc.) and finance (often, in the interest of institutional self-sufficiency, information from a ministry must be purchased). Because of the uncertainty over the extent and
degree of severity of ecological problems, there is an immediate need to develop a mechanism by which the relevant ecological data collected by existing institutions can be periodically collated, assessed and published.

E. Assessment

4.85 Ecological degradation was occurring in China long before environmental pollution. What is different today—and of critical importance—is the tremendous pressure an increasing population is exerting on the diminishing natural resource base. This has led to the spiral, described earlier in this chapter, of the overexploitation of natural resources that leads to degradation and more conversion of "virgin" land and more loss of natural ecosystems, and so on. If these trends continue, the only natural areas that will be left are those already set aside as nature reserves (or those spared development because they are completely inaccessible), and the economic consequences of conversion and degradation can be expected to increase.

4.86 China's response to its ecological problems has been directed more at the consequences, such as restoring degraded lands, than at the underlying causes, such as economic policies. This leads to strategies focused more on technological solutions than on institutional and policy reforms, more on correcting than on preventing the problem in the first place. Treating the symptoms rather than the underlying causes, however, is not only costly, it may prolong the problems and lead to more severe consequences in the future.

4.87 Closely connected is China's inadequate system of monitoring the health of natural ecosystems (discussed in the previous section). As elsewhere in the world, the rapid deterioration or gradual transformation of ecosystems in China is both more environmentally and economically crippling and much more intractable than air and water pollution. However, the most commonly used indicator of environmental quality in China is the presence of major air and water pollutants, and adequate data are not available on the status of its natural ecosystems. (See also the discussion of pollution monitoring in Chapter II.)

4.88 China's present efforts to conserve natural ecosystems also need to be substantially strengthened. Natural ecosystems are still undervalued by both policy makers and the general public and, in particular wetlands, are still being slated for conversion. Since more than 70 percent of the population depends on the land, water, and other biological resources contained in these natural ecosystems, China cannot continue on a course of unsustainable exploitation of them.

F. Recommendations

Institutions

Environment and Natural Resources Commission

4.89 A major constraint to promoting the sustainable use and conservation of natural resources and biological diversity in China is the lack of an institutional structure specifically charged with protecting the country's ecological environment. At present, the environmental management institutions
are focused primarily on urban and industrial pollution, leaving protection of the ecological environment to individual land and resource management ministries. Environmental issues, however, are cross-sectoral and require comprehensive, multisectoral solutions that are difficult to address within a single ministry. Moreover, the environmental units of these line ministries are underfunded, understaffed and relatively powerless to promote and enforce protection.

4.90 To foster the much-needed collaboration among institutions, consideration should be given to establishing a Commission for Environment and Natural Resources under the State Council (similar to the existing Environmental Protection Commission) or, alternatively, to creating a special commission within the Environment Protection Commission. The executing arm of the commission could be a task force that includes representatives from the land and water resource and environmental protection institutions (i.e., ministries for agriculture, forestry, and water resources, State Oceanographic Administration, National Meteorological Administration, and the National Environmental Protection Agency).

4.91 An urgent task for the task force would be preparation of an Environment and Natural Resource Action Plan that would include (a) a national ecological monitoring and reporting system; (b) an assessment of economic, financial and macroeconomic policies, and institutional/organizational structures that impinge on sustainable natural resource use and conservation; (c) an action program for environmental problems associated with agriculture; and (d) an action program for conservation and protection of biological diversity.

4.92 The task force should examine the organizational structure of existing institutions with responsibility for the ecological environment. Institutional issues such as whether to combine ecological management with environmental protection in institutions like NEPA, should be explored. (Currently, NEPA does not have the experience necessary for such expansion, and its involvement would require a substantial increase in budget and staff.) The establishment of a natural resources agency to focus on ecological environmental protection should also be explored.

4.93 The task force should consider establishing a leading group consisting of institutions already involved in natural resources and ecological monitoring, such as CAS, MFO, MWR and MOA. The group should discuss the important biological and ecological parameters to be monitored, ways to link existing monitoring systems, and the production of a periodic status report on the state of the environment (e.g., every two years); identify critical areas that require immediate attention; and recommend new policy and courses of action.

Policy

Agricultural Economic Policy

4.94 As discussed earlier in this chapter, the major underlying causes of ecological deterioration are policies that are counter to conservation and that provide incentives to convert and overexploit natural ecosystems. Therefore, a major focus of the task force should be on analysis and reform of
economic policy. The task force would be charged to examine policy issues and recommend ways to reduce conflicts between economic production and conservation-oriented policies. For example, on environmental grounds, it might be better to temper the goal of grain self-sufficiency with international trade and import of grain. However, the adjustment of grain policy alone would not be sufficient to stop conversion of natural areas. Another avenue that needs to be pursued is raising the productivity of existing agricultural land through, for example, the environmentally sound use of agricultural technologies and agrochemicals.

**Agricultural Sustainability**

4.95 Given the seriousness of environmental problems associated with agriculture (identified in both the preceding chapter and this one), a leading group headed by the Ministry of Agriculture should be formed to assess priority issues more closely and to recommend a program to address them.

4.96 The leading group should examine (a) the sustainability of current agricultural practices, including practices on forestland (i.e., large-scale monoculture plantations and harvesting of natural forests) and on marginal lands, including grasslands (i.e., stocking density and pasture improvement); (b) assess alternative approaches (e.g., ecological farming); (c) identify constraints to adopting these alternative approaches; and (d) recommend a course of action.

4.97 A study also should be made of the relationship between decline in soil fertility and structure, and the increase in use of biomass for rural energy. The leading group should assess the implications of such findings for developing alternative energy supplies, promoting application of inorganic fertilizers and monitoring increases in nonpoint-source pollution.

**EIA Guidelines for Land Reclamation**

4.98 Conversion for agricultural use is perhaps the biggest threat to natural ecosystems because of the scale at which it is taking place. China has already established an environmental impact assessment process, and several thousand EIAs have been conducted--some leading to redesign of projects.

4.99 This process, however, has been applied mostly to industrial, urban, and infrastructure development projects, and not to agriculture or forestry projects. This focus reflects not only the general orientation of environmental protection in China, but the institutional strength and interest of NEPA, as well; NEPA has formulated many EIA guidelines, and more are being developed, but none are in the agriculture sector. The Environmental Protection and Rural Energy Department of MOA, in concert with NEPA, should give top priority to the development of EIA guidelines for agricultural projects, particularly those involving land conversion. These guidelines should cover (a) policy, legal, and administrative arrangements; (b) identification of positive and negative impacts; (c) the analysis of alternatives to compare environmental costs and benefits under different investment design, site, technology, and operational scenarios; (d) mitigation plans to prevent, reduce, or eliminate potential impacts; (e) environmental management and monitoring plans to ensure the implementation of the proposed mitigation measures.
Several EIA guidelines for agriculture already exist and have been applied; for example, the Asian Development Bank's "Environmental Guidelines for Selected Agricultural and Natural Resource Projects" (1987) and the United States Agency for International Development's "Environmental Design Considerations for Rural Development Projects" (1980).

4.100 Since agriculture and environment go hand-in-hand, such guidelines should recognize that a properly designed agricultural project includes environmental protection criteria. For example, agricultural projects frequently address environmental problems such as soil erosion, desertification, irrigation resulting in salinization and waterlogging, misuse of pesticides, and wastes from agroindustry. However, concepts that have not been well integrated into NEPA's environmental review of agricultural projects include: integrated rural development, master planning, multiple versus single use of resources and habitats, watershed management, farming systems approaches which build on traditional knowledge, and identification of opportunities which minimize impacts to the natural environment. Particularly acute is the lack of analysis of "cumulative impacts" of sectoral and multiple project activities and the identification of interrelatedness and multilevel links that characterize the environmental impact assessment process for the agricultural sector. Managing and monitoring the environmental mitigation measures proposed also present serious problems for agricultural projects. For example, agricultural projects with multiple implementing agencies or borrowers, which may be dispersed over one (or several) large provinces must struggle with determining practical schedules and budgets to measure the success of any environmental protection measures proposed. Most agencies have some experience in data gathering, but little experience at analyzing and taking corrective action based on results obtained in the field. Monitoring for the sake of monitoring will not ensure that negative impacts are mitigated.

4.101 For land reclamation and other agricultural projects, mitigation to prevent, reduce, or eliminate potential impacts is a necessary component of project design. Through an analysis of alternatives and selection of appropriate mitigation measures, the EIA process can focus the project design team on appropriate alternatives that compensate for irreversible loss of habitat. The establishment of parks and reserves, charging entry fees to tourism areas, collection of special taxes (e.g., for timber extraction), and other mechanisms should be explored during this process.

**Protecting Wildlands**

**Integrated Protected Areas System (IPAS)**

4.102 Given the fast pace of land conversion, the only natural areas likely to be left are those already set aside as nature reserves. Therefore it is of the utmost importance and urgency to complete the system of nature reserves, to strengthen their management and to conduct the research necessary to raise awareness of the values of natural ecosystems in general (and the diversity of biological resources they harbor). It is also of utmost importance to develop guidelines for comprehensive management (which would include some conversion) of remaining natural areas outside of nature reserves.
4.103 China now has some 606 nature reserves and 100 more are being proposed under the Eighth Five-Year Plan. These existing nature reserves should be reviewed for minimum critical size, biological coverage and ecological representation. It is also possible that some reserves are too small in size or already too degraded (e.g., in the East China coastal area) to be of significance. Some ecotypes are overrepresented (e.g., some forest types) and some underrepresented (e.g., grasslands). An integrated protected areas system should be created to review and reclassify existing reserves along these lines and to establish new ones.

4.104 Developing a successful national system also will require strengthening both the institutions that supervise reserves (e.g., NEPA) and those that actually manage them (e.g., MFO, MOA). Because China's nature reserves are under the jurisdiction of several institutions, responsibility for them is somewhat fragmented. Responsibilities, therefore, should be more clearly delineated. Although NEPA has overall responsibility, a shortage of trained personnel and funds has hampered its efforts. Since funds are limited generally, a list of priority reserves should be developed to guide investment. Perhaps the best use of investment funds for institutional strengthening would be for in-service training programs such as those already being conducted by the World Wildlife Fund, the Smithsonian Institution of the United States, and in China, the East China Normal University (for wetlands).

Development of Wetland Management Plans

4.105 As discussed earlier in this chapter, wetlands are being rapidly drained and converted for agricultural use, and coastal wetlands may well be the first ecosystem type in China to disappear altogether. The most immediate action that can be taken is to ensure that the SOA coastal zone development plan pays sufficient attention to conservation and protection of wetlands. The primary need is to develop a coastal zone management plan that will maintain fisheries and agricultural production at a sustainable level, while at the same time safeguard the value of wetlands as nurseries for fish, sinks for pollutants, buffers from storms, and habitat for diverse flora and fauna.

4.106 Wetland management plans should be developed also for the two largest relatively pristine wetland areas in China--Sanjiang Plain in Heilongjiang Province and Ruoergai Marsh in northwestern Sichuan Province. Major reclamation schemes now threaten a large part of the wetlands in the Sanjiang Plain, and there are controversial plans to exploit the peat resources of Ruoergai Marsh. Wetland management plans for Yancheng Marsh in the central and northern coast of Jiangsu Province, Huang He Delta, and Laizhou Bay should also be developed.

4.107 Wetland management plans, in general, would ensure that the valuable goods and services provided by the vast wetland system are not extensively depleted in China. However, there is also a need for quantification of wetland values, and this should proceed in concert with the development of management plans. Identification of the natural and economic value of wetlands is necessary to fully estimate the benefits and costs of their conversion. Unless wetlands can be documented as valuable to the people of China, their conservation will be extremely difficult.
A Biological Diversity Action Plan

4.108 Consideration should also be given to creating a leading group for the conservation of biological diversity. China has always possessed a great diversity of biological resources, some of which now are extinct and a growing number of which are becoming rare or endangered through the loss of natural ecosystems. Although Chinese scientists place great importance on conserving this natural heritage, the government still accords it low priority among more immediate concerns. In addition, the fragmentation of institutional responsibilities (discussed earlier in this section) is an obstacle to alerting decisionmakers to this serious problem. Even if funds were available, it would be difficult to pinpoint the problems, determine priority conservation needs, and identify appropriate recipient institutions.

4.109 An action plan would (a) identify the major problems (including priority conservation areas); (b) lay out an overall strategy (for immediate and long-term goals) to deal with the problems; (c) identify priority areas in light of the critical nature of the resource and economic costs (in this case opportunity costs) of preservation; and (d) provide a detailed plan for government obligations, modification of existing projects and programs, and proposals for new investments.
V. WORLD BANK PROGRAM OF ENVIRONMENTAL ASSISTANCE IN CHINA

Overview

5.1 Based on the analysis, assessments and recommendations in this report, the World Bank has discussed with the Chinese Government an expanded program of environmental assistance that will focus on: (a) the formulation of long-term policies and programs for environmental protection and conservation of natural resources; and (b) assistance for immediate investments that will produce improvements in the short term.

5.2 More specifically, a multiyear program of World Bank environmental assistance will consist of: (a) **environmental sector studies** to provide the analyses (especially in regard to underlying causes) necessary for formulating policy, regulatory and institutional action plans, and investment programs for specific problems; (b) **technical assistance** (from the World Bank Technical Cooperation Credits and bilateral trust funds, as well as project-related technical assistance) to strengthen those institutions in China that are dealing with environmental and ecological matters; and (c) an **environment lending program** to support appropriate investments to further these objectives and to produce measurable (and monitorable) results in improving the efficiency of resource use and in reducing pollution and degradation of natural resources. Mechanisms to increase coordination with other multilateral and bilateral donors will be actively explored.

5.3 The strategy of this program is to focus assistance to Chinese institutions and enterprises in four sectors in which environmental problems are particularly severe and in which the World Bank has a comparative advantage in expertise and international experience: **energy, industry, urban, and agriculture** (including forestry and water resources). These four sectors also are likely to comprise about two thirds of the World Bank’s overall lending program to China over the next four years. In these sectors, the principal environmental issues, some of which cut across all sectors, are: (a) water resource management, including water quality; (b) air quality management; (c) solid and liquid waste management, including hazardous and toxic wastes; (d) energy conservation and industrial efficiency and pollution control; (e) natural resource management and conservation (especially forest and soil resources); and (f) sustainable agriculture practices on marginal lands. Institutional issues and environmental expenditures and financing (cost recovery, pricing policies, budget allocations) are important issues in all four sectors. These will be examined in several of the follow-up environmental studies and projects proposed below for inclusion in the World Bank’s 1992-95 fiscal year (FY) program.

5.4 In order to implement this strategy, two to three environmental projects per year will be proposed for inclusion in the Bank’s lending program to China. Among those proposed for the next four years are: three aimed at comprehensive control of urban pollution and two at provincial pollution, a project focused on provincial coal use and pollution control, an environmental technical assistance project, a forestry project, two projects on agricultural development of marginal lands and management of watersheds, a project to control pollution from ships’ waste disposal and in marine ports, and a project
to phase out the use of substances that deplete the ozone layer. Most of these are already under preparation. The following paragraphs also propose a wide range of World Bank environmental activities that can be integrated into the "mainstream" sector projects and operations of the implementing agencies.

5.5 Most environmental problems, especially pollution problems, are best tackled at the municipal and regional level because individual sources of environmental degradation and, therefore, appropriate solutions, will vary. In addition, the municipalities and provinces are increasingly becoming the primary focus of World Bank projects in China. These correspond to the principal centers of economic investment decisions. It is also around these levels of government that China's environmental policies and institutions are centered. The main focus of the environmental effort in the Eighth Five-Year Plan is on urban and regional environmental strategies. Therefore, it is at these levels that the Bank's comparative advantage can be used most effectively. It can assist with the economic analysis of underlying causes of environmental degradation and the use of economic techniques to set priorities for improving and protecting reserves. It can also provide technical help in designing policies and in making investments in particular waste reduction and pollution control technologies and projects. The design of five comprehensive urban and provincial environmental projects currently under preparation will address strategies for managing and treating water resources, minimizing industrial wastes and controlling pollution of the air, water, and land, including management of hazardous and toxic wastes. These five projects also will include components to develop long-term, least-cost environmental strategies, policies, and investment programs, as well as providing institutional development assistance to the respective provincial and municipal environmental protection bureaus, planning commissions, and public utilities.

5.6 Water pollution caused by untreated municipal wastewater and industrial effluent, coupled with severe water shortages in northern China, poses the most severe environmental problem and the one that most directly affects human health. The Shanghai Sewerage Project (FY87) was the first Bank project in China to address some of these issues. Few countries are as dependent on coal as China, and atmospheric emissions are largely due to coal burning (as opposed to auto emissions). This suggests a strategy for reducing air pollution that focuses mainly on the management of coal, energy efficiency, and possible fuel substitution over the longer term. In this regard, the Bank's China and Mongolia Country Department has completed a report, "China--Efficiency and Environmental Impact of Coal Use" (which involved counterpart teams from NEPA, the State Planning Commission and Ministry of Energy) and an energy efficiency study is under way. An air pollution control study of coal-burning thermal power plants in the coastal regions (financed under the Japan Grant Facility, a trust fund administered by the Bank) is about to get under way with the Ministry of Energy. The Global Environmental Fund (GEF) has approved several technical assistance and pilot projects in China related to greenhouse gas emissions. The greenhouse gas studies include a strategic assessment, as well as prefeasibility studies related to industrial boilers, coal use, gas transmission, distribution and rehabilitation, and a coal-bed methane pilot demonstration project.

5.7 In regard to environmental and ecological issues in agriculture, the challenge in China in the 1990s and beyond is to maintain and diversify the
production of food, fiber, and wood products, while improving the management of land, water, and forests to avoid (and to reverse where possible) overexploitation and degradation. This will require a reassessment of economic incentives, agricultural development objectives and strategies, and institutional roles. It will also require continued efforts to find and extend new techniques and technologies that are both environmentally sound and attractive to farmers. Several continuing agriculture projects and most of the agricultural development and irrigation projects currently under preparation include measures to prevent or reverse soil erosion, salinization, waterlogging, and overuse of fertilizers and pesticides.

5.8 The World Bank should increase its efforts in working with the Chinese authorities to identify the major causes of habitat destruction and consequent loss of biodiversity; for example, deforestation, soil erosion, the siltation of major inland lakes, loss of wetlands, conversion of coastal areas, and marine pollution. The GEF will finance studies related to the preparation of a national biodiversity action plan and nature conservation areas. A recently approved grant (financed under the Japan Grant Facility) will finance a large-scale environmental study of Hangzhou Bay, China's most productive but increasingly polluted bay. An afforestation project currently under implementation includes environmental guidelines for forest plantations and covers soil conservation, pest control, and species diversity; it also includes the preparation of pilot long-term forest resource management plans in several provinces.

5.9 Technical assistance related to the environment includes activities at national, provincial and municipal levels. Assistance to the National Environmental Protection Agency has been provided (through the Japan Grant Facility) to help NEPA strengthen its research, planning and implementation of environmental policies in five areas: environmental impact assessments; waste minimization and pollution control in rural industries; environmental planning and economic and financial incentives; hazardous and toxic waste management; and environmental information systems. The Bank is also providing technical assistance under various projects to the departments of environment in several sector or line ministries. Technical assistance also is and will continue to be provided to provincial and municipal environmental protection bureaus, urban infrastructure organizations, and industrial enterprises under several Bank projects. Finally, an environment technical assistance project is under preparation that will focus on assistance to the NEPA network, the Chinese Academy of Sciences and selected sector ministries.

5.10 There are also two special funds related to global environmental issues which have been set up by the international community and in which both the World Bank and the Government of China are involved. Therefore, the Bank will also be working with relevant organizations and institutions in China to further develop programs and action plans related to four principal global environmental issues: (a) ozone-depleting substances, (b) global warming, (c) loss of biodiversity, and (d) pollution of international waterways. In this regard, work is currently under way on several studies, funded from the Global Environmental Fund (GEF), concerning greenhouse gas emissions and biodiversity loss in China. A pollution control project for ships' waste disposal and marine ports that involves assistance to six of China's major ports is under preparation. This project, financed jointly from the GEF and IDA, is
designed to contribute to reducing pollution in international waters and Chinese coastal waters by providing assistance to the government and six ports for the construction and expansion of ships' waste disposal facilities. China has recently ratified the Montreal Protocol on Ozone-Depleting Substances and is preparing a program for the phase-out of ozone-depleting substances which includes investment projects to be assisted by the Montreal Protocol Interim Fund (MPIF).

5.11 In addition to the above-mentioned World Bank program of environmental assistance to China, the Asia Region of the World Bank will undertake several regional studies focusing on three priority environmental problems in Asia, all of which will involve China: urban pollution in megacities (10 million people or more), greenhouse gas emissions, and deforestation. In the decade ahead, environmental protection and rehabilitation will likely emerge as one of the most compelling issues in Asia for the Bank and the international community. Three unique characteristics of Asia combine to produce growing environmental stress—high population densities, poverty, and rapid economic growth. Asia's population will double to over 5 billion over the next 40 years. Half of the world's megacities are in Asia. Three quarters of the world's absolute poor live in Asia. Rapid economic growth is straining the region's land, water and air resources. Asia will contribute well over half of the world's incremental CO$_2$ and SO$_2$ emissions in the 1990s, and will account for three quarters of its additional chemical fertilizer use. What happens to the environment in Asia, and in China, is critical for the world environment, particularly for greenhouse gas emissions and also for forests and biodiversity. Unless the present trends in Asia are changed, the efforts elsewhere to reduce greenhouse gases will not be effective in tackling the problem of global warming; and forests and biodiversity in Asia are more threatened by population and industrial expansion than in any other region.

5.12 Finally, improved mechanisms for coordinating multilateral and bilateral assistance in China should be explored. In this regard, cooperation among UNDP, ADB, and the Government of Japan (the principal source of bilateral environmental assistance to China) is especially important. The Government of Japan is undertaking a $70-million program of technical assistance to NEPA to set up an environmental center that will focus on integrating monitoring and data processing systems, developing applied environmental technologies, and conducting environmental training (see Annex 9 for a summary of this program). The 1992 UN Conference on Environment and Development will also be an important vehicle through which the international community can coordinate its environmental efforts in China. The National Environmental Protection Agency recently set up an office to liaise with the World Bank, ADB, UNDP, and Japan on environmental matters in general and to coordinate foreign assistance from them to NEPA’s functional departments. A cooperative program between the Bank and NEPA, coordinated by this new office, has been agreed upon that covers a wide range of environmental activities and NEPA participation in the overall World Bank program in China. For example, sector seminars will be organized to exchange information and experience on the Chinese and World Bank EIA systems. All projects that are submitted to the Bank for assistance are examined by NEPA (and their respective EIAs reviewed) before they are forwarded by the State Planning Commission and Ministry of Finance to the Bank for consideration.
Proposed Work Program

5.13 The following lists summarize a proposed World Bank program of economic and sector work, investment projects, and technical assistance related to the environment, most of which is under preparation with the Government.

Environment Studies

(a) A study of the efficiency and environmental impact of coal use in China (completed);\(^1\)

(b) a study of provincial and urban environmental management (urbanization trends, institutional arrangements, environmental strategies and investment planning, and environmental expenditures and finance);\(^2\)

(c) four studies under the GEF related to greenhouse gas emissions and loss of biodiversity in China;\(^*\)

(d) a study and action plan, under the auspices of the MPIF, for the phase-out of ozone-depleting substances.\(^*\)

Sector Studies with Major Environmental Components

(a) A study on energy conservation and efficiency in industry;\(^*\)

(b) a study of rural industrialization that includes examination of pollution control issues;\(^*\)

(c) an irrigation sector study that would include environmental aspects (e.g., groundwater management and quality);

(d) a provincial economic study that would also look at the environmental management interface;

(e) an urban land management study which, among other things, will examine the interrelationship between land tenure and administration issues, and environmental pollution and ecological degradation;\(^*\)

(f) a study of the Chinese national accounts system that is under way should consider including an evaluation of the work of China's Development Research Center, which is engaged (as a part of an international research effort) in developing a supplemental series of natural resource accounts tables that attempt to adjust the stan-

\(^1\) Included in the official program agreed upon with the Government of China. Hereafter, these projects are indicated with a single asterisk.

\(^2\) Preliminary discussions have been held and an agreement in principle reached with the Government of China. Hereafter, these projects are indicated with a double asterisk.
dard national accounts for environmental and natural resources factors;

(g) a coal transport study, with the help of a model, will calculate magnitudes of coal sulfur content and solid particulate emissions and suggest tradeoffs and investments needed to select clean alternatives (e.g., continue with an existing poor-quality coal mine, build scrubbers, use a coal-washing facility or move to another high-quality coal mine and abandon the present one).*

Technical Assistance

(a) A preliminary program of technical assistance to NEPA funded through the Japan Grant Facility;*

(b) project-related technical assistance for environmental studies and components under many urban, energy, industrial, transportation and agriculture projects, including six national or sector-wide environmental studies on thermal power plants,* Hangzhou Bay ecological and pollution control,* small-scale cement plants,* marine and port pollution, vehicular pollution, and ecological farming;

(c) environmental technical assistance project;*

(d) continuation of the ESMAP rural energy assessment program.*

Proposed Lending Program

Environment Projects

(a) Five free-standing environmental projects (three municipal and two provincial);*

(b) a coal use and pollution control project (including possible cofinancing from GEF);**

(c) a forestry sector project (including possible cofinancing from GEF for a biodiversity component);*

(d) an environmental technical assistance project;*

(e) a project on agricultural development of marginal lands and comprehensive watershed management in the red soils area of central China, including a study on ecological farming, with poverty alleviation objectives integrated into project design;*

(f) a project on agricultural development of marginal lands, including water and soil conservation measures, in the loess plateau area of north-central China, with poverty alleviation objectives fully integrated into project design;**

(g) a pollution control project for ships' waste disposal and marine ports (cofinanced from GEF);*
(h) a project, consisting of multiple subprojects in different industrial sectors, for the phase-out of ozone-depleting substances (financed from the MPIF).*

Projects with Major Environmental Components

(a) A rural energy and industry project;**

(b) a rural water supply and sanitation project;*

(c) a health project that could include an environmental and occupational health component;**

(d) three agricultural area development projects which include components addressing improved management of water resources, pest management techniques, soil erosion control practices, and in one project, technical assistance and investments for improved monitoring and management of commercial fisheries;*

(e) an agriculture support services project which includes components on improved farming practices and the institutions concerned with them (research, extension, fertilization, and pest management practices, especially the potential for further use of integrated pest management techniques);*

(f) three river basin projects;*

(g) a project dealing with intensified irrigation;*

(h) four urban infrastructure and water supply projects with environmental components;*

(i) several energy and transportation projects with environmental components addressing country-wide issues (thermal power plants,* resettlement,* marine and port pollution,* vehicle pollution emissions and railway sector pollution*);

(j) several industry projects with environmental components (e.g., a national study of the efficiency of small-scale cement plants and their contribution to pollution),* some of which would emanate from the industrial efficiency and energy conservation study and others from the greenhouse gas emissions studies under the GEF;

(k) a gas development and conservation project that focuses on an important "clean" alternative energy source (with possible cofinancing from GEF);*

(l) a teacher training and services project that will consider components for environmental education at teacher training colleges.**
Underlying Objectives

5.14 The broad underlying objectives of this proposed World Bank program are to assist the Government to:

(a) Formulate long-term policies and programs for environmental protection and conservation of natural resources (including those related to global environmental issues), particularly at the provincial and municipal levels;

(b) improve short and medium-term control strategies for environmental pollution and investment programs for water, air, and solid waste management, particularly in urban areas, with emphasis on least-cost analysis that looks at cross-sector tradeoffs;

(c) improve strategies and techniques to address ecological problems and design appropriate investment programs principally related to agriculture (especially farming systems in marginal areas), on which most of China's rural population depends;

(d) implement price and enterprise reforms as important underlying structural economic incentives to improve energy efficiency and natural resource use and conservation, and industrial efficiency, which are the most cost-effective means of reducing environmental degradation. This should include reviewing input and output prices, administrative controls on production and distribution, taxation, and subsidies as they affect resource use and conservation;

(e) strengthen the capacity of the extensive network of institutions China has already established (policy analysis, planning, implementation, and operation) to deal with environmental and ecological issues, particularly at the provincial and municipal levels;

(f) design and finance a program of capital investments in pollution control based on least-cost analysis and appropriate technologies, as well as efficient operation and maintenance of facilities, and adequate cost recovery to ensure the financial viability of the institutions that operate them;

(g) develop and implement, for polluters and users of natural resources, a mix of both command-and-control regulatory measures (e.g., standards, regulations, fines, laws, environmental impact assessments, and an environmental contract responsibility system) and economic incentives (e.g., discharge fees and permits, tax credits and pricing policies, land use rights, and an agricultural contract responsibility system) to encourage efficiency and discourage pollution and unsustainable use of natural resources;

(h) improve mobilization and allocation of financial resources for investments in environmental protection (revolving funds for pollution control, tax credits, an agricultural contract responsibility system, budget allocation, foreign assistance).
5.15 These objectives focus principally on economic and institutional measures to address priority environmental issues. These measures include: (a) phased investment strategies and studies needed to improve the design and financing of sectoral investment programs and projects; (b) improved links between economically efficient use of inputs (labor, materials, energy) and pollution abatement and natural resource conservation, with emphasis on the long-term environmental impact of pricing and other economic policies such as enterprise reform; and (c) improvements to environmental regulatory and pricing systems (e.g., the design and implementation of the pollution levy and environmental responsibility systems).

Participants

5.16 This program will include the following institutions, regions and processes.

Institutions

5.17 The program will entail working with three types of institutions: first, provincial and municipal EPBs, and in some cases river basin commissions and urban infrastructure organizations; second, at the national level, NEPA; and third, key line or sector ministries (for example, the ministries for energy, water resources, agriculture, forestry, and various industrial ministries). The links between these different levels of institutions would differ from project to project and study to study, but the primary focus would be on the provincial and municipal (including county level) EPBs because they have principal responsibility for planning most environmental programs and enforcing environmental policies. However, it would be important to involve the central or national level institutions in the provincial and municipal projects in order that the techniques and experiences gained can be transferred and replicated as broadly as possible throughout China. An example of this type of link involves several of the free-standing environmental projects under preparation which, among other things, are addressing issues on waste minimization technology for rural industries, urban hazardous and toxic solid waste management, and least-cost strategies for regional environmental management at the provincial and municipal level. At the same time, these issues are being addressed at the national level through a program of technical assistance with NEPA (funded through the Japan Grant Facility) aimed at strengthening national policies on these issues. Therefore, efforts have been made to involve the provincial and municipal EPB teams and the NEPA teams in each other’s work; this includes having NEPA’s staff accompany Bank missions during preparation and implementation of these projects. An important objective of technical assistance to all of these organizations is to develop their human and institutional "capital," because even if an investment expands the supply of financial and physical infrastructure (such as a water supply system, wastewater treatment plant, a toxic and hazardous waste facility, a modern waste minimization industrial plant, or an improved irrigation system), it will have little chance of being sustainable after the project is completed unless there is enough human and institutional "capital" (knowledgeable people, organized so that they can operate and manage it effectively) to use the new facilities to advantage and ensure that the full benefits of the project are obtained.
5.18 Each of the sector ministries has a department of environment, and efforts also should be made to identify technical assistance components in nonenvironment or "traditional" projects in these sectors to help strengthen the programs and policies of those ministries in relation to environmental and ecological matters. For example, efforts to disseminate waste minimization or energy-efficient technologies should be focused within the industrial sector ministries and their associated research institutes. It is one of the strengths of the Chinese efforts in environmental management that, in parallel to the EPB network, there exist these environmental departments and bureaus within each line ministry (at the national and local levels) that could be increasingly important vehicles for integrating environmental and ecological matters with economic development in an operationally meaningful way, particularly in regard to investment plans and financial resources. In this process, there is also a need to involve the State Planning Commission, the State Science and Technology Commission, and the provincial and local planning commissions more directly.

Regions

5.19 It is recommended that World Bank assistance be focused primarily at the subnational level, where environmental policies are implemented, and in those provinces, counties and municipalities where: (a) industrial, urban, and air and water pollution problems are severe or where soil and land or natural ecosystem degradation is severe, or both; (b) the provincial and municipal level EPB network and/or sector ministry is well established; (c) commitment by the relevant government institutions and project beneficiaries is sufficient to carry out the institutional and policy reforms needed to encourage improvements in environmental management and sustainable use of natural resources; (d) a regional approach to environmental management is feasible; and (e) there is, or will be, long-term World Bank involvement with more than one project, especially repeated environmental projects, which help to ensure that our assistance will be successful in transferring the technical and management knowledge essential to sustainable improvements.

Processes

5.20 The main efforts would be: (a) at the provincial and local levels, on medium- and long-term environmental planning and investment programs (least-cost development approaches, especially applied to ranking investments in industrial and municipal pollution control and treatment facilities or, in the natural resource sectors, long-term conservation and use strategies, such as forest resource management) that are linked with financial management (budgetary implications of investments and cost-recovery measures); (b) at the national level, on macroeconomic and sector policies, especially pricing and enterprise structure links to efficient resource use and environmental management in the industrial and urban sectors, and in the agriculture and forestry sectors, pricing, land administration, and use; (c) at both national and local levels, on energy conservation, efficient resource use, and waste minimization techniques and technologies, for both new and existing industrial facilities; and (d) implementation of the levy, environmental responsibility and impact assessment systems.
Recommendations of Report and Proposed Program

5.21 The proposed World Bank program would address the principal recommendations of this report in the following manner:

Environmental Pollution Control

(a) Choosing Priorities Better. The emphasis here would be on looking at cost-effective strategies for managing water, air, and solid wastes in three municipalities and two provinces under free-standing environmental projects. Prioritizing environmental issues and developing strategies and investment programs can be most efficiently and effectively accomplished at the provincial and local level, given the wide geographical variation in environmental problems. At this level also, better integration can be achieved with economic and financial investment strategies and programs. This would be supplemented with technical assistance at the national level, principally to NEPA, in developing and disseminating methods for carrying out environmental economic analyses for policy planning and investment programs. In regard to issues in specific sectors, the recently completed coal study and the proposed new environmental sector studies would lay the foundation for policies, programs and projects that focus on coal use and pollution control, energy conservation and industrial efficiency, rural energy and industrial pollution control, and sustainable agriculture. Two projects would address the problems of rural water supply and occupational health identified by this report as requiring more attention.

(b) Improve Environmental Policy. The proposed free-standing environmental technical assistance project would, among other things, examine how to improve key elements of national policy, and the free-standing environmental projects would serve as "pilot cases" for applying many of these new or revised policies, particularly in regard to the environmental responsibility systems, levy and permit systems, EIA system, relocation policy, centralization of waste treatment and waste load allocation system. For example, consideration should be given to implementing on a trial basis a revised effluent fee system, along the lines of the German system, under one or more of the environmental projects. The recently completed coal study and the proposed environmental studies should provide additional recommendations for environmental policies, one of which, the proposed Provincial and Urban Environmental Management Strategies study, would focus on two issues which this report did not have enough information to assess in depth and which in any case are more meaningfully addressed at the subnational level. These are the institutional and fiscal or financial aspects of environmental management, especially the interrelationship between the provincial and urban EPB networks and the investment and budget allocation departments of sector ministries and planning commissions.

(c) Macroeconomic Policy Reform. The principal means for discussing these issues, of course, rests with the World Bank's economic and sector reports, and related discussions with government. For exam-
ple, World Bank economic reports have pointed out the economic disad
avantages of China's heavy industry bias and policies that dis
courage more efficient industrial management and technology--issues
that have direct bearing on control of industrial pollution. Oppor
tunities to reinforce these recommendations appear in projects deal-
ing with the energy and water sectors, in which pricing and cost-
recovery issues are particularly important, and in the industrial
sector, in which enterprise management and efficiency are paramount.
Urban land administration and use will be the subject of a forthcom-
ing sector study and, along with other things, the environmental
implications of land market reform in China will also be examined.
In another aspect of economic management, the Chinese Development
Research Center (DRC) is engaged, with assistance from the World
Resources Institute, in research on developing a supplemental series
of national resource account tables that attempt to adjust the tra-
ditional national income accounts for environmental and natural
resource factors. This work is similar to that being undertaken by
several industrial countries and the UN statistical agencies, and
should be followed and evaluated in the context of both the general
international efforts and the World Bank's continuing economic tech-
nical assistance to China on national economic accounting.

(d) Improve Institutions. The principal means for this would be (a) the
free-standing, environmental technical assistance project primarily
focused on NEPA and CAS; (b) project-related technical assistance
components under the six environmental projects focused on the urban
and provincial EPBs, planning commissions, and municipal utilities;
(c) project-related technical assistance components under tradi-
tional sector projects with the reactive line or sector minis-
tries' departments of environment. The latter would include: the
Ministry of Energy for thermal and hydro-related electric generation
issues, as well as coal use; the ministries for chemicals, light
industry and textiles, for waste minimization technologies; Ministry
of Communications for marine, port, and vehicular pollution, and the
Ministry of Railways for railway system pollution (especially the
rolling stock equipment industry). Issues of cost recovery, and
financial and operational autonomy for the municipal utilities that
will implement most of the Bank-assisted environmental projects are
also indispensable elements of institutional strengthening.

In addition, Bank-assisted projects that currently provide credit to
two Chinese financial institutions, the Agriculture Bank of China
and the China Investment Bank, could be used in the future as vehi-
cles to provide designated proportions of the Bank loans for envi-
ronmental subprojects and to support the increasingly important
manufacturing industry for pollution control equipment, which is
predominantly TVIE based (both of these institutions have agreed
upon and are implementing environmental impact assessments for all
subprojects that they finance).

(e) Research and Development. Applied research would be assisted
through the free-standing environmental project, which would include
components looking at NEPA's existing monitoring network, CAS's pro-
posed new ecological monitoring network, and economic models and information systems used by NEPA for decision-making purposes. Low-waste or waste minimization techniques in industry would be examined under several of the free-standing provincial and municipal environmental projects. The coal use and pollution control project would include components related to clean technologies and processes, and other measures recommended in the World Bank coal study. An agricultural support services project would include components looking at applied research in integrated pest management and sustainable agriculture practices. Vehicular emissions issues could also be examined as a component of the next highway project. Research on the impacts of global environmental problems would be supported through the two international trust funds (GEF and MPIF).

Agricultural Sustainability and Degradation of Natural Ecosystems

(a) **Agricultural Sustainability.** Sustainable management of agriculture in marginal areas would be the objective of three agriculture projects (Sichuan Agricultural Development, Red Soils II Land Rehabilitation, and Loess Plateau Conservation and Land Development). A proposed agricultural support service project could provide assistance for components dealing with integrated pest management, and ecologic farming and low-input techniques. The agricultural area development projects, irrigation projects, and multipurpose river basin (primarily agriculture) projects are all expected to address various aspects of soil degradation and erosion problems, as well as water resource management and water quality problems.

(b) **Agricultural Economic Policy.** A number of agriculture sector economic issues have been identified in this report that affect the rural or agricultural environment—from pricing policies and subsidies to land administration and tenure rights. These issues are being addressed in their nonenvironmental aspects as a part of the ESW program and continuing dialogue with the Government on agriculture. Where appropriate, these sector studies will also highlight the environmental implications of agriculture sector policy; for example, a study on rural industrialization also examines the concomitant problems of soil erosion and degradation, and water pollution.

(c) **EIA Guidelines for Land Reclamation.** As a start to developing a set of EIA guidelines in the agriculture sector (which now are applied in China principally only to rural industry), a study is being financed under the technical assistance program to NEPA (Japan Grant Facility) to develop EIA guidelines for agricultural projects, particularly those involving land conversion.

(d) **Biological Diversity Action Plan.** The new Global Environmental Fund, administered jointly by the World Bank, UNDP, and the UN Environmental Protection Program, will support efforts on developing a program to conserve endangered flora and fauna in China. The World Bank-assisted forestry projects in China provide another opportunity to design short- and long-term strategies and programs to preserve
natural forest ecosystems that are central to maintaining biodiversity.

(e) **Integrated Protected Areas System.** As above, both the GEF and proposed forestry projects are the principal vehicles through which the World Bank can assist China in developing a comprehensive system of well-managed nature reserves.

(f) **Development of Wetlands Management Plans.** The GEF would be a possible source of financial assistance, as would one of the agricultural area development projects that focuses on a coastal province and includes some wetland areas. A component of this project could be a national study of the issues undertaken by the Ministry of Agriculture, which has the primary responsibility for wetlands management.

5.22 In February 1990, UNDP sponsored an international workshop on the control of environmental pollution in China, in conjunction with NEPA and the State Science and Technology Commission, which focused on water and air quality, and management of hazardous chemical wastes. The workshop made a number of recommendations, primarily related to technological matters, that are consistent with recommendations made or to be applied in World Bank studies, technical assistance, and projects. For example, a central thrust of the recently completed World Bank Report, "China--Efficiency and Environmental Impact of Coal Use," is improving coal efficiency and lowering emissions in industrial combustion as a primary way of reducing air pollution. Also, the evaluation and application of specific improved efficiency and pollution control measures would be the principal objective of a proposed coal use and pollution control project. Air pollution control components under four of the six proposed free-standing, environmental projects would primarily focus on coal use issues. Another priority topic of the workshop was pollution of water by hazardous chemical wastes, which is being addressed under components in four World Bank-assisted projects under preparation (Jiangsu Chemical Sector Project, Beijing Urban Environmental Project, Liaoning Provincial Environment Project and the Southern Jiangsu Provincial Environment Project), as well as in technical assistance to NEPA, especially in regard to the implementation of waste minimization techniques in rural industry and centralized hazardous waste treatment facilities to serve major industrial cities.

5.23 All future highway projects will include studies and monitoring programs (similar to those instituted under an ongoing highway project in Shaanxi Province) to avoid archeological and historical ruins and relics.