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DISCUSSION PAPERS

CHINA

Water Quality Management—Policy and Institutional Considerations

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CHINA WATER QUALITY MANAGEMENT

Policy and Institutional Considerations

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Front cover photo, Bob Sacha Photography.

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Foreword

China's economy has grown rapidly since the nation entered the reform path in 1979, and particularly since the industrial expansion started in the mid-1980s. Over the last decades, China—which had been stricken with heavy poverty, severe production inefficiencies, and almost a standstill in economic development for over a generation prior to the reform—has become the forth largest economy in the world. This is an impressive achievement. Rapid growth, however, has been accompanied by considerable environmental side effects, one of the gravest of which is deteriorated water quality in large parts of the country's extensive water systems.

In our dialogue, the Government of China (GoC) has frequently raised the important challenge of water pollution management (WPM). Discussions focused on how China can expand WPM instruments, what kind of institutional systems need to be in place in order to ensure efficient enforcement of new instruments, what investments are needed in order to effectively improve water quality, and how China can learn from relevant international experience.

This report reflects some of the critical WPM challenges China is facing. It reviews recent trends, institutional arrangements, and some of the WPM instruments that have been applied over the last decade. Based upon international experiences, it points to factors China may take into account when revising her WPM policies. As part of a larger effort to work with key counterparts to address critical issues affecting water resource and environmental management, this report is aimed at generating constructive discussions among policy makers.

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Abbreviations and Acronyms

BOD	Biological Oxygen Demand
BOT	Build, Operate, Transfer
CAEP	Chinese Academy of Environmental Sciences
CAOE	County and Above County Owned Enterprise
CDC	Center for Disease Control (part of MOH)
CDR	Combined Division Responsibility
CEE	Central and Eastern Europe
COD	Chemical Oxygen Demand
CP	Cleaner Production
DO	Dissolved Oxygen
EASES	Environment and Social Development Sector Department, East Asia & Pacific Regional Office, the World Bank
EIA	Environmental Impact Assessment
EMS	Environmental Management System
EPB	Environmental Protection Bureaus
EPI	Environmental Planning Institute
EU-WFD	European Union – Water Framework Directive
FAO	Food and Agriculture Organization
GEF	Global Environment Facility
GIOV	Gross Industrial Output Value
GoC	Government of China
ISO	Industrial Organization for Standardization
IWRM	Integrated Water Resources Management
MOA	Ministry of Agriculture
MOC	Ministry of Construction
MOF	Ministry of Finance
MOH	Ministry of Health
MWR	Ministry of Water Resources
PE	Pollution Equivalent
PLS	Pollution Levy System
RBC	River Basin Commission
RMB	Renminbi (Chinese currency)
SEA	Strategic Environmental Assessment
SEPA	State Environmental Protection Agency
SME	Small and Medium Enterprise
TAC	Total Amount Control
TEC	Total Emissions Control
TFESSD	The Trust Fund for Environmentally and Socially Sustainable Development
TN	Total Nitrogen
TP	Total Phosphorus
TVIE	Town and Village Industrial Enterprise
WAB	Water Affair Bureau
WBMC	Water Basin Management Committees
WHO	World Health Organization
WPM	Water Pollution Management
WPPC	Water Pollution Prevention and Control
WRB	Water Resource Bureaus
WRM	Water Resource Management
WRPB	Water Resource Protection Bureaus
WRPSG	Water Resource Protection Steering Group

Executive Summary

Drivers in the economy and China's natural conditions impact water quality

Trends in water quality in China's extensive water systems can to a large extent be explained by the drivers in the economy, the nation's geological and hydrological conditions, and by patterns of water use. These factors include a slight reduction in rural population share—from 58 percent in 1978 to 57 percent in 2005—and a strong increase in the absolute urban population—from 172 in 1978 to 562 million in 2005. The most dynamic urbanization took place at the lower urban levels (small cities, town and townships), which had limited investment capacities compared to larger cities. These trends resulted in continued high water demand from agriculture in absolute terms and expanded water demand from industry and residential users.

There are striking differences in socioeconomic, climatic, morphological, and hydrological conditions between the South and the North. In the many water-scarce provinces in the North, average annual per capita water availability is less than one-tenth of the world average. Inter-annual and seasonal variations in rainfall exacerbate these differences, also resulting in droughts and flooding. These factors have contributed to a serious degradation in China's overall water quality. In the almost 500 sections of China's main river systems that are monitored for water quality, about one-third have water quality with very limited or no functional use, and only 28 percent have water suitable for drinking. A thorough review of all monitoring data over a 15-year period (made available by China's National Monitoring Center) reveals that there are hardly any improvements, particularly in the most critical rivers in the North. The core fact is that in the North, 40 to 60 percent of the region's water is continuously in the non-functional water classification categories.

Historically, industrial pollution was the main contributor to the increased pollution load. Although these industrial pollution sources have to some extent stabilized or even been reduced, the study shows that urbanization has partially offset these improvements. For example, the 10th five-year plan's (2001-2005) review of water pollution control performance indicates that it is the residential water pollution control objectives that are most off target.

Water pollution patterns vary among China's water systems. Most of the systems are characterized by a combination of organic concentrations (biological oxygen demand and chemical oxygen demand), nutrients (ammonium nitrate concentrations), and various forms of heavy metals (lead, mercury, cadmium, etc), particularly in the tributaries. While high organic concentrations, particularly high COD loads, are a critical factor in poor water quality, it also appears that increased agricultural activities and increased urbanization is resulting in significantly higher ammonia nitrate concentrations. Today, with the exception of the Yangtze River, all major rivers have excessively high ammonia nitrate concentrations.

Patterns of water pollution are thus being driven by the development of several sectors, suggesting that

China is up against a very complex challenge that needs multiple interventions.

Policy and institutional capacity: ensure the impact of an already expanded regulatory framework

Over the last 30 years or more, China has established a rather vigorous water pollution control system with an extensive set of institutions, a variety of legislation and policy instruments, and quite comprehensive investment plans that were largely shaped within the traditional five-year plan preparation process. In the earlier phases, water pollution control was characterized mostly by command and control instruments (industrial permit systems, simultaneous control programs) and partly by economic instruments (like pollution levy fees and discharge permits). In recent years, there has been a gradual increase in voluntary approaches (such as environmental management systems like ISO 14,000 and cleaner production) and public disclosure.

This report shows, however, that these instruments have severe flaws, even with the expansion in applying new policy instruments. The actual impacts appear to be limited, as shown by the fact that ambient water quality has stayed about the same or even worsened in some areas. For the eight instruments that were reviewed, the report identified a set of barriers and challenges that need to be addressed.

At the institutional level, there is often a lack of horizontal and vertical coordination, and inter-agency communication is generally poor. Agencies often duplicate tasks and responsibilities, which is not only inefficient, but also results in inconsistencies. For example, there are discrepancies in water quality monitoring techniques and findings between the State Environmental Protection Agency (SEPA) and the Ministry of Water Resources (MWR). The lack of clarity in the roles and responsibilities of different agencies is particularly apparent in emerging fields, such as cross-boundary river basin management and urban and agricultural non-point source management.

The regulatory system is incomplete and complicated, which results in lack of integration and efficiency in implementation and enforcement. Pollution management policies overemphasize the role of government agencies at the expense of the private sector and civil society, and they do not take full advantage of market-based economic instruments. Further conflicts of interest and monitoring difficulties have undermined the level of rigor with which existing regulations and policies are applied. A common issue, for example, is the inability of Environmental Protection Bureaus (EPBs) to enforce their mandate when it is in conflict with local development plans, which has led to widespread noncompliance with Environmental Impact Assessment (EIA) regulations.

Past Government interventions lacked strong continuity

The Government of China has taken several steps toward improving water resource management. Government interventions and investments in water pollution management (WPM) throughout the 9th (1996-2000) and 10th five-year plan (2001-2005) periods have resulted in some gains, such as the declines in industrial COD loads and the apparent leveling off of wastewater emissions. Furthermore, up-to-date and market-oriented pollution management policies, such as initial water pricing systems and a more comprehensive pollution charge framework, are starting to emerge. However, much more needs to be done to meet the existing and new management challenges. Achieving more effective regulations, policies, monitoring, and enforcement require strengthening institutional capacity, particularly the mandate of local environment bodies. In addition, inter-provincial pollution and complicated upstream/downstream interactions underline the need for effective river basin planning, an approach that was fully endorsed at the legislative level in the Water Law of 2002.

Significant gains in water supply and effective pollution management will also require substantial financial investments. While investments in water resource management are currently on the rise in China, particularly in the larger municipal cities in the East, they are still small compared to the funding needed to effectively deal with water pollution problems. Moreover, the government remains the main source of funding, with little contribution from other sources. A major reason for the absence of private investment is the lack of adequate mechanisms and conditions for loan repayment. This means that a successful water resource management plan must also incorporate strategies for increasing funding, diversifying funding sources, and prioritizing objectives.

Priorities for Focus: the need for increased cooperation between sectors

The Government of China recognizes the need for more effective management of its water resources. Water resource management issues are given a high priority in the 2006-2010 five-year plan. Among the many WRM issues that the government must address, priorities include (a) ensuring water availability in water-scarce areas; (b) providing a clean supply of water in order to reduce the heavy burden of water-related illness; (c) treating wastewater, with a focus on the impact on receiving water bodies; (d) rehabilitating the heavily polluted water bodies that are critical for local communities; and (e) protecting drinking water sources.

The unique nature of China's water resource management issues means that there is no "model country" that can be used as a reference point for describing optimal water pollution management solutions. However, large federal countries such as the United States, and supra-national bodies such as the European Union, may provide useful lessons. The current analysis highlights the need for an overall strategic plan for water pollution management that establishes a long-term vision and realistic targets for five-year plans over the next 20 to 30 years. Such a strategy would support the implementation of a phased development plan that systematically identifies next steps through identification of cost-effective priorities.

Improvements in the legal structure pertaining to water pollution management, particularly a reduction in the number of laws and the extent of overlap and contradiction, are needed to establish a comprehensive and simplified system. Revised instruments should be established around long-term effluent and ambient standards for industry and municipalities, as well as the gradual introduction of economic instruments, including fees and fines, and voluntary instruments.

While acknowledging the progress that China has made, particularly in tackling several forms of industrial pollution, there is a need to plan ahead for future developments in urban and industrial emissions. Both sectors are rapidly changing, and planners need to consider medium and long-term projections, as well as new technology, before deciding on investment plans. Additionally, changing agricultural practices are having a big impact on water quality, as discharges of nutrients and organic material lead to eutrophication of water bodies.

International experience has shown that regulating emissions in agriculture is more difficult than in other sectors. The first step is to establish reliable load estimates, which can be used as a basis for developing a strategy for agricultural pollution management. Attractive options—which also benefit farmers—include fertilizer planning and integrated pest management. The government should also consider adjusting the level of subsidies for fertilizers.

Establishing an effective framework for integrated water resources management should be a priority on the government's water resource management agenda. Over the long term, the Government of China should prepare the legal framework—or umbrella legislation—to accommodate the development of management plans at the river basin level. Such a measure would require a number of institutional changes and should include consideration of water re-use and cascade management approaches.

There is also a need for improved monitoring of drinking water quality. Drinking water supply and monitoring is currently overseen by several different agencies, including MWR, SEPA, the Chinese Center for Disease Control under the Ministry of Health, and the Ministry of Construction. Although there may be a need for splitting responsibilities between urban and rural areas, the current lack of coordination between the agencies has left significant information gaps about the actual drinking water situation.

Other important areas for attention include the development of an effective monitoring system, which should be of a reliable standard and harmonized across relevant bodies. Finally, in order to effectively manage its water resources and reduce pollution levels, the Government of China must generate a greater level of environmental awareness and sense of responsibility among the general public. This will require environmental education initiatives and more transparent information on emissions and water quality.

Introduction

Context and Objectives of the Report

This work was initiated at the request of the Government of China (GoC) and fits into a broader package of analytical and investment support that the Bank is providing for China's water resource management. Previous Bank-supported analytical work highlighting the urgency of water pollution issues includes *China: Air, Land, and Water; Environmental Priorities for a New Millennium*. In addition, the importance of this issue was confirmed in the Bank's *China Country Assistance Strategy (2003–05 and 2006–10)*.

Along Diance Lake

The World Bank and GoC are currently undertaking or planning numerous projects to address the management and pollution issues raised in this report. Annex 1 provides an outline of these ongoing World Bank projects. At the same time, GoC is including a major water resource management component in its 11th 5-year plan (2006–10). In this context, this report is aimed at (a) providing technical guidance for ongoing and future World Bank investment projects that include water management and pollution control components; and (b) providing the international water resource management community with an accessible source of up-to-date information on the nature of China's water pollution management challenges.

This study capitalizes on the long-term collaborative relationships between the World Bank and representatives from a number of different institutes, including the State Environmental Protection Agency (SEPA), the Ministry of Water Resources (MWR), the Ministry of Construction (MoC), and the Ministry of Agriculture (MoA). The final report is the product of collaboration among international experts, several Chinese researchers, and World Bank specialists.

Methodology

This report analyzes China's water pollution situation in both inland rivers and lakes. It provides a detailed picture of the water pollution situation, as well as an assessment of current policy instruments, institutional, and investment structures, of which these three components have formed the analytical framework for the report. It briefly refers to the pollution and management situation, using examples such as the Huai River and Dianchi Lake. To add some international perspective, it includes lessons learned and experience from water pollution management in other countries. The report also provides guidance to help prioritize initiatives in this sector.

The methodology used in this study included the collation of various sources of information to generate a detailed picture of pollution levels and the policy/institutional environment, and detailed analysis by international experts. To gather baseline information, we conducted an extensive literature review of previous studies and databases.

The Huai River Basin and Dianchi Lake catchments were used as case studies. The Huai River basin is one of the seven largest river basins in China and has been seriously polluted, particularly since the early 1990s. The river crosses several provinces and districts and can thus be classified as a "transboundary" river. After laborious work for better pollution management, water quality in the Huai River improved for a period of time. The first regulation for pollution management was enforced in this river basin. The Huai case is used to demonstrate a number of Chinese river basin management options.

Dianchi Lake is situated to the south of Kunming City in Yunan Province. The major factors that contributed to the long-term pollution and eutrophication of the lake were rapidly increasing municipal sewage discharges and agricultural non-point sources. The lake exemplifies one of the gravest examples of water pollution impacts on lakes in China and is highly prioritized by the GoC.

Structure of the Report

The paper is organized as follows. Chapter 1 describes the general water resource situation with reference to water availability, river systems, water quality, and emissions. Chapter 2 provides an assessment of water pollution management' in terms of (a) legislation and policy instruments; (b) the institutional framework; and (c) financing. Chapter 3 then provides a framework of priorities and recommendations for reforming water pollution management systems and improving water resource management in China, including references to international experience and lessons learned in other parts of the world.

1. General Water Resource Situation

Population, Urbanization, and Growth

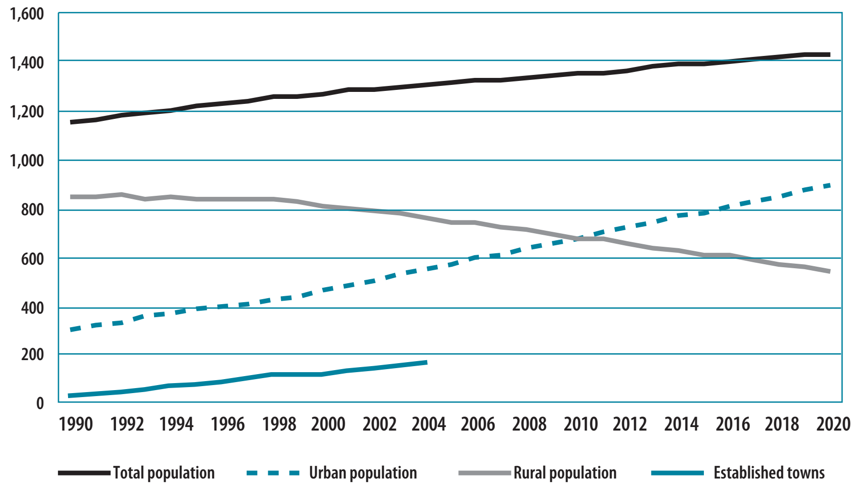
Population Growth. China has the world's largest population, 1.3 billion people, representing just over one-fifth of the global total. The country's demography has been heavily influenced by government policies over the last 25 years, and the population growth rate is now only 0.6 percent. The leveling-off that is occurring in China's population statistics is shown in Figure 1.1 below.

Lighters on the Huai River

Urbanization. The figure above also shows the development of China's rural and urban populations. The level of urbanization is striking. In 1980, the proportion of urban dwellers constituted less than 20 percent of the population, in 2000 it was 36 percent, and by 2020 it is projected to be 54 percent. The growing urban population has been accommodated through rapid expansion of existing cities and the emergence of new cities; the total number of cities in China increased from 190 in 1978 to 663 in 2000, and have leveled off since then (table 1.2).

A critical feature of China's urbanization since the early 1980s has been the expansion at the sub-city level, particularly in categories such as "small cities," "established towns," and "township concentrations." From 1985 to 2004, the number of established towns increased from less than 8,000 to almost 18,000, accounting for a non-agricultural population of 63.5 million people. Between 1990 and 2004, the established towns category increased by about 14.5 million people, which represents almost a seven-fold increase. By 2004, China's total non-agricultural population below the city level was about 100 million, and about 44 percent of China's total urban (non-agricultural) population was living in small cities, established towns, or township concentrations. In essence, these statistics indicate that the strongest drive for China's rapid urbanization comes primarily from the lower levels below the cities. The increase in urbanization results in a rising demand for water from the established water supply system and an increase in water pollution in the short run.

Figure 1.1. Total, Rural, and Urban Population, 1980–2020 (million)



Source: Chinese Academy for Environmental Planning, 2004. Study on integrated environmental and economic modeling.

Economic Development. China is experiencing rapid economic development. GDP grew by 9.4 percent in 2004. Initial information indicates it was 8.3 percent in 2005 and will be about 7.5 percent in 2006. Rapid economic growth has brought about significant improvements in the standard of living for many Chinese, but it is generating increasing levels of demand for water. By relating water demand projections to expected sector growth, projections indicate that this growth will lead to an increase in water demand of 6.5, 32, and 35 percent (2003–2020) from agriculture, industry, and residential users respectively (Chinese Academy for Environmental Planning, 2004). These figures imply that a total increase in demand for water of 83 billion m^3 will be essential if China is to maintain its current pattern of economic growth. However, with a relatively constant water supply, the increased water demand will have to be met mainly through water savings and improved water quality.

River Basins

China has nine main river basins.

i) Song-Liao River Basin (91 billion m^3/yr)
ii) Hai-Luan River (22.8 billion m^3/yr)
iii) Huang River Basin (Yellow River) (66.1 billion m^3/yr)
iv) Huai River Basin (62.2 billion m^3/yr)
v) Changjiang River (Yangtze River) Basin (951.3 billion m^3/yr)
vi) Zhujiang River (Pearl River) Basin (333.8 billion m^3/yr)
vii) Southwest River Basins
viii) Southeast River Basins
ix) Interior river basins (rivers not discharging into the sea).

Each river basin presents a specific management challenge because of its socioeconomic, climatic, morphological, and hydrological conditions. The most important feature is the abundance of water relative to population, arable land, and local GDP. Table 1.1. provides a summary of water availability, population, and arable land area.

The table shows the relative water availability in different river basins, of which the northern rivers account for less than 20 percent. It also shows water availability per capita and per hectare, which is as low as 343 and 6,000 m^3 in the north, and as high as 29,427 and 346, 350 m^3 in the south. In 2001, the water development ratio (the ratio between water supply and water availability) was 0.2, but the north has a much higher value, up to 0.93 in the Hai River basin. The northern rivers are therefore characterized by high use/availability ratio, water scarcity, and serious pollution problems.

Inter-annual and seasonal variations in precipitation are quite large across most of China, but are most

Table 1.1. Main River Basins and Their Characteristic Features

River Basin	*Water availability % (1000 m^3)*	*National Percentage*		*Water Availability per capita (to m^3)*			*Water availability per ha (m^3)*
		Pop.	*Arable Land*	*1997*	*2010*	*2050*	
Northern Rivers							
Interior R.	4.6 (130.4)	2.1	5.7	4,876	4,140	3,331	23,835
Song-liao	6.9 (192.2)	9.6	20.2	1,646	1,501	1,287	9,900
Hai	1.5 (42.2)	10	11.3	343	311	273	3,885
Huai	3.4 (96.1)	16.2	15.2	487	440	383	6,555
Huang	2.7 (74.4)	8.5	12.9	707	621	526	6,000
North Total	**19.1 (535.3)**	**46.4**	**65.3**	**8,059**	**7,013**	**5,800**	
Southern Rivers							
Yangtze	34.2 (961.3)	34.3	23.7	2,289	2,042	1,748	41,745
Pearl	16.7 (470.8)	12.1	6.7	3,228	2,813	2,377	67,515
Southeast	9.2 (259.2)	5.6	2.5	2,285	2,613	2,231	80,160
Southwest	20.8 (585.3)	1.6	1.8	29,427	25,056	20,726	346,350
South Total	**80.9 (2277)**	**53.6**	**34.7**	**34,001**	**32,524**	**27,082**	

Source: Shen (2004).

pronounced in the water-scarce north. For instance, the difference between minimum and maximum precipitation is generally 3 to 6 times in the northern regions, while in the south it is only 2 to 4 times.[1] In the Hai Luan and Huai rivers, the flow is less than 70 percent of the average once in four years and less than 50 percent once in 20 years. However, the northern rivers are also highly regulated: the annual storage capacity in the 3-H basins is about 90 percent of the average annual runoff (the country wide average is about 20 percent.

Water Availability

China's total annual renewable water resources amount to between 2,400 and 2,800 billion m^3/year (6th in the world). However, annual per capita water availability was only 1,856 m^3 in 2004 (average 2,100 m^3 2000–2004), which is about a quarter of the world average (8,513 m^3/year). The south is relatively water-abundant. Water scarcity is very severe in northern areas, where average annual per capita availability is only about 725 m^3. However, population growth will continue to undermine per capita water availability. When China's (projected) population peak occurs, at around 1.6 billion in 2030, annual per capita water availability will be only 1,750 m^3. Given that China cannot increase its water resource base, future demand can only be met by increasing water efficiency in municipal, industrial, and/or agricultural sectors, promoting water re-use, or by cleaning up water that is currently unfit for consumption.

Precipitation patterns across the country show that the rainy season is as long as six to seven months in some southern areas and as short as two or three months in more arid northern regions. In general, annual precipitation decreases from the southeast to the northwest. In eastern areas around the Changbai Mountains, annual precipitation may reach 800 to 1,000 mm—about 800 to 900 mm in the area from Qinling Mountains to the Huaihe River (Anhui province), above 1,000 mm south of the middle and lower reaches of the Yangtze River, and more than 2,000 mm in some coastal mountainous and hilly areas in the southeast and parts of the southwest. In the western regions (except for the Altay and Tian-shan Mountains), most areas are dry. In the Tarim and Qaidam basins, annual precipitation is less than 25 mm; mean annual precipitation at some stations in the Turpan basin is less than 10 mm.

1. Ministry of Water Resources, Department of Hydrology. 1992. Water Resources Assessment of China. China Water and Power Press.

Figure 1.2. National Distribution of Water in China's River Systems

Source: Chinese Academy for Environmental Planning.

Water Use

The countrywide average use/availability ratio is about 20 percent, which, seen in isolation, is not an alarming value, but at local levels there are many areas where water systems are stretched beyond their capacity. In many areas, the cost of water shortages from pollution appears severe. According to 1997 statistics for the Yellow, Huai, and Hai Luan river basins, exploitation rates reached 67, 59, and 90 percent respectively (as compared to use rates of below 20 percent in the south). With about 40 percent utilization rate, all of these northern rivers exceed international recommendations for water use. Moreover, usage in the Hai-Luan basin exceeds the sustainable yield, resulting in groundwater depletion. The net effect is that the bulk of river flows in the north comprise wastewater, and the dilution and absorptive capacity of the rivers is severely compromised.

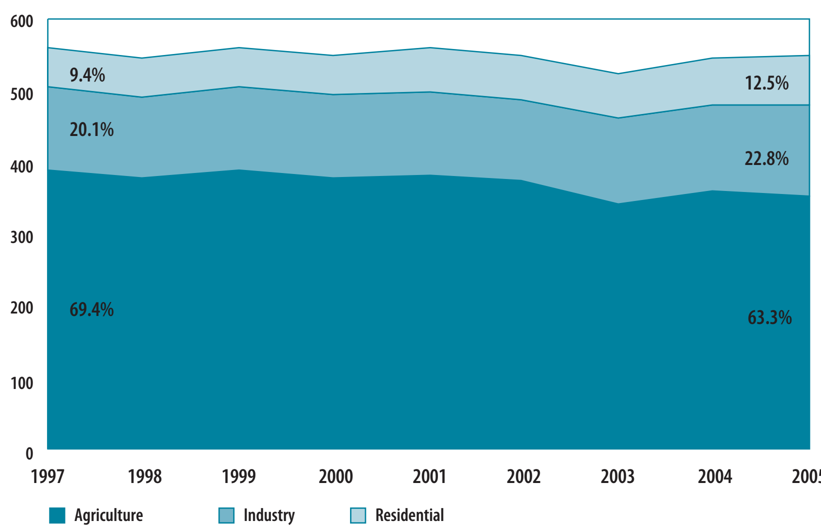
The total amounts of water use and wastewater generation have actually declined in recent years (World Bank, 2005; China Statistical Yearbook, various years). This trend is depicted in Figure 1.3, which shows that total water consumption declined by 4.5 percent between 1997 and 2005. The figure also shows the relative importance of agricultural, industrial, and consumption categories, which respectively accounted for 63.3, 22.8, and 12.5 percent of total water usage in 2005. The overall decline is due to reduced demand from the agricultural sector and has occurred in spite of increases in industrial and consumption usage.

Water savings from agriculture have been achieved through investing in more efficient irrigation systems and cultivation methods. In rice production, for example, there has been a widespread shift from traditional to water-saving irrigation systems that reduce water consumption by a third (FAO, 1996). These efficiency gains have allowed the overall water demand from irrigation to fall by about 5 percent (1997–2005), while the total irrigated area actually increased by about 5.5 percent over the same period (see Figure 1.3).

The declining proportion of water usage accounted for by agriculture is even more impressive when we consider that in 1980 it accounted for around 80 percent of total water use, and it is projected to be close to 50 percent by 2050 (World Bank, 2001). The growth that has occurred in the consumption category is driven by urbanization (4.3 percent, see Figure 2.1), and rising urban per capita residential consumption (110 l/cap/y 1980 - 230 l/cap/y 1997).

Urban and rural residential consumption both account for around 5.5 percent of water consumption. In 2001, urban water consumption surpassed rural consumption. For a long time, China experienced rapidly increasing per capita urban water consumption rates;

Figure 1.3. Trends in Water Consumption 1997–2005 (billion m^3)

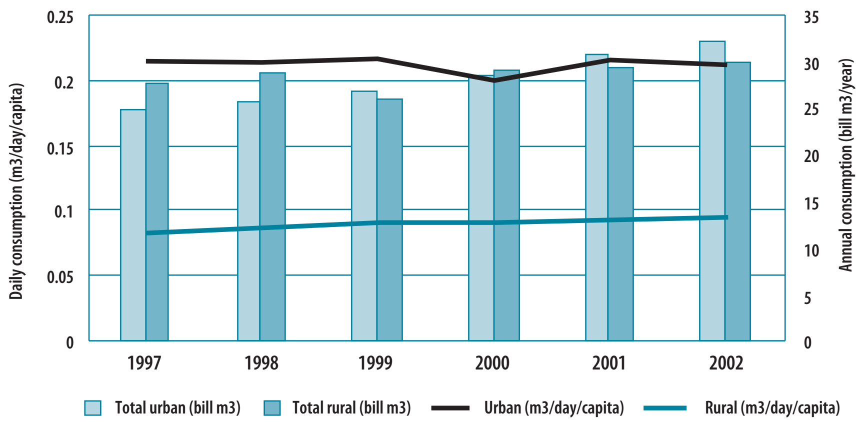


Source: China Statistical Yearbook (various years).

in recent years, this trend seems to have leveled off. Figure 1.4 shows the trend in urban daily water consumption levels.

The proportion of people with access to an improved water source (i.e. household connection or public standpipe) in rural and urban areas is 66 and 94 percent respectively in 2002 (WHO, 2004). However, other estimates are less optimistic and indicate that as much as half of the population does not have access to clean water (see Box 1.1). Of particular concern are the communities at the town and township level (i.e. below city level), which may not be captured in typical

Figure 1.4. Urban and Rural Water Consumption Rates



Source: China Statistical Yearbook (2003, 2004) and China Urban Construction Statistics Yearbook (various years).

Box 1.1. Drinking Water Trends in China

Water supply in China has increased significantly in both urban and rural areas in the past fifteen years. According to the Chinese Ministry of Health (MoH) statistics, the percentage of rural population with some kind of access to a drinking water supply rose from 75.5 percent in 1990 to about 93.8 percent in 2004, an increase of about 220 million beneficiaries. In urban areas, access to tapped water rose from 48 percent in 1990 to 88.9 percent in 2004. While these increases in the supply of drinking water represent a major achievement, trends in the quality of water supply are less encouraging.

According to a Ministry of Water Resources (MWR) survey, more than 300 million rural residents throughout the country consume unsafe drinking water. In Chongqing municipality, where the World Bank is conducting a study at both town/township and pure rural areas to examine the correlation between access to clean water and public health, 39.8 percent of the population have no access to a safe water supply.

The health risks associated with both, biological or microbial pollutants (e.g. large intestine bacilli, hepatitis B virus, cholera virus, typhoid, E-coli etc.) and chemical pollutants (e.g. heavy metals, fluorine, arsenic, benzene, oil, etc) are widespread. According to MWR, an estimated 63 million rural people in the northern, northwestern and north-eastern provinces and across the Huang-Huai-Hai (3-H) plains are exposed to drinking water with high fluorine content. In the coastal areas of North and East China, salinization of drinking water sources is affecting about 38 million people, and some 2 million people in parts of Inner Mongolia, Shanxi, Xinjiang, Ningxia and Jilin drink water with high arsenic content, which has been linked to several types of cancers.

Disease incidence and mortality rates due to microbial pollutants remain relatively low on national level. For example, according to the China National Health Survey, in 2003, infectious diarrhea (ex. bacterial and amoebic dysentery) and typhoid incidence were 35 and 4.17 cases per 10,000 persons respectively. However, the incidence rates in towns, townships and villages, particularly in heavily polluted areas, are suspected to be significantly higher.

Increasing the supply of clean drinking water, especially in rural areas, has become one of the major objectives of the Chinese government. The GoC began addressing the issue through an ambitious $2.1-billion rural drinking water supply project, completed during the10th Five-Year Plan (2001–2005). The project included the installation of 800,000 new water processing facilities, which provided access to clean drinking water to 14 million rural households. According to the MWR, the overall project is estimated to have relieved water shortages for more than 57 million rural residents.

The continued problems associated with the lack of access to clean water, have prompted the Chinese government to continue with its aggressive measures to tackle the issue. In urban areas, stricter standards for piped water quality have taken effect since June 1, 2005. In rural areas, according to MWR, China plans to cut down the number of residents without access to clean drinking water by one third by 2010 and to provide safe drinking water to all rural residents by 2020.

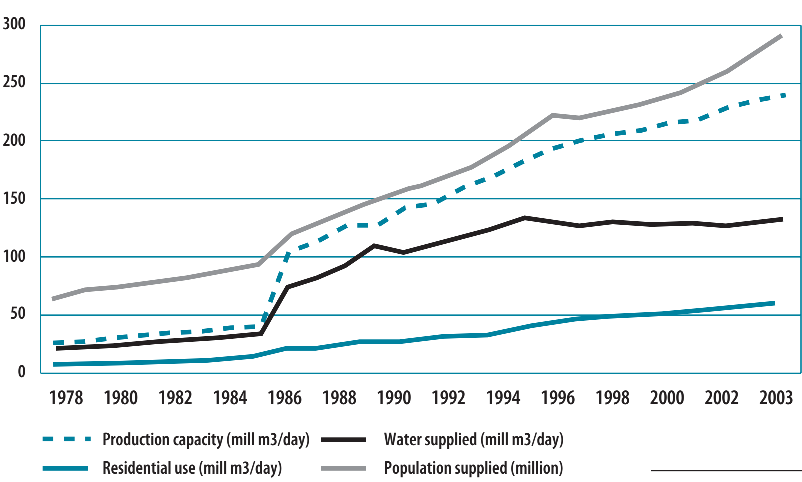
urban-rural statistics. China has 18,000–20,000 town and township centers, often with very poor access to clean water, but because of their hybrid (urban–rural) status, the Chinese institutions that would normally be responsible for infrastructure development have no clear mandate.

Urban Water Supply

The rapid growth of China's urban centers has necessitated increased level of water infrastructure. In 2003 China's national urban water supply capacity was 87.5billion m^3/year. This represents a vast increase in water capacity in China over the last 25 years. Figure 1.5 shows the rapid increase in urban population supplied with water services, which grew from 62 million in 1978 to 291 million in 2003. The urban water supply capacity increased at a similar rate, by almost an order of magnitude in the same 25-year period. In order to achieve this capacity increase there has been a nine-fold increase in the length of China's water supply pipelines, from 35,986 Km in 1978 to 333,289 Km in 2003. However, since the late 1980s total urban supply capacity has greatly exceeded the water actually supplied to the consumers. In 2003, daily capacity was 239 million m^3, but only 54 percent (130 million m^3) was supplied.

An important element to note in the figure 1.5 is the leveling-off that has occurred in total water supply since 1994, in-spite of continued increase in residential use. This pattern is thought to be related to reductions in industrial water demand connected to government initiatives to address water use and pollution from this sector. However, it also shows how urbanization is quickly negating the gains made in mitigating industrial water use.

Figure 1.5. Urban Water Supply Statistics (1978–2003)



Source: China Urban Construction Statistics Yearbook (various years).

Water Quality

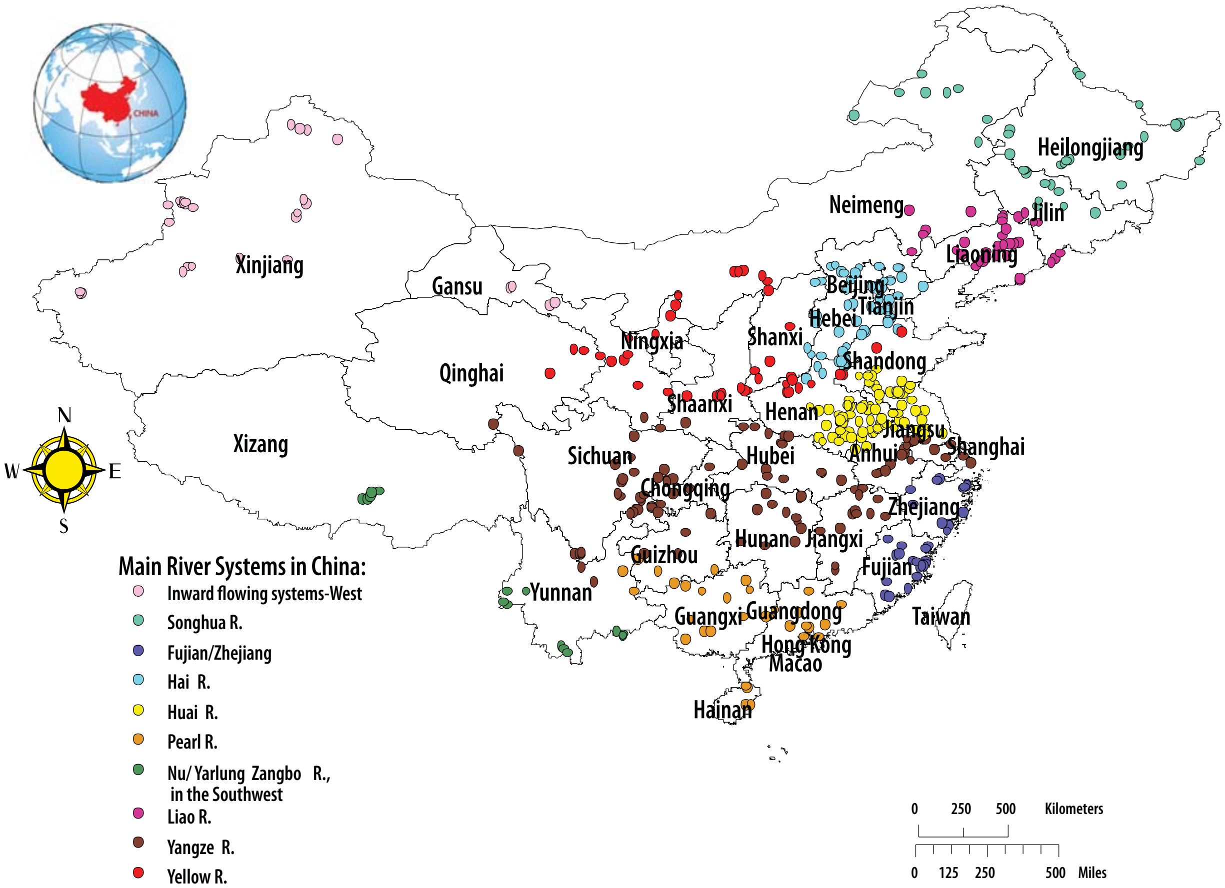
China has established a water quality classification system based on purpose of use and protection target, following Environmental Quality Standard GB3838-2002;

- Grade I – Mainly applicable to the source of water bodies and national nature preserves.
- Grade II – Mainly applicable to class A water source protection area for centralized drinking water supply, sanctuaries for rare species of fish, and spawning grounds for fish and shrimps.
- Grade III – Mainly applicable to class B water source protection area for centralized drinking water supply, sanctuaries for common species of fish, and swimming zones.
- Grade IV – Mainly applicable to water bodies for general industrial water supply and recreational waters in which there is not direct human contact with the water.
- Grade V – Mainly applicable to water bodies for agricultural water supply and for general landscape requirements.
- Grade V+ - Essentially useless.

Based upon this classification, water quality is being monitored on regularly basis in almost 500 monitored stations within China's referred nine main rivers basins through national and provincial-run water monitoring centers (figure 1.6).[2] The number of monitored sections within each river basins varies from for example 104 in the Yangze basin to only 17 in the South West rivers. As outlined in figure 1.7, the most polluted water sections are largely in Northern China and particularly in the most populous

2. The Ministry of Water Resources has also a monitoring system in place coverin about 2000 monitoring sections.

Figure 1.6. Environmental Monitoring Stations in the Main River Systems



Source: China National Monitoring Centre (Presented in World Bank 2006).

provinces of Henan, Anhui, Jiangsu, Hebei, Beijing and Tianjin. Other water pollution hotspot areas includes North East provinces and in high population concentration in Sichuan and Chongqing.

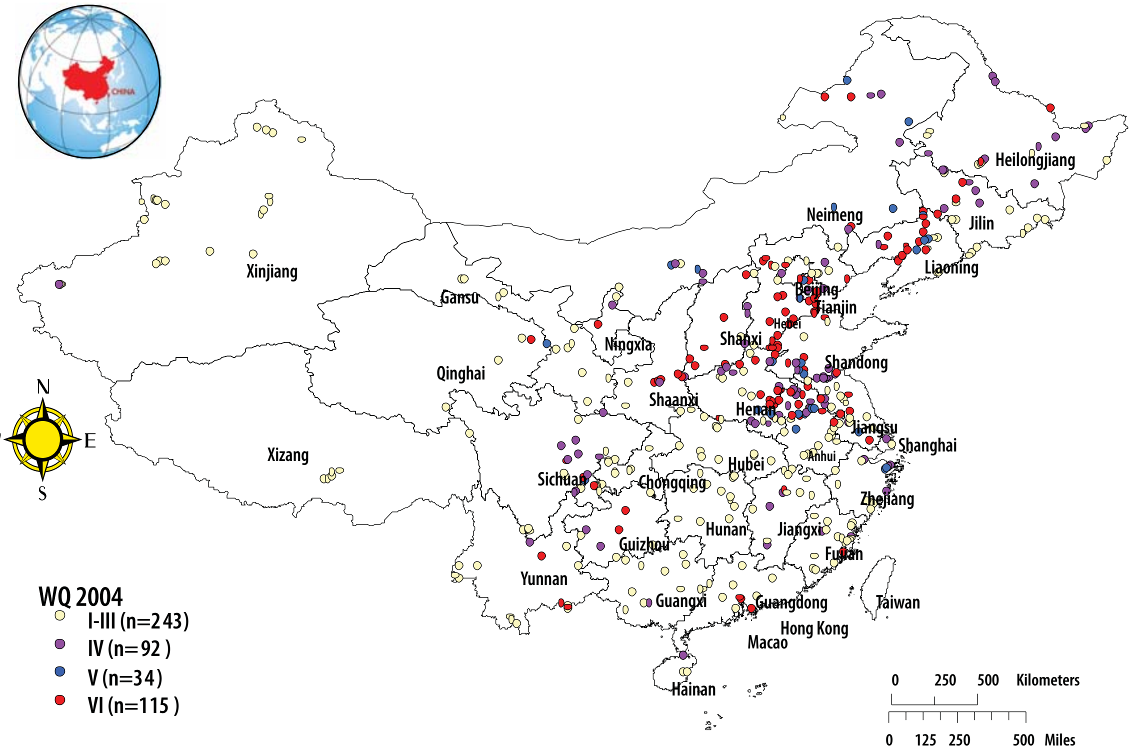
Results from ongoing water quality monitoring show overall water quality in China to be poor. In 2004, only 28 percent of monitored river water was in categories I to III, while as much as 31 percent was in the worst two categories.

As outlined in figure 1.8, the situation does not appear to have improved, where it is shown that larger shares of the water quality appears to have increased between 2000 and 2004 in particularly the northern regions.

Among the about 30 pollutants included in the overall water quality monitoring schemes, usually about 14 are selected in comprehensive water pollution indexing. The worst individual monitored pollutant establishes the water quality grade for the section. The most important indicator for triggering water quality levels was nitrogen (in the form of ammonia), followed by organic materials (BOD and COD). Figure 1.9 shows the relative importance of different indicators in terms of the frequency with which they 'trigger' a lower water quality category in China's main rivers. Many rivers have a similar pollution structure, but the Huai is heavily dominated by nitrogen (as ammonia), whereas in the Yangtze, nitrogen is never the most important pollutant.

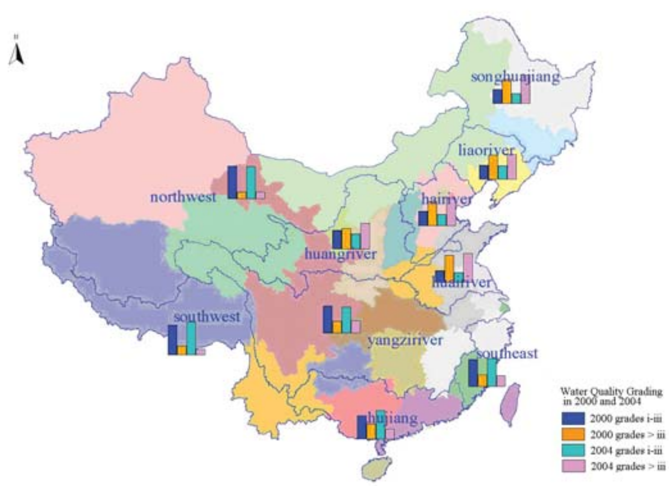
China's large lakes are also experiencing declining water quality caused by both point and non-point source emissions. Lake Dianchi is a good example of this trend, as water quality declined from Class II in the 1960s, to class V and IV in the 1990s. The lake has also undergone significant eutrophication during this period with a massive shift from a high biodiversity low productivity system to a low biodiversity high productivity state. Concentrations of organic matter and nutrients, such as phosphorus and nitrogen, show high levels, and the latter are still increasing. Organic

Figure 1.7. Surface Water Quality Levels 2004



Source: China National Monitoring Centre (Presented in World Bank 2006).

Figure 1.8. General State of Water Quality in the Main River



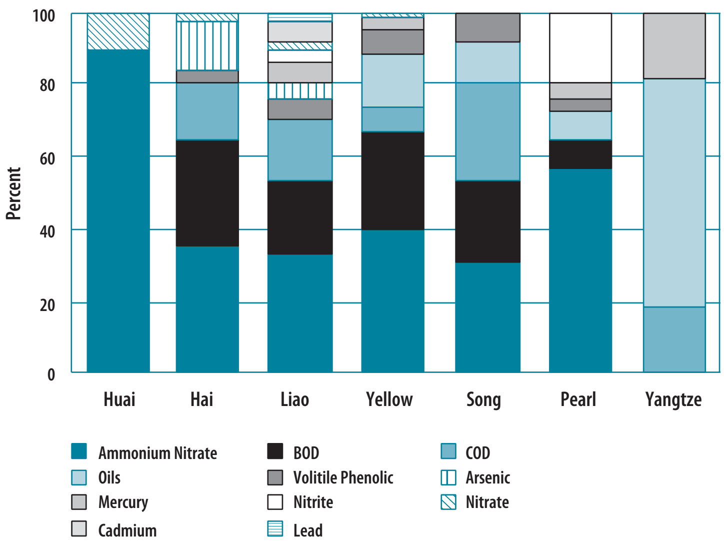
Source: Chinese Academy for Environmental Planning.

material contributes to decreased oxygen levels and bacterial growth and nutrients cause eutrophication.

Pollution sources are often grouped in two classes:

- Point source pollution is made up of industrial and municipal emissions. Recent measures to encourage industries to meet wastewater regulation standards led to a 25 percent reduction in emissions (28 to 21 billion tons) between 1990 and 2004. In 2000, industrial sources accounted for 11 percent of BOD, 4 percent of Total Nitrogen (TN), and 2 percent of Total Phosphorus (TP) discharges. Municipal sources are increasing, as population and economic growth leads to more wastewater, important elements include growth in flushing toilets and washing machines. Municipal sources accounted for 52 percent of BOD, 69 percent of TN, and 53 percent of TP in 2000.
- Non-point sources are primarily related to agricultural activities, including fertilizer and pesticide run-off from farmland, and infiltration of livestock waste. In 2000, non-point sources accounted for 37 percent of BOD, 27 percent of TN and 45 percent of TP. The excessive loads of nutrients, and

Figure 1.9. An Illustration of the Water Pollution Structure in Major Rivers



Source: China Environmental Yearbook 2002.

in particular Phosphorus, leads to eutrophication, excessive algae growth, reduced biodiversity levels, and poor quality water.

Despite considerable efforts to clean up China's major river basins the situation remains generally poor. There have been some improvements in the Yangtze and Pearl River basins where a reasonable proportion of the water is now classified at grade I or II (but all still contain areas of very poor water quality, particularly in the tributaries). However, many of China's rivers, such as Hai, Liao, Yellow and Songhua, are still dominated by water of the worst categories (V and V+). The problem is typically most prominent when rivers flow through large cities, where discharges of organic materials have caused increased concentrations levels of various pollutants.

The clean-up challenge is huge and is especially important given the water shortage problem. According to WB estimates, the cost of water shortages from pollution ranges from 1 to 3 percent of local GDP in water scarce areas (World Bank 2006). In order to address this problem, the Chinese government has already started work on a number of water transfer projects (south to north), but poor water quality in intervening rivers is a major constraint (box 1.2).

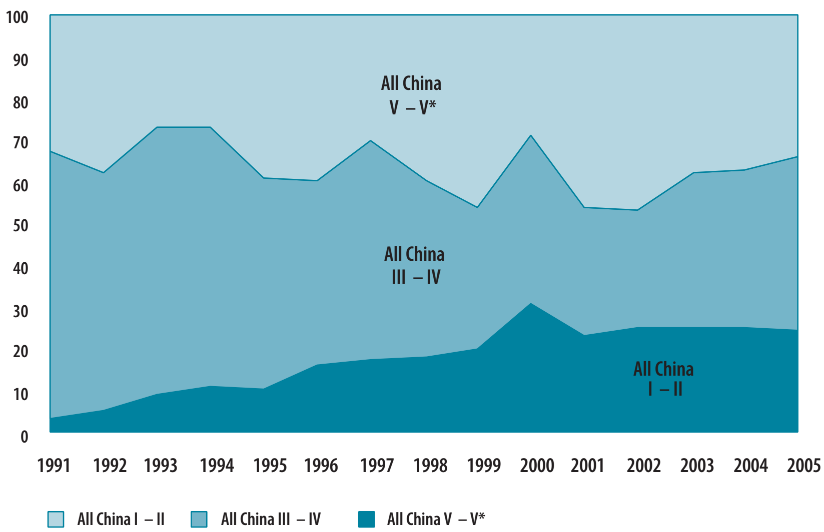
Addressing water pollution in China is also significant given its particularly high health cost and to some extent agricultural costs. The estimated cost in 2003 for the whole of China for water-related damages of four major types of crops (wheat, corn, rice and vegetable) was about 0.05 percent of GDP. Establishing the true extent of public health impacts from water pollution is challenging, because it is hard to isolate specific dose response functions given the wide range of factors, including food chain effects. Initial World Bank analysis on the environmental health impact of water pollution in China found significantly higher disease rates, e.g. cancers and spontaneous abortions, among fishing and farming communities living near polluted water sources (World Bank, 1997).

Ongoing work has indicated that improved water quality could significantly reduce the spread of the hepatitis A virus (70 to 90 percent of hepatitis A cases in China are transmitted by water). Waterborne diseases, such as diarrhea, cholera, and typhoid, which are entirely related to impure water, could be reduced by almost 50 percent by moving from heavily to moderately polluted water (World Bank, 2006). The ongoing study also estimates 9 million cases of diarrhea due to water pollution based upon the national health survey from 2003. Excessive application of fertilizers can also have health consequences; under aerobic conditions, NO_3 can be formed, which is absorbed into the body and interferes with the blood's oxygen carrying capacity.

Trends. Average water quality for China as a whole shows a steady increase in the relative abundance of the worst and best water quality categories. Figure 1.10 shows that between 1991 and 2005 the number of monitoring stations recording the worst categories (V and V+) stayed the same at about to 30 to 35 percent (but with high fluctuations), while the percent of best categories (I and II) increased from 3 to 20 percent. This pattern may reflect two main processes: (a) the difference in water quality patterns in the north and south of the country; and (b) water quality improvements in the main course versus deterioration in tributary waters.

The difference between recent water quality trends in southern rivers (Yangtze, Pearl) and northern rivers (Hai, Huai, Yellow, Liao, and Song) is shown in Figure 1.11. In the southern rivers, the proportion of water rated in

Figure 1.10. Average Water Quality in Chinese Rivers (1991–2005)



Source: China Environmental Statistics Yearbooks (various years), World Bank (2001).
Note: Figures 1.10 and 1.11 haven't been corrected for inter-annual or inter-region flow variations that might affect dilution capacity and classification.

the best categories has increased from 2 to almost 60 percent, while in the northern rivers the change is much smaller (4 to < 10 percent). However, water in the worst categories has increased in northern rivers, from 40 to 45 percent (but with fluctuations up to > 60 percent), as a result of the pollution sources outlined above and the very low levels of water available to absorb it. The deterioration of water quality is particularly severe in the Hai and Huai river basins. Annex 1 gives these trends for each river separately.

Another important reason for the simultaneous increase in abundance of best and worst categories is the fact that much of the attention in cleaning up operations has been focused on the main river course, with less effort on the tributaries. For example, in the Yangtze River, which has experienced significant water quality improvements in recent years, there is a stark difference in the relative abundance of best and worst water qualities between main river and tributaries. Figure 1.12 shows that, in 2001, the main river had no cases of class V or V+, while this accounted for 48 percent of the water in its tributaries.

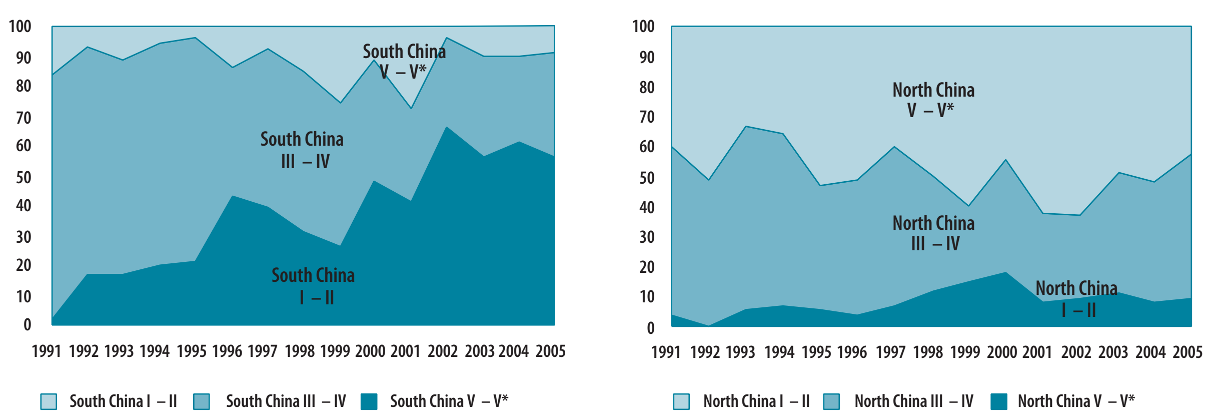
An important indicator of the pollution management efforts that have been made over the last decade is the decline in chemical oxygen demand (COD) from industrial sources in many rivers. Improvements are shown in Figure 1.13 for the Liao, Hai, and Huai rivers.

Emissions

There are three main categories of water pollution emissions: (1) industrial, (2) municipal, and (3) agricultural non-point sources. Over the last 20 years, there has been a sequential development of these sources, with the following chronology;

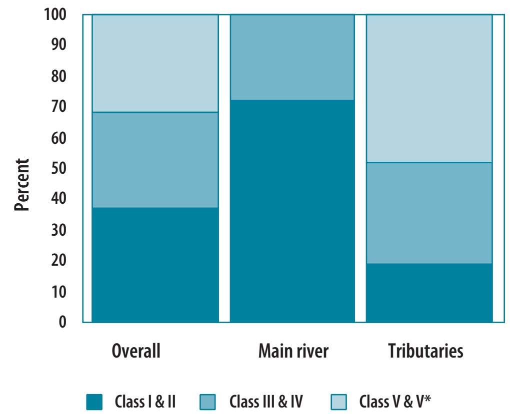
1. Country and Above Owned Enterprises dominated until the end of the 1980s

Figure 1.11. Average Water Qualities in Southern and Northern Rivers (1991–2005)



Source: China Environmental Statistics Yearbooks (various years).

Figure 1.12. An Illustration of Water Quality in Yangtze's Main River versus Its Tributaries



Source: China Environmental Statistics Yearbook (2002),

2. Township Village Industrial Enterprise emissions peaked in the mid-1990s

3. Municipal wastewater emissions increased (with urbanization), but investment in treatment infrastructure has brought about a leveling off in untreated urban wastewater emissions

4. Agricultural non-point source emissions are still increasing, rapidly in some places, and will be the next emissions issue to address.

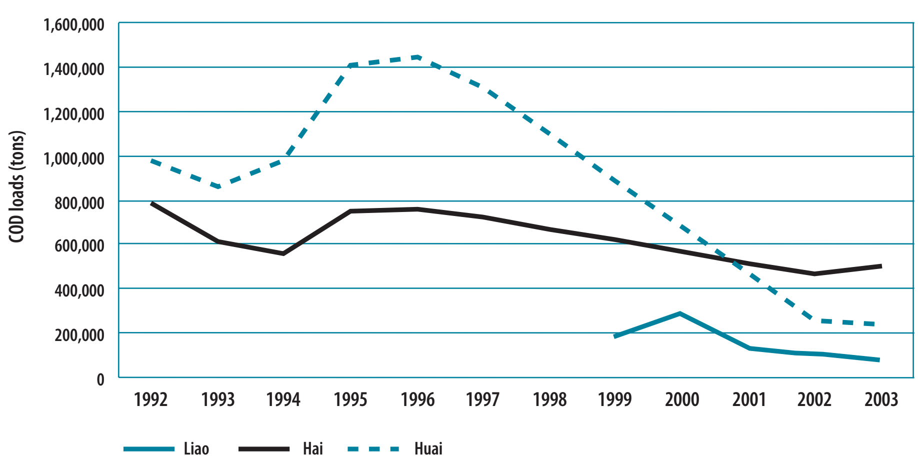
Industry. Over the last 15 years, total industrial wastewater volumes have declined from 28 to 22 billion tons, but (as Figure 1.14 shows) with a slight increase over the last year. Until 2000, most of the reductions were achieved by the country- and above-country-owned enterprises (CAOE). In the same period, there has been a slight increase in wastewater discharge at the town and village industrial enterprise (TVIE) level.

The level of chemical oxygen demand (COD) from these sources has followed a similar pattern, with most of the improvements being made since 1995 (Figure 1.14). However, in the most recent years (2000–2004), COD levels have continued to fall, in spite of the fact that the total level of wastewater emissions increased slightly. This result indicates that while total emissions have remained relatively stable in the last few years, the oxygen demand of this material has dropped, suggesting that this particular pollution problem may have been successfully addressed.

In relative terms, these figures show that total wastewater flow and COD from industrial emissions have fallen by 29 and 49 percent respectively (1989–2004). There are a number of reasons for this trend, including;

- Improved and more stringent regulations have led to large-scale closures in 15 categories of small-scale TVIEs. The policy was very efficient from a pollution reduction point of view, but there may have been economic and social costs from enterprise closure.
- Improved industrial processes and an increase in the volume of wastewater treated.

Figure 1.13. Chemical Oxygen Demand Loading, 1992–2003 (tons)



Source: Water Pollution Management (Vol I), and China Environment Yearbook (2002, 2003).

The level of water pollution generated by different industrial sectors is not even. The most important sectors in terms of total wastewater discharge volumes are paper and chemicals, which both release over 3 billion tons annually. By comparing the gross industrial output value (GIOV) and the level of COD from emissions in each sector, we can assess the pollution generated

Box 1.2. Water Transfer Projects

The uneven distribution of China's water resources between the water-scarce north and water abundant south is forcing the Chinese government to seek measures to ensure sufficient water availability for people living in northern regions. One such measure is the 'South to North Water Transfer Project' (other projects include the World Bank-funded Wanjiazhai project). The project is designed to divert 13.4 billion m^3/yr of water from the Yangtze to Beijing, and the project will supply many other cities along the route. The plan foresees a total water transfer capacity of 44.8 billion m^3 by 2050[1]. Work began in 2002, the first supplies are to reach Shandong and Beijing in 2007 and 2010 respectively. Total project expenses, which were initially projected at $60 billion, have been increasing.

The project faces a number of logistical challenges, including the need to clean up water bodies at intersections that the canals will pass through. The 1,154 km eastern route of the project, largely following the Grand Canal route from the Yangze River through Jiangsu and Shandong provinces to Hebei and Tianjin, crosses through 53 rivers sections in China's most heavily water-polluted area. In most cases, these sections have water quality of category V+. Cleanup operations will account for 37 percent of the total investment. If completed on schedule it will represent one of the most comprehensive water cleanup operations in the world. The water improvement objective is to reach category III throughout the transfer scheme, requiring an average water improvement (for critical water quality and pollution parameters) of between 82 and 99 percent for pollutants such as nitrogen, BOD, COD and oils. However, at present, China has no track record in cleaning up polluted rivers at this level. Challenges include implementation and effectiveness of wastewater treatment plants, ensuring inter-provincial dialogue, and agreement on project components.

The vast cost of the projects may mean that water pricing will be a problem for some consumers (between 3.2 and 4.8 Yuan/m3 in many cities and as high as 7 Yuan/m^3 in Beijing[2]). Also, stricter enforcement of pollution regulations and continued closedown policies may have a significant impact on industries in some locations along the transfer route.

1. http://www.nsbd.mwr.gov.cn/nsbd/intro.
2. See http://www.people.com/cn/GB/14576/28320/31049/31054/2266569.html

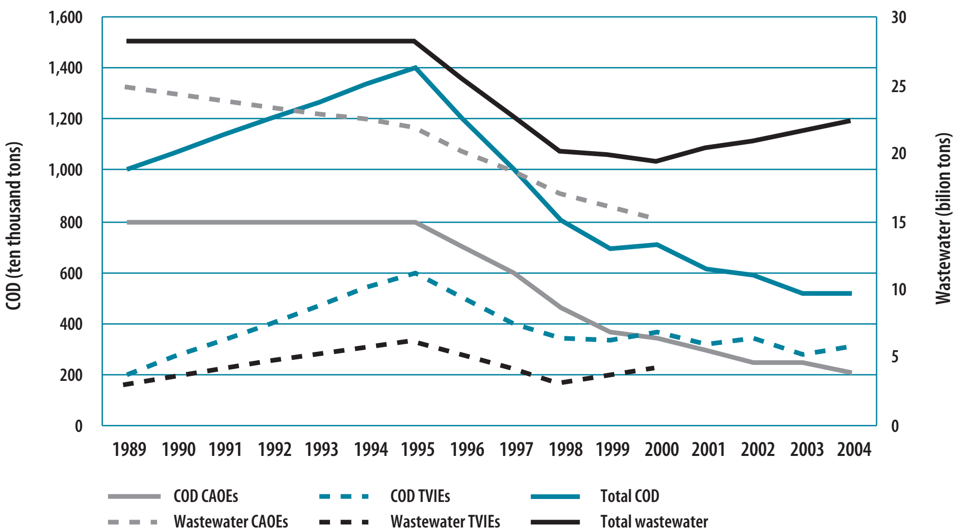
by sector in relation to its economic importance (see Figure 1.15). The pulp-and-paper and food industries generate the most COD in relation to their contribution to the economy (GIOV). This result suggests that the paper and food industries represent a good target for reform initiatives. However, the other sectors (chemicals, textiles, tanning, and mining) all have the potential to discharge pollutants with more serious human and environmental impacts than COD.

Municipalities. The demand for water in China's cities has increased dramatically over the past few decades. Between 1990 and 2004, urban water consumption increased by about 6.3 percent annually, to 23.4 billion tons. At the start of the 1990s, municipal wastewater treatment capacity was only able to handle a fraction of the consumption levels (4 and 10 percent in 1991 and 1998 respectively). Increases in water consumption levels meant that even greater rates of expansion in wastewater treatment capacity and sewage facilities would be required in order to increase the coverage. However, construction of treatment facilities has now, in many places, out-paced the development of an effective sewer network. As a result, a significant part of the capacity at the treatment works is underutilized, and a significant part of the wastewater generated is still discharged without any treatment. Furthermore, investments in wastewater treatment capacity have been disproportionately concentrated in larger urban centers. In 2003, centralized wastewater treatment rates of super, mega, high, medium, and small cities are 43, 42, 20, 18, and 16 percent respectively in northern regions (World Bank, 2005).

The continued growth in municipal wastewater discharges (Figure 1.16) has effectively offset the gains made in industrial pollution management (Figure 1.14). In 2003, the total amount of municipal wastewater was 24.1 billion m^3 and industrial wastewater 21.2 billion m^3.

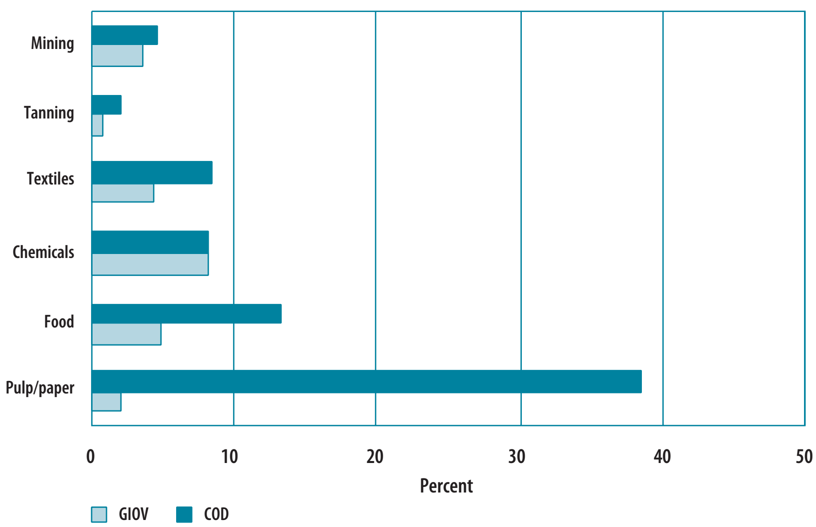
Agriculture. Fertilizer application, which is often excessive and inefficient, is a major cause of the growing agricultural non-point source pollution problem. Fig 1.17 shows the increase in fertilizer use over the period 1978–2004. Average levels of fertilizer application increased five-fold over the period; in 1999, the average level was about 320 kg/ha/y (though maximum values may be 4 to 5 times higher). Nutrient pass-through from fertilizer overapplication, which is increased through inefficient forms of irrigation, is one of the main driving forces behind increasing levels of eutrophication in Chinese lakes and near-shore marine waters. For instance, it is estimated that 70 percent of the nutrient load of Lake Dianchi comes from agricultural diffuse pollution; the picture is similar in Lakes Chao and Tai.

Figure 1.14. Trends in Industrial Wastewater and COD Emissions



Source: China Statistical Yearbooks, data for 1990 – 1994 and 1996-1997 are extrapolated from 1989, 1995 and 1998 data points.
Note: Country and Above Country Owned Enterprise (CAOE), Town and Village Industrial Enterprise (TVIE).

Figure 1.15. COD Loads and GIOV Shares in Industries, 2004



Source: China Environment Yearbook (2005).

There is a high likelihood that the use of, and pollution associated with, pesticides is also increasing; however, data on this issue is missing. The lack of appropriate monitoring and data collection systems is indicative of the problems that the government is facing in the management of pesticide use. Given the impact that pesticides can have on water quality, the issue is assumed to be a serious problem.

Finally, China's economic growth and the increasing affluence of the population are resulting in a changing diet and consequently a major increase in livestock production. Figure 1.17 shows that total weight of pig, sheep, and other (cattle, horse, donkey and camel) increased 54, 86, and 62 percent respectively between 1978 and 2004. This presents a new water pollution problem because the potential of growth and the difficulties in regulating this industry mean that manure generation could have serious consequences on water quality.

Compared with the industrial and municipal sectors, initiatives to address agricultural emissions have been very limited. This sector is especially challenging, because there are a growing number of small-scale farm units that are difficult to supervise, and, as the economy continues to open, the government's influence over farming practice is diminishing.

Summary of Findings

A combination of unprecedented economic growth and urbanization is putting significant strain on China's water resources. Water shortages are increasingly a reality, particularly in the northern part of the country, and the declining quality of the existing water resources only exacerbates the country's problems in the water sector.

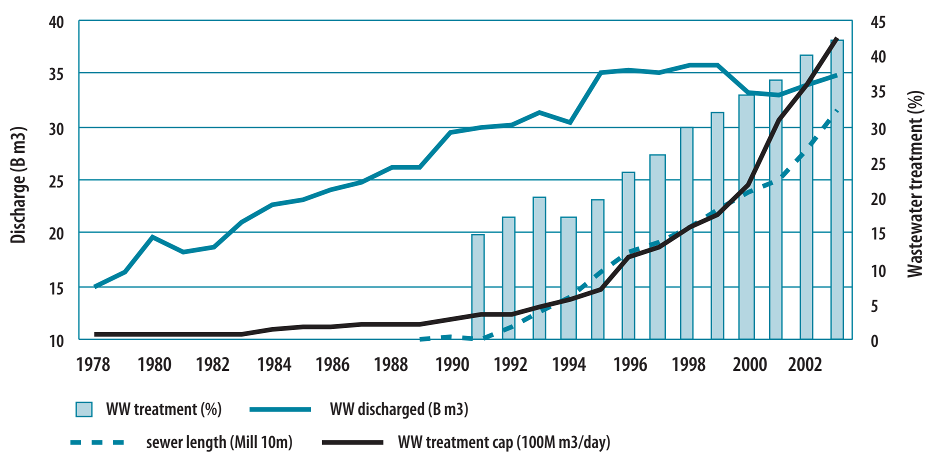
Water consumption is increasing in spite of efficiency gains in agriculture and industrial water use. The

Table 1.2. Urban Indicators and Water Use

	1990	*1995*	*2000*	*2003*	*2004*	*Annual Growth (percent)*
Water consumption residential (billion m³)	10	15.8	20	22.5	23.4	6.3
Per capita water consumption residential urban (ton)	69.7	71.3	95.5	77.1	76.9	0.7
Municipal wastewater treatment capacity (mill m³/yr)	2.77	7.14	21.58	42.54	49.12	23.4
Length of sewer pipelines (10,000 km)	5.8	11	14.2	19.9	21.9	10
Municipal Wastewater treatment rate (percent)	13	19.7	34.25	42.39	45	9.3
Official urban population (million)	301	351	459	523	543	4.3
Number of designated cities	467	640	663	660	661	2.5
Built-up city areas (km²)	12,856	19,264	22,439	28,308	30,406	6.3

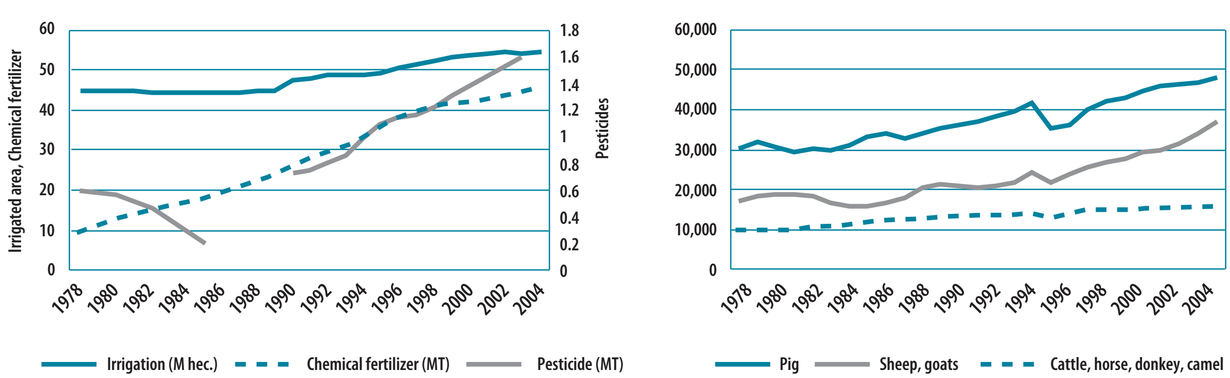
Source: China Statistical Yearbook (1992, 2000, 2004, 2005) and China Urban Construction Statistics Yearbook (various years).

Figure 1.16. Municipal Wastewater, 1978–2003 (billion m³)



Source: China Urban Construction Statistics Yearbook 2003.

Figure 1.17. Irrigation, Fertilizer, Pesticide, and Livestock Levels (1978–2004)



Source: China Statistical Yearbook (various years).

primary culprit for this trend is the rapid growth in urban populations and simultaneous increase in urban per capita water consumption. The growing demand for water in northern cities has resulted in major water transfer projects. Having resulted in increased government attention to water quality, these projects have generally had positive ecological impact. However, the resulting increase in water prices will be a problem for many consumers.

Overall water quality in China is poor. In 2004, only a quarter of China's rivers were classified as category I and II (highest water quality), while about 40 percent were in the most polluted categories. Most of the pollution in China's rivers is caused by the discharge of nitrogen (in the form of ammonia) and organic materials, such as BOD and COD. Much of this discharge originates from non-point sources, primarily agricultural runoff, which is difficult to regulate.

Industrial pollution has decreased substantially since 1989. More stringent regulations have led to the closure of many highly polluting small-scale TVIEs. Improved industrial processes and higher volumes of treated water can also account for the pollution reduction.

In recent years, water quality in China has improved in the rivers classified in the best water quality categories, but it has worsened for the worst categories. These trends reflect the difference in water quality patters in the northern and southern parts of the country, as well as concentrated efforts on improving quality in the main river courses, with less effort in the tributary waters.

2. Policy and Institutional Issues

Legislation and Policy Instruments

At the time of the first Chinese water pollution policy, which was formulated in 1972, the focus was on abatement of point-source pollution. Since then, the approach has undergone a number of profound changes, including a shift toward pollution prevention, the use of integrated management approaches, multi-source financing schemes (replacing government budget allocations), and policy instruments integrated with command and control measures. New policy instruments include effluent standards, EIA requirements, discharge permits, fee and levy systems, ISO 14000, and Total Load Control.

A sluice along the Huai River

The current policy structure has had some success in reducing water pollution from the industrial sector. Between 1995 and 2004, the absolute discharge of wastewater decreased from 28 billion m^3 tons to 22 billion m^3, though the situation deteriorated somewhat in the last few years. Between 1999 and 2004, the percentage of industrial wastewater meeting discharge standards increased from 67 to 91 percent. Target levels for the reduction of industrial discharges of eight of the main water pollutants (mercury, cadmium, hexavalent chrome, lead, arsenic, cyanides, oil, and COD) were achieved over the period 1990–2000, but more recently some of the critical water pollution reduction targets have not been achieved in the 2001–05 period (World Bank, 2006). In particular, less progress has been made in addressing COD loads and concentrations, and the modest gains that have been achieved have been offset by increases in COD from municipal sources (Statistical Yearbook, 1990–2005; China Environmental Statistical Yearbooks, 1990–2005).

This situation reflects the fact that the legal system has been focused on industrial sources and has been unable to account for "new" water pollution problems, such as agricultural non-point and municipal sources. The approach is entirely dependent on government agencies and does not take advantage of the potential for participation from the private sector and civil society. Furthermore, the system is heavily reliant on protection and command-and-control tools, as opposed to economic and voluntary instruments.

A major problem with respect to water pollution management (WPM) in China, as in many parts of the world, is that well-designed policies are often poorly enforced. Further complications exist in areas where rivers cross administrative boundaries, between municipalities or provinces, because agencies pay more attention to protection of water resources that affect their clients than to discharges transported out of their area of responsibility. This behavior causes conflicts between upstream and downstream administrative units.

The following WRM policy instruments are currently employed in China:

Pollution Charges. The pollution levy system (PLS), initially established in 1982 and revised in 2003 (see Box 2.1), has become the most important economic instrument for environmental protection. The PLS not only serves as an incentive to change polluters' behavior, but it is also a source of funding for investment in pollution management and capacity building for environmental protection agencies. In 1999, total water pollution charges amounted to about 0.3 billion Yuan, about 5 percent of total environmental charges. Under the old system, charges would only be levied against the most significant element of pollution in excess of the effluent standard. With the 2003 revision, however, there are charges for all elements, e.g. COD is charged at 1.2 Yuan per Kg. An example of the charge system is given in Box 2.1.

The initial problems associated with the pollution levy system included:

- Polluters limited ability to pay resulted in a system where charges did not reflect environmental costs;
- Charges were collected against the pollutant with the highest concentration, which implies that other pollutants were not penalized;
- The system was based on concentrations rather than on loads.

The above-mentioned problems appear to have been solved with the referred new pollution charge regulation, but further detailed reviews should perhaps also be undertaken.

Box 2.1. China Pollution Levy System Reform

The new pollution levy system was initiated in July 2003, and includes new regulations on principles, charge basis, charge rate schedule, revenue, and use policies. The main change is the shift from a concentration-based to a total load charge system, i.e. charges are levied against discharges regardless of whether the concentration is above the discharge standards or not. The charge basis covers more than 100 pollutants, affecting water, air, solid waste, noise, and radioactive pollution.

Pollution charges are calculated using a pollution equivalent (PE) system, which represents the aggregate volume of pollution from each source. Each constituent pollutant has a specific PE coefficient, and the total charge is calculated as the sum of PEs multiplied by the local charge rate. For example, a firm is in compliance with the relevant effluent standards, discharging 50kg COD, 8kg SS, and 1kg oil per month. Under the previous system, there would have been no charge for these emissions, as the effluent standards have not been exceeded. However, under the new system, each PE is charged at a set rate. If we assume the rate is 0.7 Yuan/PE, then the total charge will be 43.4 Yuan/month [((50/1)+(8/4)+(1/0.1)) x 0.7].

The pollution levy is collected by local EPBs (at city and county levels) and the revenue is distributed to respective finance bureaus. Revenues from pollution levies are allocated through budgetary management, that is, financial bureaus and respective EPBs are responsible for allocating fines and selecting projects based on the criteria given in the regulation. In order to strengthen the effective utilization of pollution levy revenues, 20 percent of the total revenue is allocated to the central financial body, the Ministry of Finance (MOF), where it is managed by MOF and SEPA to fund projects of national significance. MOF has the final say in terms of budget allocation, while SEPA decides on selection. Provincial governments might also set aside a portion of the pollution levy revenue to fund projects of provincial significance. It appears, however, that the principle of setting aside revenue for national and provincial projects and strengthening of budgetary management has discouraged the local EPBs in pollution levy collection.

Industry Permit Systems. Acceptable total discharge loads are set in each region according to the local recipient carrying capacity. Based on these limits, polluters are allocated discharge licenses with a specified maximum volume, and permission is granted through permit decrees. In 1989, the State Council approved implementation regulations for the Law of Water Pollution Prevention and Treatment, stating that the discharge permit certificate is a management measure for reporting and registration of pollution. Initially, implementation was carried out on a test basis. The water pollution permit system involves reporting and registration of pollutant discharges, allocation and issuance of pollution permits, supervision, and management. After piloting the system in several provinces, including Shanxi and Jiangsu, SEPA announced the end of the trial period in 1994 and initiated the implementation of a nationwide wastewater discharge permit system.

This discharge permit system has improved pollution management and has moved the system from a concentration-based approach (referred to above) to a total load control system based on assimilation capacities in recipient water bodies. This has led to significant water pollution decreases, particularly in pollution from industrial sources. Application of the permit (total load) system runs in parallel with effluent standards. The former is seen as more stringent, but the polluter is required to meet both requirements and is liable for disciplinary action if either is exceeded. The total load system is, therefore, not used in isolation but in combination with a variety of the other instruments. However, problems still exist, including:

- Technical/scientific challenges in establishing the ecological status of water bodies and in the calculation of assimilation capacities of the receiving water bodies. This has resulted in significant delays in the implementation of load-based management systems.
- Coordination difficulties between the permitting and the total load control systems. In particular, it is difficult to be confident in total load limits, which are set for provinces, cities, and towns through self-monitoring and assessment processes. The lack of an independent monitoring system to guarantee the required load reduction and water quality criteria is a significant concern.
- Equitable allocation of permits between existing and new pollution sources. Difficult technical and political decisions have to be made in the cases where local assimilation capacities are already being exceeded. This raises issues related to effectiveness, methodology, allocation, and equity.
- Difficulties in aligning targets to regional water quality and load-bearing capacities.
- Problems in integrating agricultural non-point pollution and urban pollution management into the discharge permit system.
- A fully efficient and "fair" discharge permit system requires improvements in emission monitoring and supervision.
- The weak scientific basis and poor monitoring means that strict legal enforcement is difficult, and enterprises can get away with permit violations.

Close-Down Policy. While total load control permit systems are used for firms that comply with effluent standards, firms that exceed effluent standards are faced with the threat of closure. Firms receive a warning and guidance about their need to comply, but ongoing breach of regulations can lead to closure. Application of the close-down policy is closely linked to local development policies. For example, regulators are less likely to enforce closure in areas where local economic development is weak, while closure is more likely where pollution from firms affects important investments such as within the South-North Water Transfer Project area.

When the government assessed industrial pollution across different sectors, it identified fifteen categories of enterprises that are defined as serious polluters. The "Fifteen Small" enterprises policy then recommended that these categories be phased out. The most important category is TVIE Pulp and Paper factories. By 1997, more than 64,000 "Fifteen Small" enterprises were shut down, accounting for 86 percent of non-complying units. However, strategically important enterprises located in economically struggling regions were allowed to continue operating. The policy encountered significant resistance because of its socioeconomic implications, but from an environmental perspective, the results were encouraging. The evaluation of the policy concludes that:

- Direct positive environmental impacts include the annual reduction of more than 3 billion m^3 wastewater discharges and 1 million tons of COD load from pulp and paper factories;
- Estimates indicate that the policy produced a net benefit for society, with the 42 billion Yuan cost (80 percent born by enterprises) more than being offset by the economic and environmental benefits;
- The policy showed the seriousness with which the government intends to address water pollution problems;
- Only limited attention was paid to local economic and social impacts, such as job losses and associated local economic impacts. However, only about 1 percent of the total number of TVIE staff appear to have been affected by the close-down policy.

Centralized Wastewater Treatment Plants. The Water Pollution Prevention and Control Law (1996, article

19) requires centralized treatment of municipal sewage, and prescribes that relevant government bodies should incorporate water protection and treatment infrastructure into urban planning.[1] A centralized system refers to an urban wastewater treatment plant and its pipeline sewerage network, as opposed to treatment infrastructure for specific firms. The revised law also indicates that users will be charged a wastewater discharge fee for sewage treatment services, and those who pay should be exempt from separate pollution discharge fees. Revenue from these fees is used exclusively for construction and operation of facilities for central treatment of urban sewage. However, many cities are still quite far from the situation envisioned in this municipal wastewater management policy, which includes the development of sewerage systems and large treatment plants. In many places sewerage and treatment facilities are either absent or very partial, and industrial enterprises have to treat their own emissions.

The development of the required sewage and wastewater treatment facilities is a difficult process, and planning, coordination, and timing have all been stumbling blocks. A crucial element determining the capacity and technology of these plants is the projected quantity and composition of wastewater generated. Another problem is the appropriate pricing of water, as underpricing leads to overconsumption and increasing levels of wastewater generation. In Beijing, which has the second highest average per capita consumption rate[2] (248 l/day), water prices have been increasing over the last few years. The latest increase, in May 2005, was from 3.7 Yuan to 4.5 Yuan (0.55 USD) per M^3 for residential consumers. This rate is one of the highest in China (Kunming is 1.8 Yuan/m^3) and compares to urban disposable income levels of 15,637 Yuan/year (Beijing Municipal Statistical Bureau, 2005). About three-quarters of this price is used to cover water supply, and one-quarter is assigned to cover sewage disposal costs.

The implementation of centralized wastewater treatment policies has raised a number of issues:

- **Cost:** Construction and maintenance costs are high, and the onus is on local users to pay for these facilities. However, full cost recovery may not be realistic in smaller cities that cannot take full advantage of efficiencies of scale.
- **Financing:** Various sources of funding can be explored including government budgets, private partnerships, and foreign investments.
- **Pre-treatment:** Criteria for the pre-treatment of some industrial discharges, prior to entering the central system, may need to be developed.
- **Incentives:** Positive incentives or stricter enforcement may be required to make enterprises move from existing systems to centralized treatment facilities.
- **Fees:** Effective cost recovery systems, such as user fees, need to be established.
- **Technology:** Identification of the most appropriate technical approach for wastewater treatment is difficult. For example, the socioeconomic conditions in many municipalities indicate that state- of-the-art technology may not necessarily be the best option and that low-cost, labor-intensive solutions are more appropriate, even if treatment capacity remains sub-optimal in the short run.
- **Integrated approaches:** New wastewater facilities should be integrated with existing water supply, sewerage, wastewater treatment, and sludge handling systems. Furthermore, facilities for peri-urban areas might be linked into the urban systems.

Environmental Impact Assessment (EIA). The Environmental Impact Assessment (EIA) and approval system has become an important element of pollution management in China. The EIA system is used to establish critical conditions for pollution prevention in new developments. In 2002, the Environmental Impact Assessment Law was issued, requiring not only EIAs for specific projects but also for overall plans. Some of the problems faced in implementing the EIA requirements are:

- EIA enforcement can be difficult, especially when projects have strong political backing. However, SEPA has recently taken a much tougher stance with respect to EIA enforcement and has released information on projects that are breaking the rules;

1. Reform of Environmental and Land Legislation in the People's Republic of China. Asian Development Bank, 2000
2. After Shanghai (330.6 L/day) but water availability is much lower in Beijing.

- The timing of EIAs often lags behind the feasibility study of construction projects. This has reduced the potential positive impact that the assessment can have as important design and location decisions may already have been taken;
- Public participation in the processes remains low, reducing the validity and acceptance of the EIA results, even though the current law has provisions to encourage public participation.

River Basin Water Pollution Management Planning and Implementation. China has a long history of river basin management in various forms, including the establishment of river basin commissions (RBC) for the seven main river basins in the early 1950s. However, an approach reflecting needed differences between the basins was undermined by the 1998 Water Law, which stressed that "the State shall exercise a system of *unified administration* on water resources in association with administration at various levels." Moreover, the 1998 law undermined the powers of river basin management organizations (e.g. enforcement), left them with ambiguous legal status, and limited their influence in many WRM areas. The 2002 Water Law (re-draft) addressed river basin management directly, specifying that "the state shall adopt a 'combined division responsibility' (CDR) system of river basin management in conjunction with jurisdictional management." It indicated that river basin management shall be set up by the water administration department under the State Council, and set out the following river basin management functions: (a) planning; (b) protection of water resources water areas and projects (including pollutant discharge loading and sewage facilities); (c) water resource allocation and saving; and (d) water dispute resolution.

Voluntary Approaches for Pollution Management. Compared with mandatory approaches, voluntary approaches are more flexible and easier to introduce. In developed countries, voluntary approaches have become more and more important elements of environmental management. Those approaches can be applied both to polluting enterprises and to the general public. Preventive approaches, such as ISO14000, environmental labeling, and cleaner production (CP) principles, can be adopted by polluting enterprises. The general public can have an influence through involvement in decision making and applying environmentally conscious consumption principles.

Cleaner Production. **C**hina's *Cleaner Production Promotion* Act was enacted in 2002 to promote CP, reduce pollution, and improve the environment. It requires the continuous application of measures for design improvement. The law sets out responsibilities for the State Council and other administrative departments to ensure more sustainable resource use, including the establishment of product labeling systems, "naming and shaming" heavy polluters, and compulsory recycling lists. The measures are designed to enhance energy and water conservation, and to increase the level of water reuse and recycling. They are seen as the first step in developing a more ecologically based economy. The relevant government departments have started to implement an industrial policy based on cleaner production and given guideline standards for cleaner production in their respective sectors. In order to strengthen implementation of the CP Promotion Act, CP standards for several industries were promulgated in 2004 (e.g. for petroleum refineries and coking and tanning industries).

Environmental Management System (ISO14000). **S**ince the late 1990s, PRC started environmental management system (EMS) auditing and ISO14000. In several years, SEPA successively issued management documents and established a set of effective management measures. SEPA initiated pilot certification of EMS in 1996 and identified 55 pilot enterprises for the certification of ISO14001. In 1997, SEPA approved 13 pilot cities (areas) for implementing ISO14000 series. By the end of 1999, 263 enterprises had obtained ISO14001certificates.[3]

From the demonstration experience, there are three main barriers or problems for implementing ISO14000 in China:

1. Both enterprise management and environmental management awareness levels are low. It is difficult for enterprises that do not focus on product quality management to pay attention to EMS auditing.

2. The enterprises' technological capacity is low and means of production are not highly developed. Most enterprises are oriented toward the domestic market and have limited understanding of the requirements needed by international markets.

3. http://www.zhb.gov.cn/iso

Therefore, they often hardly meet the requirements of ISO14000.

3. Some current environmental management policies and regulations do not embody the sprit of the process management approach (CP), and only focus on end-of-pipe issues. Many environmental regulations and standards do not comply sufficiently with ISO14000 series and international conventions.

Information Disclosure. ***I***nformation disclosure and invitations for public involvement have been important factors in forming the political basis for strict enforcement of control measures in many countries. The enterprises are concerned about their public image and, in most cases, will be sensitive to public pressure. In some rather developed regions of China, environmental information disclosure has been extensively used and plays an important role in promoting enterprise pollution reduction and in improving the public's environmental awareness. Unfortunately, a wider introduction of a disclosure policy has been restricted because of the "traditional" ideas and attitudes among management institutions.

Institutional Framework

National Structures. The government structure in China is built around central institutions, such as the State Environmental Protection Administration (SEPA), and local-level counterparts, such as the Environmental Protection Agencies (EPBs). Central and local levels of governance are therefore structured along similar lines. In terms of water pollution management, at the central level SEPA is in charge of overall pollution policy, while other ministries—such as MWR, MOC, and MOA—contribute in specific fields of responsibility. At the local administrative levels (mainly provinces, cities and counties), the structure is a replica of this central blueprint. The legal basis for this institutional arrangement is set out in;

1. The Environmental Protection Law (1989). This is the principal law for environmental protection in China. It defines the rights and duties of all levels of government, industries, organizations, and individuals with respect to environmental protection. It gives SEPA the authority to coordinate supervision and management of environmental protection work on a national level and to establish national standards for environmental quality (including water quality standards) and for discharge of pollutants. It also gives the "competent administrative departments" the authority to supervise the management of the protection of respective natural resources. In the case of water, the responsibility is given to MWR.

2. The Water Pollution Prevention and Control (WPPC) Law (1984, revised 1996). This law gives SEPA and EPBs the responsibility to supervise and manage the prevention and control of water pollution (qualitative aspects), and defines SEPA as the leading central administrative body for water pollution management. The draft amendments clarify the responsibilities for water monitoring, and the protection of water sources for drinking water purposes.

3. The Water Law (1988, 2002). This law prescribes that MWR and WRBs are in charge of the administration and supervision of the quantitative aspects of water resource management. The 2002 revision is designed for rational development, utilization, saving, and protection of water resources, and is notable for its treatment of river basin management - prescribing that "the state shall exercise a WRM of river basin management in conjunction with jurisdictional management."

Further revisions of the Water Pollution Prevention and Control Law are currently being developed in order to address overlaps with the Water Law. Article 12 of the Water Law indicates that MWR and the WRBs are responsible for unified administration and supervision of water resources, while article 4 of the WPPC law stipulates that SEPA and the EPBs should supervise and manage the prevention and control of water pollution. This framework has undermined cooperation between the two agencies; specific problems include widespread functional overlaps in responsibility for managing surface and underground water resources, implementing general management and pollution prevention plans, pollution quantity control, water quality monitoring, protecting drinking water, and industry regulation, enforcement, and disciplinary action.

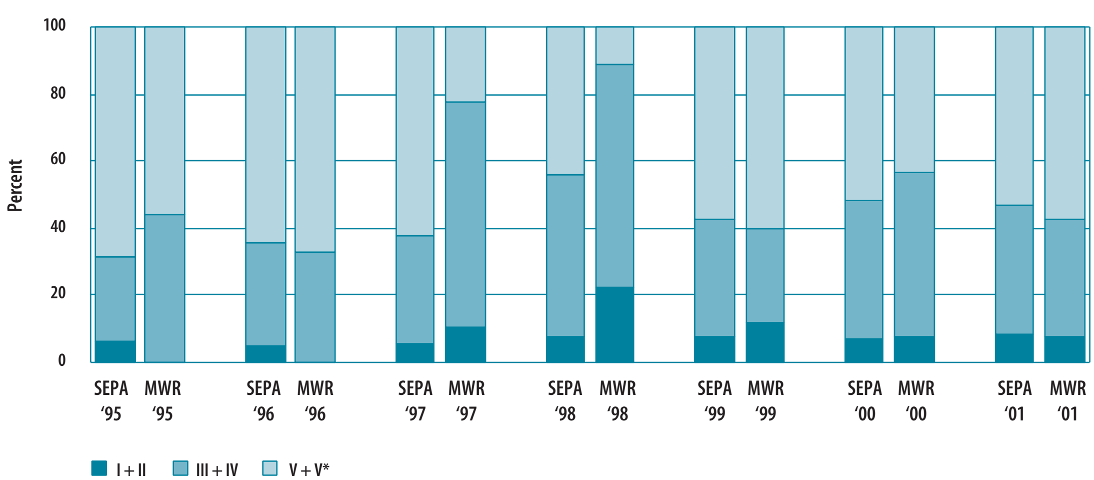
This legal framework assigns responsibility for overall water resources management to MWR and the WRBs, while SEPA and the EPBs (under the leadership of local government) are in charge of water pollution management. However, since laws and regulations are quite general, there remains some ambiguity with respect to exact responsibilities, and many problems emerge in the practical execution of water management. The often-unsatisfactory level of cooperation and coordination between water resource management and the water pollution management agencies compounds this problem. Indeed, the issue of inter-agency coordination (in planning, implementation and control) is widely regarded as one of the most important constraints to an effective integrated water management system in China. The overlap or conflicting responsibilities of SEPA and MWR often leads to counterproductive duplication of efforts. Problems exist in the following fields:

- The river basin management institutes are under the jurisdiction of MWR, but its relationship with SEPA and the EPBs is not clear, which makes it hard to judge how plans are implemented.
- The relationship between environmental protection plans of SEPA and EPBs and the water resources protection plan of the MRW and WRBs is not clear.
- The system of Water Environmental Function Zones established by SEPA and the system of Water Functional Zones used by MWR are not compatible, as their relations and functions are not clear. Function zones are areas designed to fulfill a specific function with a management approach designed to ensure appropriate use of water resources and the environment.
- There is poor coordination between MWR and SEPA on many WRM issues, such as water quality management.

Data inconsistencies from MWR and SEPA are common. Figure 2.1 (below) shows the differences in MWR and SEPA data on average water quality in the Huai River basin. The data from these two sources are often inconsistent; in the reviewed period (1995-2001), there was an average difference of 11 percent. Data reliability is a serious concern for the development and enforcement of appropriate policies. In spite of the fact that 15 of the 37 surface water parameters are monitored by both agencies, there is no common database of water quality information.

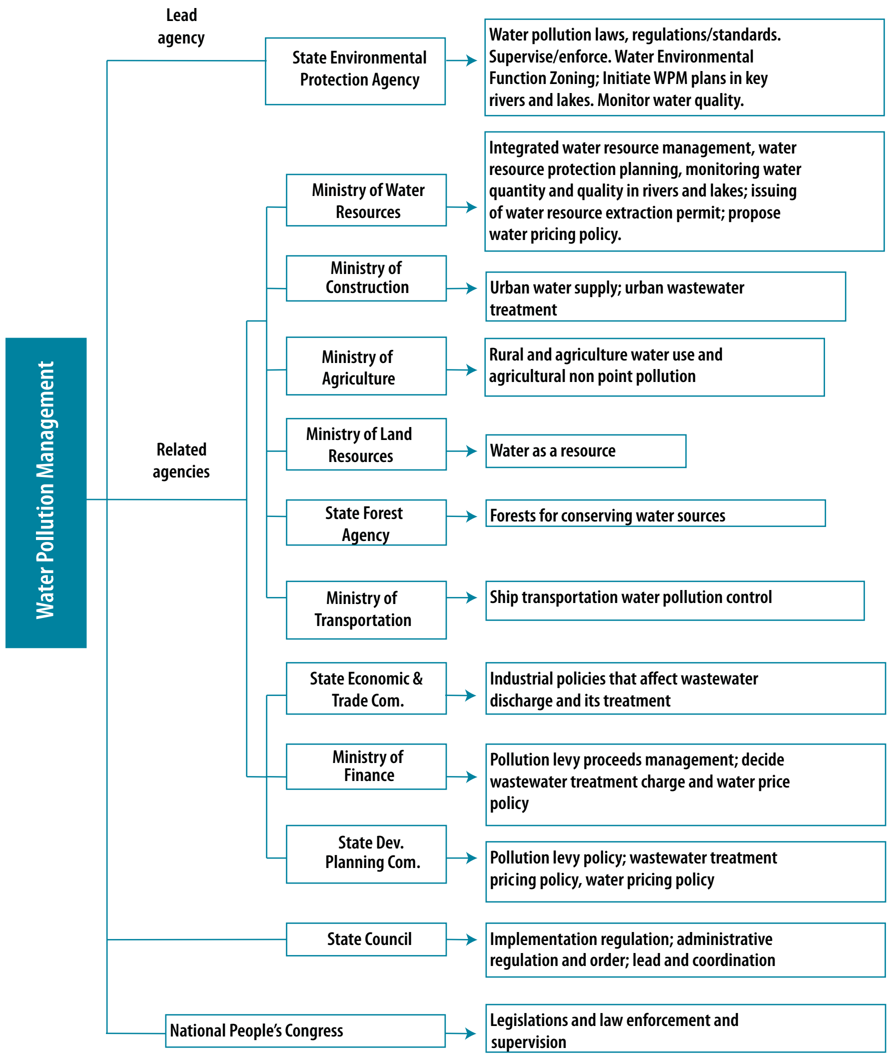
SEPA and MWR are not the only ministries with jurisdiction over water pollution issues. The full institutional framework is set out in Figure 2.2, which shows the various institutional responsibilities for water pollution management in China. The figure shows the complexity of the managerial structure and gives an indication of the challenges faced in implementing integrated water management and pollution control. Given the complexity of this management structure, the occurrence of conflicts and poor coordination is less surprising. However, evidence suggests that sectors frequently act in their own interests, and their policies do not always support the overall goal of water pollution management. In the current structure, the

Figure 2.1.Discrepancies between SEPA and MWR Monitored Water Quality for Huai River



Source: China Environment Yearbook (various years), MWR Statistical Yearbook (various years).

Figure 2.2. Ministries and Authorities at National Level Involved in Water Pollution Management



State Council and the National People's Congress are supposed to play a coordinating role through the enactment of laws and inspection of their implementation.

Apart from the SEPA–MWR nexus, the relationship between these ministries and the MOC is particularly important. The latter is responsible for a number of activities with a significant impact on water pollution management, such as construction and operation of sewage treatment plants and urban water supply facilities, and water conservation. Unfortunately, SEPA, the EPBs, MWR, and the WRBs are not always included in this process.

The diversification of responsibilities among different government agencies—including SEPA, MWR, the Center for Disease Control (CDC) under the Ministry of Health (MoH), and MOC—is also critical in the management of the drinking water supply and monitoring of drinking water quality. Urban drinking water supply and quality falls under the authority of the MOC, while rural drinking water is overseen by the MWR. MoH through CDC oversees the monitoring of rural drinking water quality. This disaggregation in the authority has resulted in lack of consistent and comprehensive data on drinking water quality.

River Basin Management. In the current water management system, there is no fully integrated system for management of water resources and water quality aspects. There are, however, a number of models for river basin management and coordination. SEPA and

MWR will typically advocate for the use of a specific approach, but the final decision on which model to use is made by the State Council. Models include;

1. Water Basin Management Committees (WBMC): As referred, these were set up for many of the main rivers after the foundation of the People's Republic and were responsible for flood control, river transportation, hydraulic engineering, and construction and operation of water services facilities. Increasing pollution levels led to the establishment of Water Resource Protection Bureaus (WRPB), which were under the dual supervision of MWR and SEPA. The latter provides technical guidance and covers relevant operational expenses. According to China's institutional classification, these bureaus were public technical institutions with limited administrative power. The WBMCs were, therefore, not able to act as strong coordinators for water pollution management.

2. Water Resource Protection Steering Group (WRPSG): These groups are co-chaired by SEPA and MWR and include deputy governors of river basin provinces as members. Meetings are used to express interests and coordinate activities, which require approval. This loose organizational structure brings together the relevant bodies, and facilitates coordination and implementation. This approach is used in the Huai River basin.

3. Joint Meeting for Pollution Management System: This State Council-endorsed model, which has been used in the Tai Lake basin, differs from the above in that SEPA plays a leading role, with the participation of local EPBs and other cooperating departments. The main limitation is that the system is only operating on an ad-hoc basis.

In practice, the management of shared river basins includes a combination of horizontal and vertical processes. The former operates within current boundaries (i.e. *kuai kuai guan li*) and has more administrative power, while the latter operates through MWR (i.e. *tiao tiao guan li*) and has more technical authority. River basin organizations provide technical directions and guidelines to local governments within the basin, while the local governments are responsible for implementation.

The models all provide a forum for consultative information sharing and joint planning that can be used for proposing actions and policies. However, in spite of the participatory and inclusive approach, there have been conflicts between the two main parties. As a result of the increased authority of the MWR, SEPA decided in 2002 to distance itself from participation in the WRPB within the WBMCs and rather to exercise its increased authority through a direct SEPA–local government alliance and the application of a "joint meeting system" (see below). Therefore, although the planning process for water quality management is basin-wide (SEPA formulates specific pollution management programs such as Liao, Hai and Huai), the actual implementation is conducted through local governments. A more decentralized approach, with river basin authorities holding executive power for water-related activities in river basins, has not been implemented in China.

Urban Pollution Management. At the local level, decentralization has led to the creation of urban Water Affair Bureaus (WABs) that are responsible for planning and operating water utilities. This structure means that there are two parallel management systems (EPBs and WABs) responsible for pollution management in the urban water sub-sector.

Environment Protection Bureaus (EPBs): EPBs are responsible for zoning of water bodies, issuing pollution permits, protecting drinking water and controlling pollution sources, while monitoring and management is often delegated to Environmental Monitoring Stations. Financing for these activities is subsidized with income from wastewater pollution charges and fines. However, in cases where local economic development plans are in conflict with the EPB mandate, their authority to enforce environmental regulations and collect fees is often constrained (though this will vary between areas).

Water Affair Bureaus (WABs): The urban WABs are subordinated to the Water Resource Department of the Ministry of Water Resources. The WABs provide an integrated management for city and county water services and are designed to establish an integrated water resource management strategy at the local level by breaking down the segmentation that exists between administrative regions and different departments.

With the development of institutional reform of the counties, more and more cites and counties have established WABs. By the end of 2001, 633 WABs had been established, comprising;

- 1 provincial WAB (Shanghai)
- 4 sub-province WABs (Shenzhen, Wuhan, Haerbin and Dalian)
- 59 city WABs
- 569 county WABs

One of the specific tasks of the WABs includes reforming the water affair and utility management systems. For example, Heilongjiang Province was the first to introduce a water utility management system at the province level, but Heibei, Inner-Mongolia, and Shandong provinces have set them up in 50 percent of their counties and cities. A number of southern provinces with abundant water resources—such as Jiangsu, Guangdong, and Yunnan—have also actively carried out water affair management system reforms. These reforms, which have been promoted by MWR in order to unify water management, are rarely integrated with wider river basin management and are typically applied within the administrative boundaries of specific cities, countries, or provinces.

In spite of the apparent success of the "WAB" model and new management systems, a number of institutional issues remain. For example, it is unclear if the WABs should operate as governmental departments or as public cooperatives, of if they have a cocoordinating or a supervisory function. Similarly, the relationship between the City Bureaus and the River Basin Water Resources Bureaus is not well defined. These issues can lead to conflicts and undermine the effectiveness of the river basin institutions.

Financing Water Pollution Management

Between 1995 and 2000, China invested more than 360 billion yuan in environmental protection, which was only 80 percent of the budget set out in the 9th Five Year plan ('95 – '00) and about 0.87 percent of the country's GDP. However, actual investment in environmental protection has increased yearly in the 10th Five Year Plan period from 1.13 percent of GDP in 2000 to 1.40 percent in 2004 (China Statistical Yearbook, 2005). In the most developed regions (Peking, Shanghai and the Pearl River Delta), the share of GDP spent on environmental protection exceeded 3 percent, two-fifths of which was used for water pollution management, e.g. industrial control and urban wastewater treatment. The allocation for environmental protection is projected to increase significantly in the 11th (2006–2010) and 12th (2011–2015) plans, and by the 13th Five Year Plan (2016–'20) it is projected to reach 524 billion yuan (Figure 2.3)

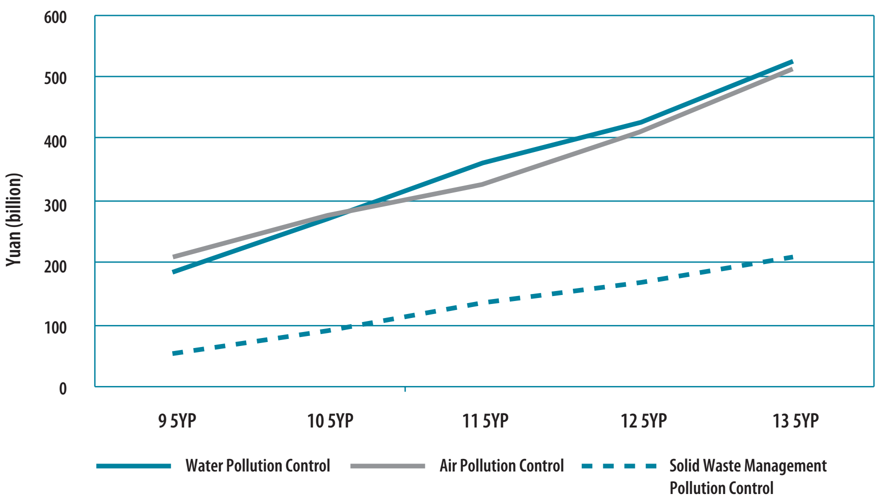
Infrastructure-related investment is steadily growing and amounted to more than 15 billion yuan in 1998, which is ten times higher than the corresponding investment in 1991. Investment in technology innovation and cleaning up "old industries" is still high and accounts for about half of the industry-related control costs. If we consider the 14 provinces and cities in Northern China, investments in municipal and industrial wastewater treatment plants and sewerage systems in the period 1998 to 2004 amounted to around 49 billion yuan, and had been steadily increasing over the period (World Bank, 2005; Statistical Yearbook, 2005). The urgent need to develop sewerage systems appropriate for local treatment capacity has, to some extent, been recognized; between 1998 and 2003, annual investment in sewers (in northern regions) increased 272 percent.

Establishment of sewers and treatment facilities has not been even across the country, with more developed areas receiving greater investments (perhaps reflecting their ability to pay for these facilities). This pattern is reflected in the level of centralized wastewater treatment, which was 30 percent on average (2003), but up to 50 percent in Beijing, and as low as 15 percent in north Hubei.

In order to achieve a centralized wastewater treatment rate of 60 percent, it is estimated that a total investment of around 14 million RMB will be required between 2003 and 2010 (World Bank, 2005). Investments of 5.6, 7.6, and 0.65 million RMB are required for wastewater treatment plants, sewer networks, and sludge handling facilities respectively (World Bank, 2005).

Funding sources. Sources of funding for water pollution management in China include central government, financial institutions, and the private sector. Funds planned under the five-year plans represent central and local budget commitments to water pollution management, and foreign sources would represent additional streams of investment. The dominant source of investment in pollution management is still public

Figure 2.3. Investment Projections in Five Year Plans (1995–2020)



Source: World Bank 2002, Chinese Academy for Environmental Planning (2004).

money, provided as allocations from national or regional budgets, including revenues collected from environmental fees and fines. However, with increasing trust in China's market mechanism and economy, financial institutions and the private sector have shown increasing interest in investing in environmental protection. As a consequence, there is an increasingly diverse range of financing sources for pollution management.

In the 10th five-year plan (2001–2005), the government set out to restructure these financing mechanisms by integrating regulation with market-based approaches. Measures have been taken to develop private and public financing, to subsidize key infrastructure construction, to increase loans to enterprises, to focus more on pollution abatement and clean production, and to upgrade the pollution charge system.

The next step in setting up financing options will be to open investment in pollution management to private capital markets. In addition, or in combination with this, it is envisaged that wastewater facilities will come under private management, which will require the setting up and collection of sewage disposal fees that meet investor's expectations.

The existing investment system has evolved under a regime of strict central planning dominated by government investments. However, the government is also responsible for defining environmental and social goals, and the current set-up has no mechanism for cost-benefit-based prioritization. This approach has a number of shortcomings:

- It is based on a single investment channel, which lacks economic driving mechanisms and inhibits the use of private financing. Consequently there are insufficient funds for investments in pollution management.
- To compensate for the lack of governmental funding, several projects have been financed through international loans. This approach has favored use of foreign technology and has therefore constrained the development of domestic technology.
- The existing investment system does not include a market mechanism, so input-output and cost accounting systems have not been established.

Water Pollution Management Case Studies

General. While every water body in China presents a different set of physical and socioeconomic challenges, many features are common across similar rivers and lakes, and water pollution management lessons can be gained by looking at certain case studies. The Huai River and Lake Dianchi cases are particularly interesting for a number of reasons. Both represent water bodies that have been the focus of considerable national and international attention, with many projects and initiatives yielding a mixed set of results. As typical for a northern river, per capita water availability in the Huai River basin is low (~ 450 m3/capita/year) and industrial pollution has been a major problem. The case of Lake Dianchi is typical of many shallow lakes in China, as it is experiencing increasing levels of eutrophication from growing municipal and non-point pollution sources. The sections below highlight a few general features of the water pollution experiences from these locations.

Conditions. ***O***ver the last 15 years, water quality in the Huai River basin has declined significantly, and quality in tributaries is a particular concern (see Figure 4A, Annex 1). Initiatives over the last decade, targeting

Figure 2.4. River Basin Management—The Case of Huai River

Source: Chinese Academy for Environmental Planning.

industrial pollution, have led to some improvements, and some sections of the river now have relatively clean water. Significant reductions in COD loads from industry and urban residential discharges following completion of urban wastewater treatment plants have alleviated the problem of organic pollution. The main problem now is non-point sources such as fertilizer runoff. Now nitrate and nitrogen (in the form of ammonium nitrate) are dominant in the river's pollution structure. Both pollutants are primarily associated with agricultural runoff.

Institutional Framework. The Huai River passes through different administrative regions so authority for water pollution management in the basin is divided among four provincial EPBs. Technical supervision and inter-provincial coordination is undertaken by SEPA, which also heads up WRPSG (along with MWR). Other relevant institutional bodies include the Huai River Water Resource Protection Bureau, which is responsible for water supply and protection; and the WRPSG, which coordinates water resource management and pollution control (including dispute resolution).

Legislation and policy tools. A range of legislation and policy tools has been applied in the Huai River basin. Total Amount Control (TAC) targets—for counties, cities, and enterprises—provided a positive stimulus for various pollution management initiatives. Implementation of the "Fifteen Small Shutdown Policy" has successfully eliminated a large amount of pollution from the dirtiest industrial sectors, with 3,860 firms closed as of 2002. However, social equity implications have made it hard to sustain this initiative, and many enterprises have re-opened and continue to pollute.

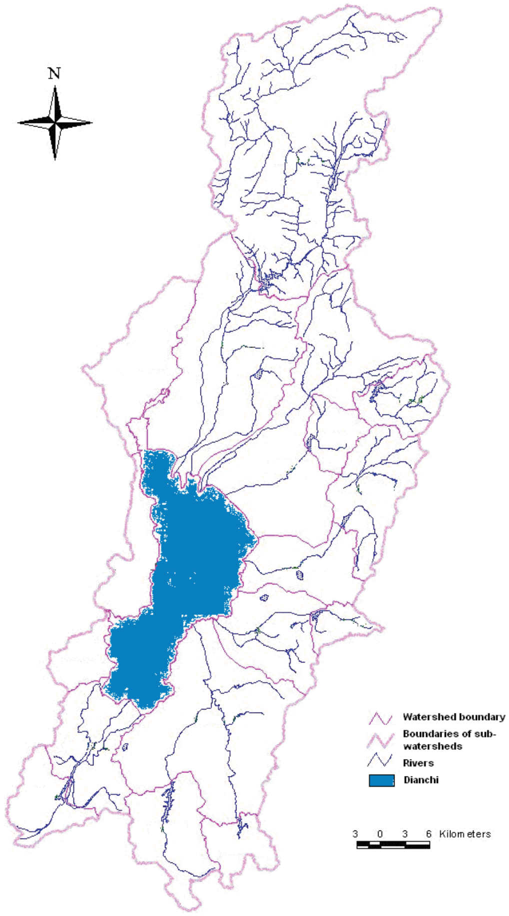
Prices for water supply and treatment and pollution levies are generally considered to be too low, but reforms for price increases are being implemented. The pollution levies and wastewater treatment charges are levied in all provinces of the basin, and proceeds are used to raise funds for construction and operation of treatment plants. Local officials consider pollution levies to be one of the most effective tools available. However, monitoring of progress has been difficult and has tended to focus excessively on COD loads.

Investment in Water Pollution Management. The 9th five-year plan (1995–2000) required 52 wastewater treatment plants to be established, 30 of which are complete or under construction. Progress, however, has been much slower than planned, and established units cannot run at full capacity due to a lack of complementary sewer networks. As a result, targets for COD pollution were exceeded by 8 percent by 2000. During the 10th five-year plan (2000–2005), COD loads were restricted to 1.3 million tons/year. The target for the 11th five-year plan is a five percent reduction of this quantity.

A major obstacle for investment in water pollution management infrastructure is the low level of recognition it receives among local authorities. A fundamental element in this problem is the inter-disciplinary nature of river basin management and the incentive problems this creates; for example, the benefits from expensive abatement in one province will be felt further downstream. However, the majority of funding for pollution management investments must come from local budgets (user fees or loans), with only minor central commitments. This represents a major challenge for SEPA and the WRPSG.

General situation. Economic growth, increasing local urban population, and changing agricultural practices around the Lake Dianchi basin have increased water shortage problems and the pollution loads entering the

Figure 2.5. Shallow Lake Management—The Case of Lake Dianchi



Source: Yunnan Institute of Environmental Science.

lake. Nitrogenous, phosphoric, and organic pollution of the lake is so heavy that the water body is highly eutrophic, causing incidents of severe algae blooms. Total levels of N, P, and COD discharges into the lake in 2004 were 14,446, 1,312, and 71,891 tons respectively. Targets for reductions by 2010 are 8,829, 766, and 34,228 tons respectively. Blue-green algae concentrations are high (thousands or ten thousands mg/m^3). In the summer months, sections of the lake experience oxygen deficit (anoxic conditions). Under these conditions, water turns black and has a very unpleasant odor.

The status of the lake's two sub-sections can be summarized as follows:

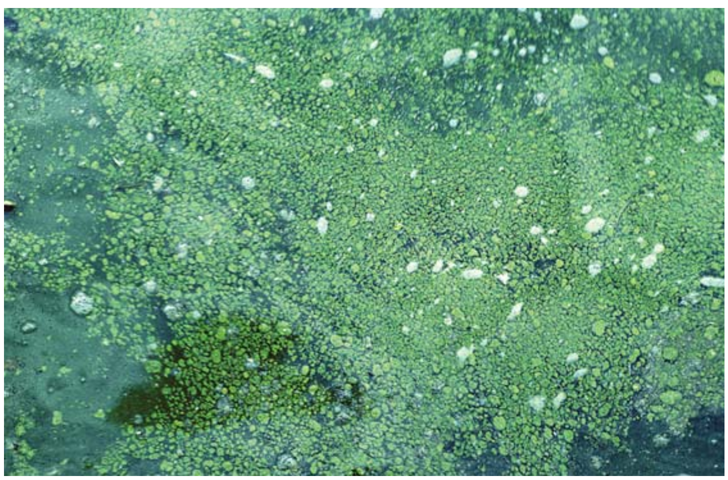
- "Caohai": Over the last decade COD has been effectively controlled, but total concentration of P (TP) and N (TN) increased two- to three-fold. This part of the lake suffers severe eutrophication and oxygen depletion.
- "Waihai": COD, TN, and TP pollution is less severe.

Institutions. The Kunming Environmental Protection Bureau, which is the city-level EPB reporting to the Kunming city government, and its subsidiary bodies are responsible for water pollution and quality management, project implementation, and application of environmental law around Lake Dianchi. The Dianchi Protection Committee was initially established as a watershed management authority to enforce the Dianchi Protection Ordinance, but has since been strengthened and is now the lead agency for decision making on major issues concerning lake protection and treatment. The Dianchi Administration Bureau and the Kunming Dianchi Management Office both sit on the committee. The former is responsible for law formulation, promulgation, and enforcement, as well as monitoring impacts and managing funds. The latter consolidates and organizes management activities for the lake, but this process overlaps somewhat with the EPB's role.

Legislation and policy tools. ***T***he requirement for EIAs has generally been well-enforced in the area and implementation of the emission permits system has now reached 780 enterprises. A system for the collection of fees for wastewater drainage and emissions has been established for large-scale factories, but the inclusion of small-scale operators has been more problematic. Supply of water in Kunming is currently charged at 1.8 Y/M^3 (includes a sewerage fee of 0.56 Y/M^3), which is very low compared to other areas (4.5 Y/M^3 in Beijing). Incentives for water conservation or re-use are therefore limited and scarce water resources are significantly overused. The charge for sewage costs is also considered low and has led to underfunding and closure of wastewater collection and treatment facilities.

Other local initiatives to support lake water quality have included the banning of phosphorus in detergents in order to reduce the influx of this pollution into the lake (phosphorus loads are a key element in the eutrophication process). The local government has also been actively trying to raise public awareness about the vulnerability of the lake and the need for environmental protection through media and propaganda events. Finally, there has been extensive engagement with local industry, with clean production audits in 71 polluting firms, and the provision of clean production training to 242 key enterprises, with more planned in the future. The clean production message seems to be getting through, as some of the larger firms are now becoming interested in ISO 14000.

Investments. During the 9th five-year plan period (1995–2000), 65 treatment projects were completed, including the establishment of four sewerage treatment facilities with a combined capacity of 365,000 tons/day (65 percent of wastewater production in Kunming). However, similar investments were not made in the sewage pipe network. Collection rates are only around 33 percent, which means that many of the treatment facilities are either closed or only partially operational. Delayed implementation meant that much of the planned work (12 projects, 1.29 bill RMB) could not be completed before the 2000–2010 period, and lake water quality targets were not met (in fact, lake water quality deteriorated).


Eutrophication in Dianche Lake

Pollution management was a major feature of the 10th five-year plan, including 4.2 billion RMB allocated for 10 pollution management projects, and 3 billion RMB for investments in municipal pollution management. However, less than half of the projects were completed within the five-year period, and many have only just started. The lack of preparatory research and poor evaluations of completed works have been sighted as significant shortcomings in the approach.

Initial indications are that the 11th five-year plan (2005–2010) will include funding for (a) pollution management, (b) supervision, (c) administration, and (d) science/technology demonstration. Investments in municipal pollution management will account for the largest fraction of the budget. Financing for these activities has largely been through government budgets, but increasing attention is now being paid to options such as build-operate-transfer (BOT) schemes. However, charges for tap water, drainage, sewerage, and treatment are universally low and this is potentially an important area of finance.

During the 10th five-year plan period, the central government outlined its objective that provincial capitals, including Kunming, should reach a 100 percent wastewater collection rate (sewage) by 2010, which would ensure full utilization of installed urban wastewater treatment capacity. However, following strong interventions from local governments, including Kunming city, the plans had to be extended to about 2020. The extension of collection systems into old city areas and certain outskirts has a particularly high investment cost. This means that the installed wastewater treatment capacity may hardly be fully utilized, and by the time a collection system is completed, certain wastewater treatment plants may have become outdated. In certain cases, it may have been more feasible to establish wastewater treatment plants closer to the users.

3. Toward a Future WPM Policy in China

Introduction

This chapter provides recommendations for further improvements in water pollution management in China based on, (a) analysis set out in the preceding chapters, (b) dialogue with Chinese counterparts during the preparation of the study, and (c) experiences from the complex history of evolution of pollution management and integrated water resources management in other parts of the world. The recommendations that we provide are described at a relatively generic level. For more details on some of the issues, we refer to the main (2003) report.

Water treatment in Kunming City

Basic Condition and Major Features of Water Management in China

There is no country in the world with the same institutional structure, the same water-related problems, or the same economic development pattern as China. Thus, there is no "model country" to use as a reference point in establishing an efficient water pollution management system. Valuable lessons can be learned, however, from several countries or regions where the development of pollution management has similarities to development in China.

To find potential "model" cases, we noted the following major features of water pollution management in China:

- The country is the size of a continent.
- The economy of the country is developing very rapidly, resulting in urbanization and changed industrial structure.
- Huge regional variability exists in the economic structure.
- Huge regional variability exists in the availability of water resources.
- In many regions, serious water scarcity and water quality issues appear both in surface water and groundwater.
- Coexistence of many pollution problems is typical for many regions.
- Controlling industrial emissions and toxic materials was initiated relatively early and successfully; however, industrial pre-treatment is often missing.

- Water- and environment-related laws and decrees are not properly harmonized and often overlap.
- The institutional system is complicated with many levels and administrative units, both vertically and horizontally. There is a tendency to decentralize, but the state still plays a strong role in pollution management, particularly through its role in financing and defining economic principles.
- Today, major concerns include (a) urban pollution management due to rapid urbanization and the low level of infrastructure, and (b) the growing need for emerging agricultural non-point source pollution management.
- Water quality legislation still focuses primarily on protective measures, incorporating tools such as standards, ambient water quality criteria, fees and fines, total load control etc. However, there is a lack of integration between these approaches. Furthermore, the target for each of these is often not set properly and thus they have little or no impact in practice.
- Water monitoring and legal enforcement is weak or lacking.
- Huge investments are needed in water pollution management.

The most useful analogy can probably be found between China and two large, multi-state or multi-country entities, the United States and the European Union. Like China, both are characterized by the fact that administrative borders do not coincide with river basin geography, which implies the need to address shared water resource issues. Additional experiences may stem from Central and Eastern Europe (CEE), which has been going through tremendous economic transition during the past fifteen years (see Box 3.1).

Box 3.1. Water Pollution Management in Transition Economies—Experiences from Central and Eastern Europe

CEE countries have gone through unprecedented political, social, economic and institutional transition during the past fifteen years. This process enabled some of them to join the European Union (EU) in 2004. From a water quality management perspective, this transition was associated with the need to simultaneously address many different coexisting problems, e.g. point and non-point sources, traditional and toxic contamination, surface and subsurface waters, and local and regional problems. Most fully developed countries managed these issues in a step-by-step manner over several decades.

The transition resulted in many changes in the management of water pollution, particularly:

- Market-based pricing led to a drastic reduction in fertilizer application and diffuse pollution;
- Abolishing outdated technologies in industry and introduction of clean technologies has significantly reduced emissions;
- Increased tariffs for water use and wastewater handling have reduced water consumption.

The combination of these factors has led to remarkable improvements in surface water quality, highlighting the linkages that exist between economic restructuring and environmental management.

Municipal emissions largely remained untouched during the transition. However, increased tariffs for water use led to reductions in public water consumption by 40 to 50 percent. As a consequence, many of the previous hydraulically overloaded municipal wastewater treatment plants ended up with excess capacity. The changed (denser) composition of the raw sewage caused serious operational problems.

Lack of industrial pre-treatment was found to be a serious issue. Residence time in water distribution networks increased significantly, which also resulted in water quality problems.

During this period, the central issue was how CEE countries could achieve the largest improvement in the short run, using the scarce financial resources available, and how they could design a process to ensure further improvements in order to meet EU requirements and standards. A number of detailed studies led to the proposal for "step-wise" development with a time horizon of two to three decades. Within this development process, the first few years should be devoted to identifying and dealing with priority "hot spot" issues, and applying least-cost water quality management policies on the river basin scale. The second phase should focus more on sewer renovation, wastewater treatment plant upgrading, and other developments to meet EU criteria.

In order to implement the above ideas, it was recommended that policy makers initially define phased effluent and ambient standards in harmony with multistage upgrading and development of wastewater treatment plants, accompanied by tightening requirements and promoting best management practices in industry and agriculture.

Focusing on Strategic Planning

In spite of the extensive effort that has gone into pollution management in the last decades, China still has a long way to go to handle existing water pollution problems and to keep pace with new and emerging issues. There is a clear need for an overall strategic plan for the coming two to three decades. This plan should be developed with the following elements:

- Definition of a long term vision for water quality, including specific targets (see Box 3.2);
- Identification of sub-periods within the total time frame, with realistic targets set for each of these periods. The "5-Year Plan" periods may be considered as suitable "sub-periods."

A strategic approach should recognize the need for a long-term perspective in pollution management. Realistic targets and time schedules should be set for pollution reduction and water quality improvement. Achievable targets are needed, because many of the required measures will not have a measurable impact for some time, and institutional actions and legal and economic changes may take several years to implement. Ideally, targets—such as percentage of infrastructure development for urban and rural areas; level of meeting drinking water quality standards; municipal, industrial and agricultural emission reductions; water quality improvements in terms of quality classes; fees collected; level of cost recovery; and budget for planned investments—should be quantified.

A change in strategic focus is also envisaged. In previous periods, the focus has been on industrial pollution and treatment of municipal wastewater, particularly aimed at controlling COD and heavy metals. In the future, water pollution prevention in China should pay more attention to nutrients (N and P) and persistent organic pollutants. More efforts will be needed to address emerging water pollution issues, such as agricultural pollution and surface runoff. These new problems will also require new or modified means and strategies for policy implementation and enforcement.

Box 3.2. The European Union—Water Framework Directive

Since 1975 nearly thirty so-called "daughter directives" have been created by the European Commission. They define water quality standards for various substances and uses and cover topics such as drinking water quality, bathing waters, dangerous substances, municipal wastewater treatment, and integrated pollution prevention and control. In the 1990s it became apparent that directives alone would not lead to an integrated water management strategy. Thus the unified water policy of the EU, the Water Framework Directive (EU-WFD), was approved in 2000 and is now under implementation in 25 countries.

The EU-WFD establishes a framework for the protection of waters regardless of national borders with a long-term approach to management. The basic unit for management is the river basin, which is defined as an area of land from which all surface runoff flows into the sea at a single river mouth, estuary, or delta.

The principal concept of the EU-WFD is to ensure the "good" status of waters. The purpose is to protect and, where possible, to enhance the state of water ecosystems, the aquatic environment, water quality, and groundwater by a variety of measures. It is also used to promote sustainable water use and to mitigate the effects of floods and droughts.

Cost recovery is one of the main pillars of the EU-WFD. A crucial element in this approach is to develop plans based on affordability that can be implemented. However, it is not yet clear how this approach will perform in cases where user groups and beneficiaries are not well-defined (e.g. flood control).

A crucial element for implementation of the EU-WFD is the river basin management plan. This plan addresses major characteristics of a river basin, the various human activities, monitoring, objectives, and a program of measures. The deadline for the program is 2015, with reviews and updates every six years thereafter.

With growing levels of urbanization (see section in chapter 1), there is an increasing need for municipal wastewater collection and treatment facilities. In this development process, all related forms of infrastructure, e.g. water supply, wastewater, water and sewer networks, treatment and reuse facilities, should be seen in connection. By considering the broader picture, it is easier to spot and assess imbalances between the coverage and capacity of collection and treatment systems.

Phased development is also an important concept to follow. This approach can be applied on the basis of comprehensive planning, which systematically identifies the next steps through the identification of the most cost-effective priority actions.

Adjusting Policy and Regulations

China has an extensive set of legal instruments related to water pollution management. However, this legislation appears unnecessarily complex, with many areas of duplication and overlap. Improving this legal structure, particularly by reducing the number of laws and regulations, would result in a more comprehensive and simplified system.

Standards are technical instruments used to control emissions and the receiving water quality. In most industrialized countries, effluent standards are mandatory, with ambient water quality criteria used for additional "fine tuning" and to control non-point sources. In these countries, total emission control (TEC) is rarely applied except for lakes, river deltas, inland seas, and transboundary issues.

Based on international experience, the following recommendations can be made for improving China's WPM legal instruments:

- Set basic effluent and ambient standards for industries and municipalities, which are to be implemented over the long run;
- Develop embedded river basin, sub-basin, region etc, water quality management plans as an element of broader management planning to define hot spots, priorities and impact driven cost-efficient actions. Priorities should be defined on the basis of possible positive multiple impacts on water uses, health, ecosystems, regional water quality, and others;
- On the basis of the aforementioned plans, define areas that can have different (regionally variable) effluent standards and minimum requirements, which should be gradually tightened over time;
- As a final step, make the basic effluent criteria mandatory and assign the usual "fine-tuning" role to the ambient criteria.

Integrated Water Resources Management

There is no universal institutional system for integrated water resource management, even though many different approaches have been tried. The present tendency is to develop integrated water resource management (IWRM) projects at the river basin scale. In many countries, the lead agency has been the environment ministry; in other cases, new authorities have been established, which often leads to conflicts with existing institutions. Overall experience has shown that it has been difficult to establish a management system that is fully integrated at the institutional level.

China should prepare the legal framework for an integrated approach to water management and pollution control (umbrella water legislation). However, the process of establishing and implementing such a framework could take decades. The umbrella legislation should accommodate the development of management plans at the river basin, provincial, and other levels, as in the United States and EU.

Institutionally, a number of changes may be required. If SEPA were elevated to a cabinet ministerial level institution, this would give the same political authority to the relatively new field of water pollution management as is the case with the "older" quantity and water use-related activities.

For the next decade, China should consider shifting the highest WRM-related responsibility to the State Council. This might be a pre-condition to realizing a strongly coordinated, subsidiary-based decentralized system at the lower levels. China's State Council is currently preparing for a new round of institutional reform; institutional restructuring for water management is an important issue on the agenda. Since this process will inevitably affect the interests of existing departments, and there is no fixed model for reform, the structure indicated here should be considered indicative only, and further studies and stakeholder consultation would be required before a final formal structure could be developed. This might lead to the following division of responsibilities for the two main actors in water and water quality management:

- SEPA to have the leading role on issues related to water quality and pollution management, including water quality monitoring, definition of water environmental functional zones, and relationship with river basin institutions. In these areas, SEPA's responsibilities should cover all issues, from policy formulation and program implementation to law enforcement.

- MWR to have the overall responsibility for the quantitative aspects of water resource management, including hydrological monitoring, water planning, management of distribution, and conservation of water.
- Close cooperation with SEPA will be needed to find optimal solutions for water management issues, especially for developing the river basin perspective in planning.

An important feature of water resource management in industrialized countries, independent of institutional structure or location, is that the authority for management of utilities is kept separate from, and has no institutional linkages to, the authority for control and regulatory functions (be it water pollution management, quality control, tax control, etc.). This approach is also recommended to be followed in China. As part of the ongoing reform of water management and the implementation of the new Water Act, the roles of respective agencies (SEPA and MWR) and the departments in charge of construction and operation of water utilities should be clarified.

Part of the rationale for IWRM is the fact that many aspects of pollution control cannot be separated from water resource management, particularly not in countries, such as China, where scarcity is a problem. Under such conditions, it is essential to look for ways to close water and material cycles and increase re-use and recycling. China has many such opportunities, primarily in rural areas. The "cascade management" approach should also be considered. This implies that water is used several times and is transferred among different sectors and use categories (municipal, industrial, agricultural, etc.), where treatment is performed only at the level prescribed by the subsequent use. The application of this kind of an approach obviously influences standard setting.

Strengthening Economic Instruments

Fees and fines are important instruments in pollution management. Fines are supposed to penalize emitters for discharging wastewater of a volume or concentration violating effluent standards. Fees are taxes based on well-defined economic principles, normally set equal to or just above the marginal cost of wastewater treatment, so that treatment becomes more economical than pollution. The reasons for both measures are to avoid social damage and excess profits for polluting entities at the expense of society.

If a system for Total Load Control is used together with trading of discharge permits (e.g. for managing a lake eutrophication problem), fees should not be applied, since they would contradict the principle of trading.

In the development of a future Chinese fee and fine system, the following principles should be considered:

- Fees and fines should be introduced gradually in parallel with the development of the water quality standards and ambient criteria;
- Fines should be highest for discharges of toxic materials;
- Affordability constraints may mean that it is impractical to apply realistic fines above phased effluent standards for municipal wastewater discharges. Under such conditions, it is probably more realistic to declare a lower level of fines, specified for instance on the basis of discharges measured in population equivalent (standard discharge generated per person per day);
- Money collected from fees and fines should be invested in water pollution management systems, e.g. for water treatment, monitoring, or dispersed trough an environmental fund.

Strengthening Financing

There is a wide range of potential sources for financing. Options include cash flow from user fees, charges and penalties, international aid, concessions from multilateral and bilateral agencies, national subsidies, grants and soft loans (from central government), subsidies from local and central government budgets, debt cancellations, commercial loans from local bodies, and loans from international banks at market rates. A lot of emphasis has been placed on private investment as a source of new finance for water utilities, and China has piloted new project finance schemes (including various BOT forms) from the early 1990s, including in the water sector.

Box 3.3. Financing and Use of Economic Instruments in Central and Easter European Countries

Central and Eastern European Countries have gone through dramatic economic transition with fundamental changes in the management of water pollution (see Box 3.1). Their experiences with respect to economic instruments and financing are briefly described here.

Market-based economic instruments have not yet been fully implemented. While charges and fines have been implemented and have increased over time, fees are generally not high enough to cover the marginal cost of water and wastewater service provision. The fees have been gradually increased to change the behavior of users and to improve service performance. Collected fees are often channeled into environmental funds to be re-distributed for environmental projects by the state and not used exclusively to support water facilities, though there are also examples of a combination of the two allocations.

Investments in the water sector are increasing, but more effort is needed to achieve compliance with EU standards and directives. In the more developed CEE countries, it is estimated that, assuming 15-year implementation plans, water-related expenditures will be about 1 percent of the GDP. Assuming the principle of cost recovery is applied for water services, inhabitants should pay about 4-5 percent of their net income for water supply and treatment. Thus affordability is a crucial issue, and in less-developed CEE countries, the realization of plans will need much more than the 15 years indicated for richer countries.

Sources of finance for investments include national funds, grants, soft loans, EU aids (often inefficient), subsidies, loans from national and international banks, etc. In many cases the financial plans are weak and the state budget remains important. The involvement of private investors and operators has not materialized as expected, and better mechanisms for sound private-public partnership have to be found.

Pre-conditions for accessing the international sources of financing include:

- a) Stable national economies.
- b) Well-developed plans, including cost-benefit calculations and feasibility studies to justify the investment.

While the region is on the brink of achieving the first condition, many shortcomings remain in the plans and studies developed for the required investments.

When privatization occurs, most cases involve foreign participation in operating companies, with asset ownership remaining in public hands and the public sector responsible for raising finance for new investment. The present situation is that many governments are resistant to further private involvement in the water sector, and the leading multinational private water companies have an increasingly selective attitude toward overseas exposure. Instead of being a major source of financing, it is more realistic to regard multinational private companies as catalysts that can unlock previously inaccessible sources of funds through their know-how, beneficial impact on projects and institutions, and through the goodwill that comes with their involvement.

An appropriate government strategy to raise initial investment capital would therefore be to maximize uptake of grants and soft loans available from international agencies. The government will have to decide how much of a public subsidy should be extended to the water sector to fund "public goods," and phase out remaining subsidies as quickly as possible. The government should also decide how much privatization is desirable / feasible, where, and of what type, and seek to attract private partners and organize long-term international and commercial loans to cover remaining needs.

Over the long run, the principle of cost recovery should be one of the basic pillars of water pollution management in China. This will have a major impact on tariffs, which in the future might have to cover the full cost of new investments. This would require the gradual phasing out of subsidies. Experiences from other countries in the same situation show that with increasing tariffs, household consumption in urban areas is likely to settle in the range of 120-140 m^3 per capita/day.

Urban Pollution Management

Under conditions of transition from a planned to a market economy, it is important to avoid the establishment of unnecessary future excess capacity. The volume of wastewater produced and the chemical composition of the water might be changed as a result of increased water tariffs and structural changes in industry. Future design conditions of various facilities must not be extrapolated from past data and needs. Incentives should be used to ensure that water supply, sewerage, wastewater treatment, and sludge management are constructed simultaneously and in an integrated way.

In large cities and towns, appropriate or alternative technologies are often not feasible. In these cases, the only alternative is to consider the phased, step-by-step development of traditional technologies from mechanical treatment. Development into more advanced treatment can then be gradually investigated if necessary, e.g. chemically enhanced mechanical treatment, high- and low-load biological treatment, bio-film, advanced treatment with nutrient removal, etc. Design of treatment facilities should ensure a certain degree of flexibility, so that appropriate technologies can be incorporated in the future.

Industrial pre-treatment is crucial to avoid problems with operation and sludge disposal at municipal plants.

In peri-urban and rural areas, options other than traditional sanitation should be considered due to the high costs of installing sewerage networks.

In urban pollution management, the roles and tasks of the Municipal Environment Protection Bureaus and Municipal Water Boards need to be clarified.

The *Municipal Environment Protection Departments* should be in charge of the following tasks:

- Drafting water pollution management policies, laws, regulations and standards, and supervising and enforcing their implementation.
- Organizing the target-setting process; determining total load control targets; preparing water pollution management and ecological protection plans for the main rivers, and supervising their implementation.
- Carrying out monitoring of water quality and pollution sources, resolving disputes on trans-county pollution, and compiling/distributing information from the monitoring activities.
- Determining conditions and organizing measures for protection of drinking water sources against pollution.

The following recommendations are made for the functions of the *Municipal Water Boards:*

- Administrative, regulatory, and business operation functions of Municipal Water Boards should be separated.
- All water enterprises under Municipal Water Board jurisdiction should be established as independent economic units.

Industrial Pollution

China has made significant progress in managing industrial pollution. With the development of new production technologies, pollution mitigation opportunities are constantly changing.

In principle, the available funds for pollution treatment should be allocated to sectors where the greatest impact can be achieved. It is important to select the preferred investment sector to gain the socially optimal effect of investments in pollution management. For instance, the main COD discharge sectors are pulp and paper production, food processing, chemicals, pharmaceuticals, breweries, textiles, and the metal smelting and processing industries. If the average treatment cost for one ton of COD is compared across sectors (Table 3.1), it is evident that the food processing industry and the breweries have the lowest cost and thus will be the sectors where the highest environmental benefit per unit investment can be attained.

Wastewater recycling technologies can reduce urban natural water demand, mitigate water pollution, and reduce the impact of wastewater on water quality. In appropriate cases, full treatment of wastewater can be introduced with the recycled water used in agriculture, industry, and municipal facilities. In water-deficient areas, the water recycling processes should be integrated into wastewater treatment works.

Legislation should focus on supporting the transfer of clean technologies, and efforts should be made to introduce environmental management systems at the company level. Cleaner and more efficient industrial production should also be a priority for policy makers. The main aim would be to reduce water use, and thus the level of wastewater discharge per unit product. Technological innovation with a focus on increasing water efficiency should be encouraged. Given the relatively high levels of COD load compared with GIOV shares observed in the pulp/paper and food industries, these sectors would seem like an ideal starting point. Closed-circuit technologies for water treatment should be promoted in the iron and steel, electric power, chemical, and coal industries.

Table 3.1. Comparison of Treatment Cost in the Main COD Discharging Sectors.

Sector	The decreased rate (percent)	The average treatment cost (RMB/t)	The marginal decreasing cost (RMB/t)
Paper and paper ware industry	40	2,181.4	225.8
Food industry	75	1,248.2	494.1
Chemical industry	44	1,810.0	211.7
Pharmaceutical industry	73	2,610.3	925.0
Breweries	62	528.5	121.0
Textile industry	67	2,624.3	730.4
Steel industry	20	1,790.9	72.1

Source: Cao Dong, et al., 1999.

Agricultural Pollution

Agriculture contributes to water pollution through point and non-point source discharges of nutrients (P and N), organic materials, organic micro-pollutants (primarily pesticides), and heavy metals (contaminated fertilizers). These pollutants can lead to eutrophication of water bodies and contamination of food products. Internationally, studies have shown that 60 to 70 percent of the nutrient load of many rivers and watersheds stem from agriculture. The importance of reducing agricultural pollution is starting to be recognized in China. However, experience from many countries shows that it is more difficult to apply strict pollution controls and to implement environmental regulation in the agriculture sector than it is in the industrial and municipal sectors.

The first step toward managing non-point source pollution is to derive reliable load estimates. This can be done by (a) monitoring the flux of pollutants in watercourses in agricultural areas, or (b) preparing pollution production and retention budgets. Ideally, these two approaches should be used in parallel.

The next step would be to develop a well thought-out strategy for agricultural pollution management, starting with the establishment of a consensus among the relevant parties on the current pollution situation, i.e. the different pollution sources and environmental impacts. Unless such an understanding is reached, it will be difficult to develop a consensus on the required measures.

In establishing the aforementioned consensus, and particularly for the policy implementation of the measures, agriculture extension services have to be emphasized more assertively. Local agriculture representatives and grassroots officers should take care of the primary contact with the individual farmers. Unless the need for action has support from the agricultural sector representatives, little progress will be seen.

Following this assessment, it is necessary to identify different options for pollution reduction related to non-point source activities and calculate the cost-efficiency of each measure.

In the implementation of pollution management actions, win-win options, which will save money for farmers and reduce pollution, should be sought out. Examples include fertilizer planning and integrated pest control. The pricing mechanism—for instance, reducing subsidies on fertilizer and other production inputs—should be investigated with care because farmers need time to adjust to new economic framework conditions. Agricultural subsidies that do not support water protection should be decreased and gradually phased out. Experience has shown that legal measures are generally less efficient than economic measures and information.

Management of agricultural pollution is a long-term policy objective and should be approached by developing tools that have to be carefully tailored to each type of activity. The pollution management program should initially target the easiest and least controversial opportunities and gradually expand when a wider understanding and general acceptance of the measures has been developed.

Improving Water Quality Monitoring

Water quality monitoring incorporates a number of interrelated issues, such as sampling, analysis and inter-calibration, water information systems, evaluation of data by statistical and other methods. Incorporation of these elements depends on the objectives of the monitoring system, which often differs between different users of data. These objectives will determine sampling sites, sampling frequency, and duration of monitoring.

If design is inadequate, then significant resources can be spent without obtaining information on the desired confidence level.

One of the problems of the existing monitoring system in China is the lack of harmonization and quality control to secure that the data from different sources can be compared (similar sampling techniques, analytic techniques, etc.). A functioning monitoring system would require constant updating and maintenance of the system for data storage, distribution, and presentation.

In recent years, the development of data management software has created an opportunity for large integrated water data management and decision support systems. However, experience has shown that in many countries the ambition for such systems has been too high. For example, when trying to satisfy too many purposes in the same system, the eventual outputs may not manage to do anything properly.

Water quality monitoring should be supervised by SEPA, while hydrological monitoring (quantity monitoring conducted for water management purposes) should be managed by MWR. However, uniform standards should be applied, and a coordinated organization for water monitoring should be established. By coordination of the existing monitoring organization, the quality of data and information can be improved and duplication can be avoided.

Box 3.4. Designing Water Quality Monitoring Systems

A water quality monitoring system has to be designed for the specific purposes it is supposed to serve. The monitoring data can, for instance, be used for:

- Determining baseline environmental conditions;
- Making quality classification and thematic of maps;
- Detecting trends;
- Determining annual or monthly averages of certain parameters;
- Monitoring critical conditions (annual maximum or minimum values of certain water quality parameters);
- Monitoring violation of standards;
- Studying cause-effect relations between discharges and water quality impacts;
- Provide input to water quality planning models;
- Giving an early warning of accidental spills (primarily for micro-pollutants and oil products);
- Studying watershed transmission and retention processes for nutrient load estimates;
- EIA purposes (see also Box 3.2 for objectives related to the EU-WFD).

Not all of these objectives can be met with the same sampling methods or analytic approach. The purposes will determine sampling sites, frequency, duration of monitoring, and the need for more specific and detailed recipient studies.

Design of the monitoring system should also consider the fastest and slowest changes in concentration and the behavior of the pollutants in the water body. Simple water sampling and analysis of a few chemical parameters will only give "snapshots" of the water quality situation. The present tendency in Europe is to monitor a limited number of sites at higher frequency. Increased sampling frequency enables the collection of information with a higher statistical reliability and makes it possible, for instance, to analyze trends. In some cases it might be more efficient to monitor indicators (concentration in plant material, concentration in sediments, survival of certain organisms etc) rather than to try to monitor the chemical parameter in the water itself. This is particularly true for toxic micropollutants that are found in very small concentrations in the water or where the discharge is a result of accidental release.

One important bottleneck in monitoring is quality control. A system of quality control has to include, (a) technical manuals describing in detail the procedures of water sampling, sample transport and storage, analytical methods, "meta-data" requirements etc, and (b) an inter-calibration procedure for laboratories involved in the monitoring activities.

Box 3.5. European Union—Water Framework Directive Monitoring Program

The EU Water Framework Directive prescribes a system for water quality monitoring consisting of three elements. These are:

Surveillance monitoring to provide information for:

- Supplementing and validating the impact assessment procedure;
- Efficient and effective design of future monitoring programs;
- Assessment of long-term changes in natural conditions;
- Assessment of long-term changes resulting from widespread human activity.

The results of such monitoring are reviewed and used, in combination with the impact assessment procedure, to determine requirements for monitoring programs in the current and subsequent river basin management plans.

Operational monitoring in order to:

- Establish the status of those bodies identified as being at risk of failing to meet their environmental objectives;
- Assess any changes in the status of such bodies resulting from the measures taken.

The program may be amended during the period of the river basin management plan in light of information obtained. Such amendments may include a reduction in sample frequency where an impact is found not to be significant or the cause of pollution or stress is removed.

Investigative monitoring shall be carried out:

- Where the reason for any pollution levels above the standards is unknown;
- Where surveillance monitoring indicates that the objectives for a body of water are not likely to be achieved and operational monitoring has not already been established;
- To ascertain the magnitude and impacts of accidental pollution.

The monitoring shall also inform the establishment of a program of measures for the achievement of the environmental objectives and specific measures necessary to remedy the effects of accidental pollution.

Before launching an integrated water data monitoring and management system, careful analysis of the needs and costs are needed. The system might be more effective and cost-efficient without some of the many possible aspects outlined above. However, cost-cutting should not be allowed to undermine or compromise the effectiveness of the system, so that it cannot satisfy the real information needs of the potential users.

In light of the above, it is often found appropriate to distinguish between three separate water quality monitoring and data management systems:

- Internal control of water facilities operation and industrial process control. This will also provide data for reporting, if the principle of self-auditing is applied. The monitoring program has to be tailored and operated by the facilities themselves.
- Monitoring of facilities' and enterprises' compliance with pollution standards or discharge concessions by the relevant authorities. Parameter and sampling frequency will have to be decided for each individual case, and the analytic and sampling quality control will have to be strict, since the results might be used to apply fees and fines and could be challenged in court.
- Monitoring to establish the state of water resource quality. The objective here is to follow the trends in water quality and to present this information to the general public and decision makers. This type of monitoring should concentrate on a few general parameters that are held constant over longer time periods, so that different water bodies can be compared on an equal basis, and so that time series can be produced.

Planning and Capacity Building

Many advanced computer tools are marketed for water-related planning. The key to practical planning is not the presence or absence of such tools, but the overall understanding, level of participation in the planning processes, and the commitment of the key parties to implement the plans. Nowadays, the focus is on an "open" planning procedure where the essence is the involvement of the public from the very beginning of the project in question. Experiences from CEE countries, for instance, show that this new approach for planners and the public alike requires a long-term effort to create a culture of public participation.

A critical mass of expertise is required in order to develop new legislation, harmonize laws, modify the institutional system, and prepare strategies/plans for implementation. Experts are needed to transfer knowledge from other countries to interpret "local" conditions to which innovative applications should be performed. Thus, exchange programs, training, and capacity building in a broad sense are inevitably important.

Environmental Awareness and Public Participation

The support and pressure from the general public is an important factor in enforcing stricter water pollution management and improved environmental standards and the quality of products. The basic condition for such involvement is a certain level of knowledge about the situation and a general awareness of the need for changes and the risk faced when doing nothing.

The disclosure of information about pollution loads and environmental risks is an important element in building this level of interest and awareness. This is particularly relevant for results of environmental monitoring. The data from such monitoring should be processed and made public in a form that makes it understandable to the general public.

In the processes of preparation and approval of EIAs, the concerned parties should have a clear role. The rights and duties of the public should be clearly spelled out in the EIA regulations and guidelines.

The public might also influence the productive sectors as consumers of goods and services. Again, information is needed for the public to make a qualified choice. Based on the international environmental labeling standard and China's technology level, a system of environmental labeling for food products should be established. Sector management authorities and sector experts should be involved in developing environmental labeling standards and classification.

Annex 1

Trends in River Water Quality

The following figures have been generated by summarizing all available water quality information form the China National Monitoring Center for each of the rivers for the 1991–2005 period. (For the location of the monitoring stations in each of the river basins, refer to Figure 1.6 in Chapter 1).

In spite of massive investment in the past 15 years, water quality in China's main rivers is showing few signs of improvement. In fact, there are a number of cases where average water quality is declining. In four out of the seven rivers presented below, between one-third and one-half of the monitored water quality is in the worst two categories, i.e. no longer fishable and of questionable agricultural value.

Figure A1. Average river water quality Liao River (1991–2005)

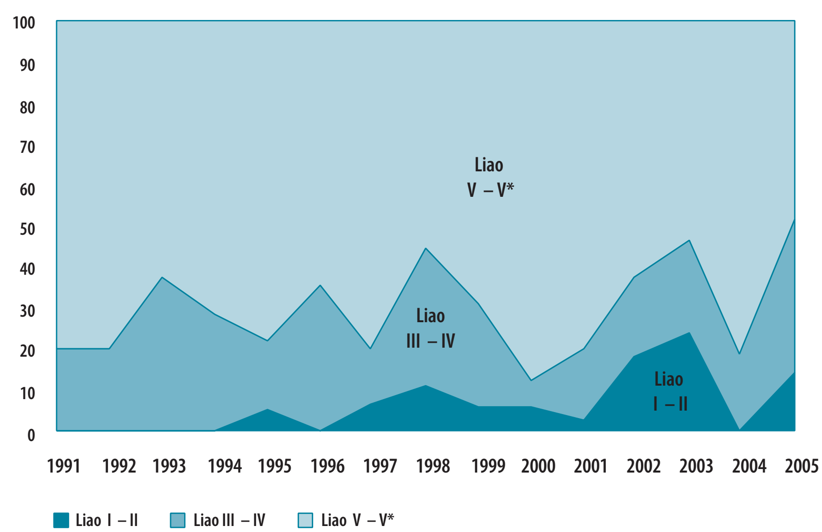


Figure A2. Average river water quality Yellow River (1991–2005)

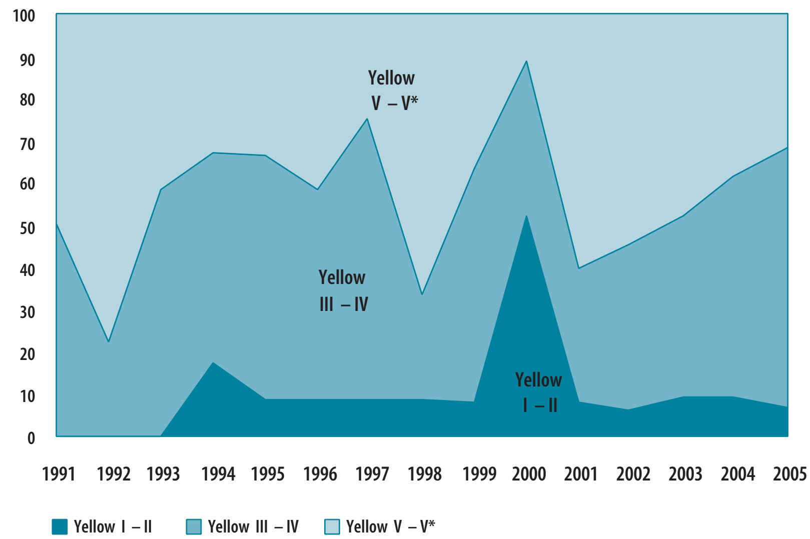


Figure A3. Average river water quality Song River (1991–2005)

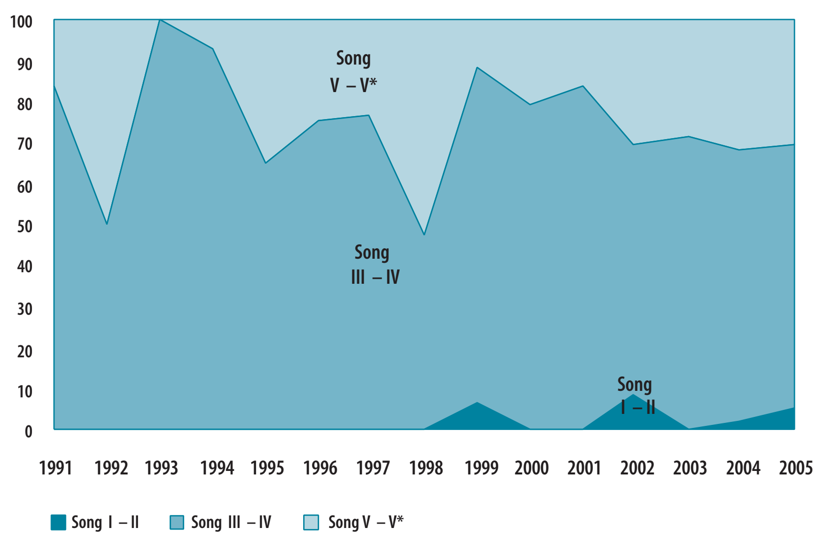


Figure A4. Average river water quality Huai River (1991–2005)

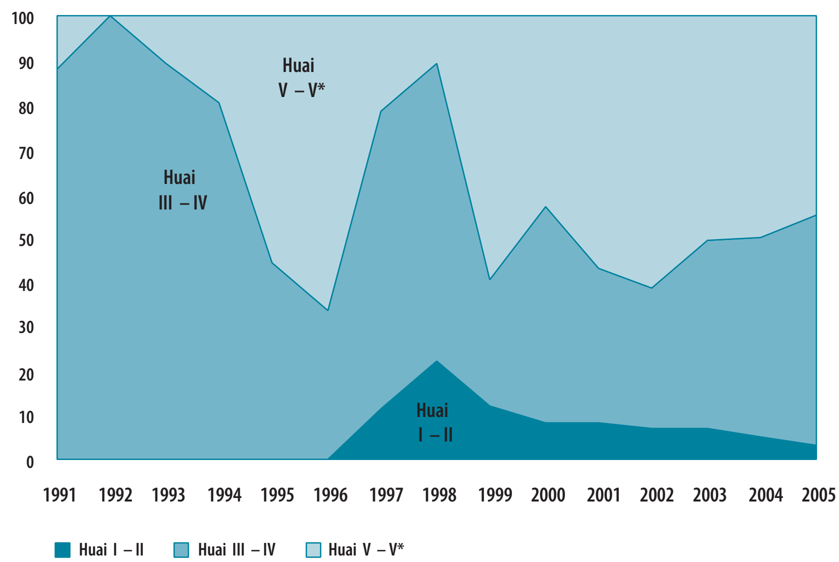


Figure A5. Average river water quality Hai River (1991–2005)

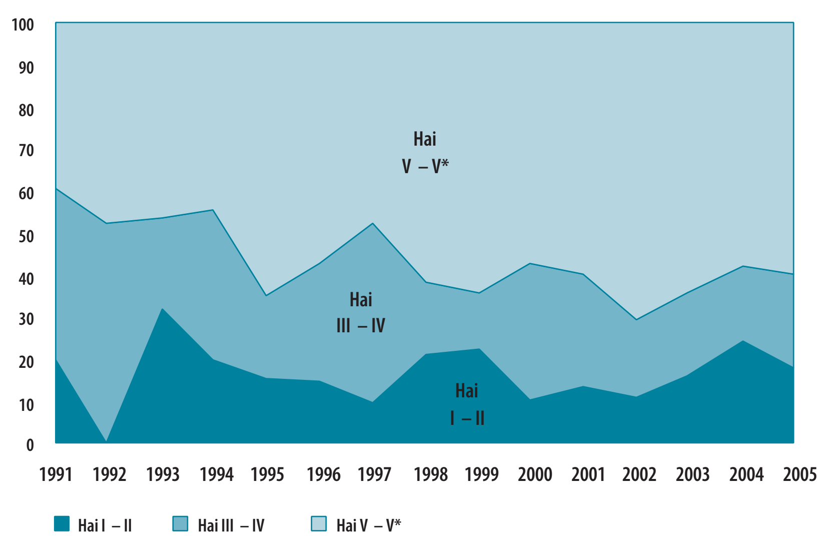


Figure A6. Average river water quality Yangtze River (1991–2005)

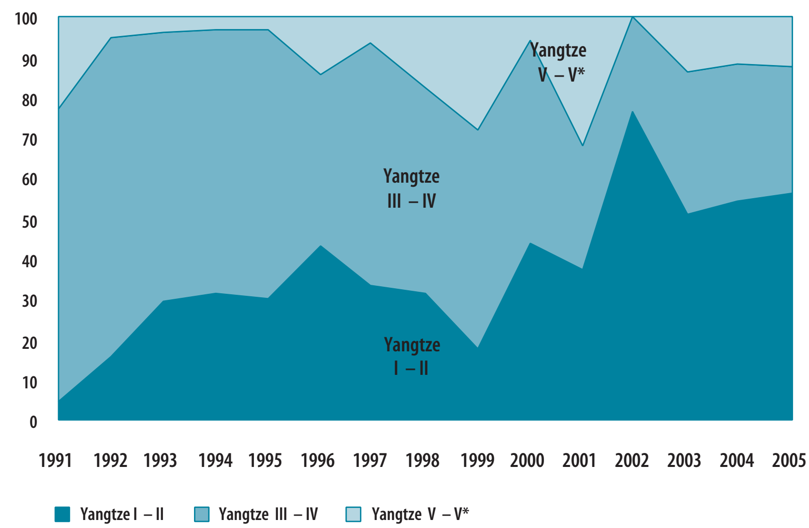
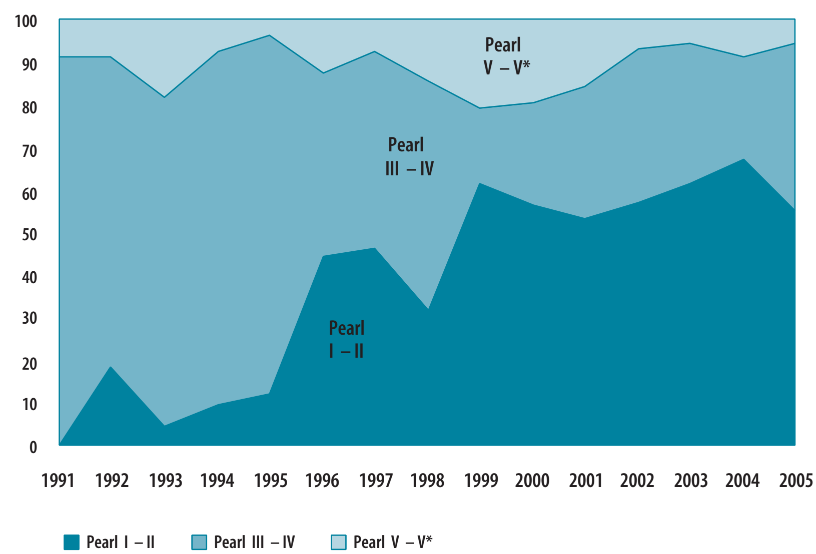


Figure A7. Average river water quality Pearl River (1991–2005)



Annex 2

Relevant World Bank Projects

The World Bank is closely engaged in China's Water Resource Management sector, with many ongoing, recently completed, or pipeline projects that address water pollution-related issues. The depth of this engagement testifies to the seriousness with which the World Bank regards the issue in China. This work ranges from rural to urban environments and includes dedicated investment projects and analytical and capacity building initiatives. Relevant examples are given below.

China Water Resource Assistance Strategy

The China Water Resource Assistance Strategy (2002) was developed as a joint Bank-client venture to set out a framework for future World Bank assistance. The strategy highlights the key unresolved problems for WRM in China (water shortages, flooding, and pollution) and stresses that the ineffective and fragmented water management systems are a critical unresolved problem. The focus is, therefore, on improved water resources management and the need for coordinated and integrated approaches.

In order to capture all the dimensions of the water resource management challenges in China, the report breaks the subject down by key themes and issues. Themes include environmental preservation and financial and political support; key issues include institutional development (data, rights, pricing), water scarcity (transfer projects), and pollution control (wastewater management, environmental flows). However, the strategy also notes the lack of a strategic relationship on water issues in China. The Chinese government has typically developed project ideas from the conceptual to implementation stage and only enlisted Bank support when financing was required. The strategy sets out proposals for a closer relationship, where the client can take advantage of more upstream dialogue and AAA assistance from the Bank. For example, there should be increased emphasis on parallel World Bank analytical and capacity building in addition to the loans for physical infrastructure.

Hai River Basin Integrated Water Resources Management Project (GEF)

The Hai River is one of the most polluted bodies of water in the country. It is a major source of pollution in the "stressed" Bohai Sea. So far, the government's efforts to manage pollution in this area have been focused on large municipal and industrial sources. However, despite considerable reductions in these sources of pollution, water quality has continued to decline. Reducing pollution from secondary cities as well as town and suburban industries is required in order to make an impact on overall water quality in the area.

The overall objective of this project is to catalyze an integrated approach to water resource management and pollution control in the Hai basin. The project activities are designed to meet this objective by promoting a more integrated approach to water resource management, providing technical and financial assistance for wastewater management and canal clean-up in small cities, and funding pre-investment studies for innovative projects. The project is developing top-down and bottom-up mechanisms for integrated water and environment management. In order for this management approach to be successful, great emphasis is being placed on coordination among relevant ministries/bureaus and the central and local levels of governance, such as SEPA, MWR, EPBs, and WABs. If successful, the benefits should include improved public health, healthier ecosystems, and various water- and agriculture-related economic benefits.

Huai River Pollution Control Project

The development objectives for this project focus on supporting the government's work to improve the environmental quality of the Huai River and its tributaries through improved collection and treatment of wastewater. The project is providing facilities for collection and treatment of wastewater and establishing competent municipal wastewater utilities responsible for managing facilities. It is also bringing new and innovative approaches to WPM in China, such as the integration of septic tank management into the wastewater program. This includes investments in sewerage and associated infrastructure, wastewater treatment plants, and logistical facilities (such as laboratories and technical equipment) in the Anhui and Shandong provinces.

In order to ensure the sustainability of these undertakings, the project is taking advantage of the recently enacted Tariff Regulation 1192, which sets a framework for tariff policy geared toward sustaining wastewater operations. The creation of autonomous utility companies with proper management and direct use of their collected revenues should foster the development of wastewater companies as business undertakings that would apply modern management principles. Furthermore, comprehensive training combined with a focused technical assistance program would build up the competence and motivation for implementing, operating, and maintaining the wastewater treatment plants.

Lake Dianchi Freshwater Biodiversity Restoration Project

Environmental improvement in Lake Dianchi and its watershed is a major national priority. The basin is a hotspot of freshwater biodiversity and endemism. The objective of the project is to restore and manage habitats around the lake in order to secure the conservation of the remaining endemic species of Lake Dianchi and its immediate tributaries. This water resource management project links with the World Bank's Yunnan Environment Project (see below) by applying a biodiversity overlay to the ongoing infrastructure, policy, and regulatory measures. In order to achieve its objective, the project is establishing stable breeding habitats, providing biological survey data, monitoring lake quality, and raising public awareness of the region's unique biological environment.

Expected project outcomes are categorized into four areas: (1) wetland management and restoration; (2) improved monitoring and species conservation; (3) capacity building and training; and (4) public awareness. The first component seeks to restore natural habitats to some semblance of their natural state, with interventions integrated into broader local government plans that will build capacity and can be scaled up. The other components have been designed to provide the required data, capacity, and public support to ensure the sustainability of these environmental benefits.

Yunnan Environment Project

This recently closed project was part of a phased development program to improve environmental conditions and sustain urban services in Yunnan Province. The project's principal objective was to provide a sustainable environmental framework for the long-term economic and social development of the province. It had specific objectives to (a) strengthen policies, regulations and institutional arrangements for pollution management; (b) improve lake water quality; (c) facilitate pollution management investments; and (d) introduce a comprehensive approach to urban environmental infrastructure investment planning. Components included establishment of physical works such as water supply, wastewater treatment plants, and solid waste landfills, and an improved institutional setting with an increased role for private enterprises in water supply and wastewater management.

Guangdong Pearl River Delta Urban Environment Project

The fragile environment of the Pearl River Delta and South China Sea region has deteriorated as a result of the region's rapid economic growth. Between 1990 and 2000, average regional GDP growth was 14.7 percent. However, this growth has led to regional immigration (Guangzhou had a migrant population of over 4 million in 2000) and increasing levels of waste generation (wastewater: 11.5 m m^3/dy in 2000, 12.3 m m^3/dy in 2010). The region lacks appropriate environmental management capacity and is experiencing severe deterioration in local water quality. This deterioration is attributed to factors such as poor regional planning, lack of treatment facilities for domestic and industrial wastewater and solid waste, inadequate water quality monitoring, and inappropriate pricing systems.

In order to address this decline and improve water quality in the Pearl River Delta and the South China Sea, this project will support Guangdong Province in addressing environmental service delivery and associated investment in an integrated manner. It will support an environmentally sustainable development process by improving the management of water resources and hazardous waste management through interventions in the following areas: (a) comprehensive and regional planning; (b) jointly managed environmental infrastructure; (c) wastewater management; (d) hazardous waste management; (e) improved water quality monitoring and industrial pollution management. These activities are being complemented by policy and institutional reforms, such as the promotion of regional planning approaches, adoption of demand management to conserve water, the formation of a financially autonomous water company, and improved water quality monitoring and management regulations.

Related Watershed Management Projects

The World Bank has been involved in numerous projects designed to protect the watersheds of China's river basins. Two good examples of this work are the long-term forest management program and the Tarim Basin projects. Over the last 20 years, the Chinese government and the World Bank have made tremendous efforts in the forestry sector. One of the major results has been the reversal of the trends in deforestation, but another major objective in most of these projects is improved watershed management. The maintenance of an appropriate surrounding environment is essential for China's river systems to supply and dispose of water in the required manner. For example, the current China Sustainable Forestry Project includes specific objectives for protecting watersheds in order to maintain river structure and reduce flooding. The Tarim Basin I and II projects supported rehabilitation and improved irrigation, drainage systems, and agricultural services in the Tarim Basin in northwestern China. The projects have improved water resource management in the basin, dramatically reduced sedimentation levels, and strengthened local water management bodies.

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