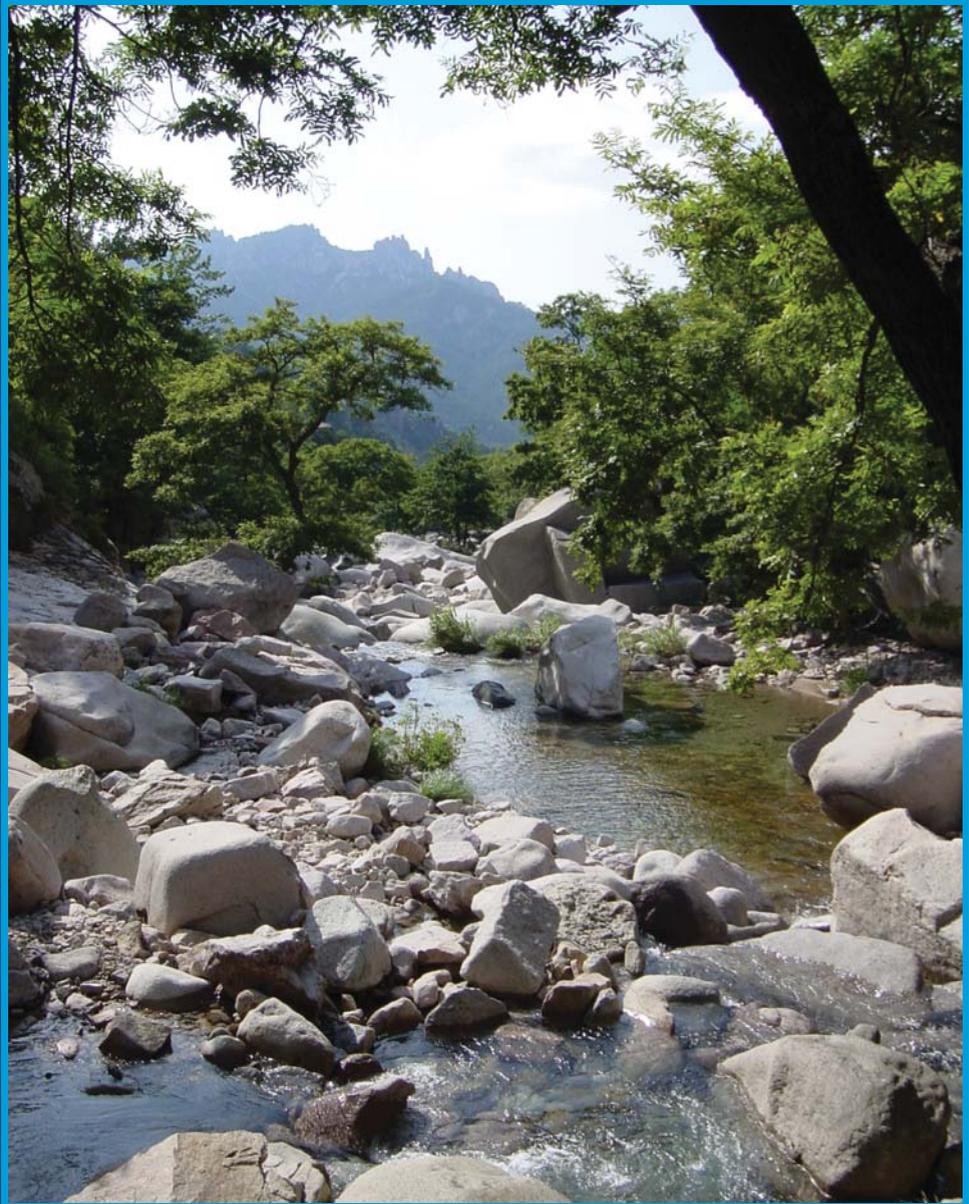


47111

Addressing China's Water Scarcity

*Recommendations for Selected
Water Resource Management Issues*



THE WORLD BANK

Public Disclosure Authorized

Public Disclosure Authorized

Public Disclosure Authorized

Public Disclosure Authorized

Addressing China's Water Scarcity

Addressing China's Water Scarcity

*Recommendations for Selected
Water Resource Management Issues*



Jian Xie

with

Andres Liebenthal, Jeremy J. Warford, John A. Dixon, Manchuan Wang, Shiji Gao, Shuilin Wang, Yong Jiang, and Zhong Ma



THE WORLD BANK

© 2009 The International Bank for Reconstruction and Development / The World Bank
1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org
E-mail: feedback@worldbank.org

All rights reserved.

1 2 3 4 5 11 12 10 09

This volume is a product of the staff of the International Bank for Reconstruction and Development / The World Bank. The findings, interpretations, and conclusions expressed in this volume do not necessarily reflect the views of the Executive Directors of The World Bank or the governments they represent.

The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgement on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Rights and Permissions

The material in this publication is copyrighted. Copying and/or transmitting portions or all of this work without permission may be a violation of applicable law. The International Bank for Reconstruction and Development / The World Bank encourages dissemination of its work and will normally grant permission to reproduce portions of the work promptly.

For permission to photocopy or reprint any part of this work, please send a request with complete information to the Copyright Clearance Center Inc., 222 Rosewood Drive, Danvers, MA 01923, USA; telephone: 978-750-8400; fax: 978-750-4470; Internet: www.copyright.com.

All other queries on rights and licenses, including subsidiary rights, should be addressed to the Office of the Publisher, The World Bank, 1818 H Street NW, Washington, DC 20433, USA; fax: 202-522-2422; e-mail: pubrights@worldbank.org.

ISBN: 978-0-8213-7645-4
eISBN: 978-0-8213-7825-0
DOI: 10.1596/978-0-8213-7645-4

Library of Congress Cataloging-in-Publication data has been requested.

Cover photo by Jian Xie.
Cover design by Circle Graphics.



Table of Contents

FOREWORD	xi
ACKNOWLEDGMENTS	xiii
ABBREVIATIONS	xv
EXECUTIVE SUMMARY	xix
1 Introduction	1
Background	1
Objectives and Scope	2
Conceptual Framework and Approach	3
Outline of the Report	6
2 Water Scarcity in China: Current Situation	9
Spatial and Temporal Disparities	9
Water Pollution	11
Environmental and Social Impacts and Economic Loss	14
External Driving Forces of Water Problems	21
3 Water Resources Management in China: An Overview of Determinant Variables	25
Technical Solutions Are Available and Economically Feasible	25
Government Commitments, Plans, and Implementation	27
Excessive Fragmentation of the Water Management System	29
Policy Failures in Water Management	34
Summary	40

4	Improving Water Governance	41
	The Concept of Water Governance	42
	The Legal Environment for Water Management	42
	Institutional Arrangements for Water Resource Management	47
	Transparency and Information Disclosure	52
	Public Participation in Water Management	55
	Summary	59
5	Deepening Water Rights Administration and Developing Water Markets	61
	Theory of Water Rights and International Practice	61
	Development of Water Rights in China	67
	Water Rights Reform in China: Case Studies and Project Insights	69
	Basics of Water Market and Trading	71
	International Experience with Water Markets	73
	Emerging Experience of Water Trading in China: Case Studies	74
	Challenges and Lessons for China	77
	Recommendations	80
6	Improving Efficiency and Equity in Water Pricing	83
	Water Pricing in China: Policy and Practice	83
	Pricing for Environment and Depletion	86
	Social Impact and Affordability	88
	Protecting the Poor	91
	Other Implementation Issues	94
	Recommendations	95
7	Protecting Ecosystems in River Basins through Market-Oriented Eco-Compensation Instruments	97
	Ecological Compensation Mechanisms in China	98
	Concept and Methodology of Payment for Ecosystem Services (PES)	100
	The Growing International Experience with PES Systems	103
	Potential Use of PES in China	105
	Recommendations	109
8	Controlling Water Pollution	111
	Seriousness of Water Pollution	111
	Causes of Pollution and Key Challenges for Pollution Control	112
	International Experience	119
	Emerging Institutional and Policy Issues	121
	Recommendations	123
9	Preventing Water Pollution Disasters	127
	Water Pollution Incidents in China	127
	Concept and Framework for Pollution Emergency Prevention and Response	128
	International Experience	129
	Environmental Emergency Prevention and Response in China	132
	Recommendations	135

10	Summary, Action Plan, and Issues for the Future	137
	Summary	137
	Action Plan	140
	Issues for the Future	140
	Concluding Remarks	143
	APPENDIX: BACKGROUND PAPERS TO THIS REPORT	145
	REFERENCES	147
	INDEX	153
	BOXES	
1.1	The World Bank’s Analytical and Advisory Assistance Program— “Addressing China’s Water Scarcity: From Analysis to Action”	3
1.2	Recent Water Resource Management Studies at the World Bank	4
2.1	Water Crisis in Wuxi in 2007	21
3.1	China’s 11th FYP for Water Resources Development	28
3.2	Case Study: Evaluating the Implementation of the Water Pollution Prevention and Control Plans for the Huai River Basin	30
3.3	River Basin Agencies in France	33
3.4	Planning Scarce Water Resources Using Evapotranspiration (ET) Quotas	35
3.5	Distorted Economic Incentive for Pollution Discharge	39
4.1	The U.S. Experience in Promoting Law Enforcement	44
4.2	River Basin Management Legislation in the United States: the Case of the Susquehanna River Basin	47
4.3	Three Models of Water Resource Institutions in Europe	48
4.4	The EU Water Framework Directive	49
4.5	Integrated River Basin Management	50
4.6	EU Directive on the Freedom of Access to Information on the Environment	54
5.1	Water Rights in New Mexico	63
5.2	From Formal Rights to Contracts and Claims	63
5.3	Water Allocation Priorities in the Middle East: the Case of Israel	65
5.4	Registering and Monitoring Users: International Comparisons with Groundwater Management	65
5.5	Determining and Defining Environmental Flows	66
5.6	From River to Farm: Water Rights and Allocation in Inner Mongolia Water Resources Allocation Plan for the Yellow River	70
5.7	Defining and Allocating Consumptive Water Rights in the Hai Basin	71
5.8	The Colorado–Big Thompson (C-BT) Project	73
5.9	Idaho Water Supply Bank	74
5.10	Water Markets in the Murray Darling Basin, Australia	75
5.11	Channel Lining and Water Transfer: Experience from Hangjin Irrigation District, Inner Mongolia	76
5.12	Defining, Allocating, and Trading Rights in the Heihe Basin	77

6.1	The Marginal User Cost of Water in the Hai River Basin	88
6.2	Making Price Increases Acceptable: the Case of Chongqing	93
7.1	Additional Examples of Payments for Ecological and Environmental Services (PES)	104
8.1	Implementation of Water Pollution Control Plans for the Huai River Basin	114
8.2	Public Participation and Compliance with Environmental Standards: the Case of Japan	120
9.1	Water Pollution Incident in the Songhua River	128
9.2	The Sandoz Chemical Spill in Switzerland and Extending down the Rhine	130
9.3	Examples of National Legislative Systems	130
9.4	The Buncefield Incident, U.K.	131

FIGURES

1.1	Water Resource Management	5
2.1	Spatial Distribution of Annual per Capita Water Resources in China	10
2.2	Industrial Wastewater Discharge, 1995–2005	12
2.3	Industrial COD Discharge, 1995–2005	13
2.4	Trends in Water Quality at Monitored River Sections in China, 1991–2005	15
2.5	Trends in Water Quality Changes at Monitored River Sections in North and South China, 1991–2005	16
2.6	Surface Water Quality, 2000 and 2004	16
2.7	Groundwater Depletion by Province	18
2.8	Polluted Water Supplies in China	19
2.9	Rural Households with No Access to Piped Water and Diarrhea Incidence	20
2.10	Mortality Rate for Cancer Associated with Water Pollution in China, 2003	20
3.1	Ministries and Authorities Involved in Water Resource Management	31
3.2	MEP and MWR Water Quality Data for Huai River, 1998–2004	32
3.3	Integrated Economic Values of Water and Water Withdrawals in the Primary, Industrial, and Service Sectors in Eight Regions	38
6.1	Municipal Water Tariffs and Wastewater Charges by City	85
6.2	Share of Water and Wastewater Services Expenses for Average and Low-Income Households	90
7.1	Main Ecological and Environmental Services by Type of Service	101
7.2	The Simple Economics of Payments for Environmental Services	102
7.3	The Flow of Compensation from Beneficiaries to Land Users in a PES System	102
8.1	Water Quality in Chinese Rivers, 1991–2006	112
8.2	Percentage of Sections with Water Quality Grade IV to Grade V+, 2001 and 2005	113
8.3	Provincial Sewage Treatment Investments in Yellow River Watershed	117
8.4	Centralized Sewage Treatment Rates and per Capita GDP in 14 Provinces in Northern China, 2003	118
8.5	Centralized Sewage Treatment Rates by City Size in 2003	118
9.1	Common Elements of an Emergency Response System	128

TABLES

2.1	Spatial Distribution of China's Water Resources and Other Social Variables	11
2.2	Wastewater and Pollutant Discharges, 2000–05	13
2.3	Current Trophic Level of Lakes and Reservoirs in China	15
2.4	Water Supply and Renewable Water Resources in China, 2005	17
2.5	Projected Water Demand	22
3.1	Performance in Meeting the 10th FYPEP Targets for Water Pollution Control	29
3.2	Wastewater Treatment Cost for Major Industrial and Domestic Sectors	37
3.3	Virtual Water Content of Selected Products	38
3.4	Urban Fixed-Asset Investment during the 9th and 10th Five-Year Period	39
6.1	Water Tariffs in Beijing, 1981–2007	85
7.1	Summary of EES, Service Providers, and Service Beneficiaries in the Lashihai Case Study, China	106
7.2	Suggested Increase in Lijiang Old Town Visitors' Fee to Fund PES Scheme	107
7.3	Suggested Entrance Fees to Lashihai Nature Reserve to Fund PES Scheme	108
8.1	Planned Water-Related Investment Shares between the Central Government and Local Sources in Wei River Basin	116
8.2	Water Quality of Qixinghe Natural Reserve, 2007	117
10.1	Recommended Action Plan	141



Foreword

This report synthesizes the main findings and recommendations from over 30 technical reports, case studies, and background papers prepared for the World Bank's Analytical and Advisory Assistance (AAA) program entitled "Addressing China's Water Scarcity: From Analysis to Action." Each of the papers responded to a specific government request. Most were prepared as partnerships among Bank staff, international consultants, and Chinese research institutions.

The objective of this report is to provide an overview of China's water scarcity situation, assess the policy and institutional requirements for addressing it, and recommend key areas for strengthening and reform. In light of the magnitude and complexity of water issues in China, and the availability of earlier studies in this area supported by the Bank and others, the report does not attempt to be comprehensive. Instead, it focuses on selected areas where more analysis was needed to deepen the understanding of policy and institutional issues, and to develop specific actions to address them. The issues covered in the report are water governance, water rights, water pricing and affordability, watershed ecological compensation, water pollution control, and emergency prevention.

We are particularly pleased with the participation of various Chinese and international institutions in the thematic studies of this AAA. We believe their participation has helped build a consensus around strategically important water issues and a common understanding of the priority actions needed to address them.

Overall, China faces a major challenge in managing its scarce water resources to sustain economic growth in the years ahead. This is a daunting task, but the analysis of past experience in China and elsewhere provides useful lessons on how to proceed. China's 11th Five-Year Plan has already prepared the ground by moving strategically toward increased reliance on market-based approaches, supported by the twin pillars of integrated water resource management and rigorous pollution control. The report's recommendations, summarized in the plan of action, identify the key measures needed to effectively move forward in this direction. We trust it will assist the government in accelerating its efforts to address China's water scarcity.

James Adams
Vice President
East Asia and Pacific Region
The World Bank



Acknowledgments

This report synthesizes the main findings and recommendations of the World Bank's Analytical and Advisory Assistance (AAA), entitled "Addressing China's Water Scarcity: From Analysis to Action." The AAA was launched by the World Bank in fiscal 2006 to assist the Chinese government in developing, adopting, and implementing policy and institutional reforms needed to more effectively address China's water problems.

The AAA benefits from the participation and support of various Chinese and international institutions and individuals as well as the U.K. Department of International Development (DFID). DFID provided both technical and financial support to the AAA.

The AAA was developed under the general guidance of Christian Delvoie, David Dollar, Teresa Serra, Magda Lovei, Rahul Raturi, Bert Hofman, Elaine Sun, Ede Jorge Ijjasz-Vasquez, and Susan Shen at the World Bank. It also received valuable guidance from Mr. Li Jiange.

This report was prepared by Jian Xie, with Andres Liebenthal, Jeremy Warford, John A. Dixon, Manchuan Wang, Shiji Gao, Shuilin Wang, Yong Jiang, and Zhong Ma. Douglas Olson, Geoffrey Spencer, Jie Feng, Junkuo Zhang, Liping Jiang, Roger Calow, Tracy Hart, and Xuejun Wang also provided valuable inputs. The report is based on a series of case studies,

background study reports, and World Bank policy notes prepared by a team of Chinese institutes and international groups commissioned by the World Bank. Contributors to these reports also included Ariel Dinar, Geoffrey Spencer, Greg Browder, Hua Wang, Jostein Nygard, Liping Jiang, Qun Li, Shenhua Wang, Thomas Zearley, and Ximing Zhang of the World Bank; Linjun Zhou, Qi Dong, Wenchao Jiang, and Zhi Zhang of Chongqing City; Shiqiu Zhang, Liangchun Deng, Peng Yue, and Huishan Cui of Peking University; Hao Wang, Hong Gan, and Lin Wang of the MWR Institute of Water Resources; Kunimasa Nishigaya of ALMEC Japan; MWR Development Research Center; Alessandra Sgobbi, Anil Markandya, Alessandra Gorla, and Carlo Giupponi of Fondazione Eni Enrico Mattei Servizi Italy (FEEM); Zhi Lu, Guangchun Lei, and Yi He of Conservation International China Program (CI); Shuang Zhang of the Nature Conservancy China Program (TNC); Haixia Zheng and Lubiao Zhang of China Academy of Agriculture Sciences (CAAS); Liqin Mu of Lijiang City Policy Research Office; Zhong Ma, Guojun Song, Zhuoni Wang, and Hongfeng Chen of Renmin University; Yufei Pu, Xueying Zhang, Min Liu, Rui Zhao, and Lei Sheng of the State Information Center; John Warburton, Susanna Smets, and Leo Horn of DFID China; Roger Calow,

Robert Speed, and Dajun Shen of the Australian-China Water Entitlements and Trading Project; as well as Junkuo Zhang, Jie Feng, Jennifer Coleman, Yuyang Gong, Hongjun Zhang, Yi Wang, Weihua Zeng, Guozhi Liu, Gangyan Zhou, Lili Yan, Y.S. Cao, Satoshi Murakuni, Honglin Li, Jingjie Chu, Lian Jiang, and the UK National Chemical Emergency Center. Robert Livernash provided editorial assistance. Yan Wang and Minhnguyet Le Khorami provided administrative assistance to the AAA. Circle Graphics handled the design and typesetting. Ke Yuan and Sukanya Venkataraman also assisted in the publication process.

This report benefited from the written comments of Vahid Alavian, Julia Bucknall, Mei Xie,

and Susanna Smets (DFID-China), who served as peer reviewers, as well as Jan Bojo, David Dollar, and Lee Travers during the World Bank internal review. It also benefited from discussions with participants of the technical review and consultation workshops held in Beijing in November 2006 and November 2007, in Chongqing City in November 2007, and in Lijiang City in March and November 2007, as well as an international workshop in Beijing in February 2008. In these workshops, a draft of this report or its chapters or background reports were reviewed and discussed.

The participation, support, and guidance received during the preparation of this report are highly appreciated.



Abbreviations

AAA	World Bank's Analytical and Advisory Assistance
ADB	Asian Development Bank
AQSIQ	Administration of Quality Supervision, Inspection and Quarantine, China
BAT	Best available technology
BOD	Biochemical oxygen demand
CAEP	Chinese Academy of Environmental Planning
C-BT	Colorado–Big Thompson Project
CCICED	China Council for International Cooperation on Environment and Development
CIWRHR	China Institute of Water Resources and Hydropower Research
COD	Chemical oxygen demand
COMAH	Control of major accident hazards
CVM	Contingent valuation method
DFID	Department of International Development, United Kingdom
ECMs	Ecological compensation mechanisms
EIA	Environmental impact assessment
EPBs	Environmental Protection Bureaus, China
ESCAP	Economic and Social Commission for Asia and the Pacific, UN
ET	Evapotranspiration
EVW	Economic value of water
FAO	Food and Agriculture Organization, UN
FECF	Forest Ecosystem Compensation Fund
FEEM	Fondazione Eni Enrico Mattei
FYP	Five-Year Plan, China
FYPEP	Five-Year Plan for Environmental Protection, China
FYPNWRD	Five-Year Plan of National Water Resources Development, China
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GoC	Government of China
HAZMAT	Hazardous materials

HRN	Huai River basin, China
IBT	Increasing block tariff
IDWR	Idaho Department of Water Resources, U.S.
IRBM	Integrated river basin management
IWQI	Integrated water quality index
LTO	License to operate
m ³	Cubic meter
MAPP	Major accident prevention policy
MDC	Marginal delivery cost
MEC	Marginal environmental (or external) cost
MEP	Ministry of Environmental Protection (formerly SEPA), China
MHURC	Ministry of Housing and Urban and Rural Construction (formerly MOC), China
MLR	Ministry of Land and Resources, China
MOA	Ministry of Agriculture, China
MOC	Ministry of Construction (now MHURC), China
MOC	Marginal opportunity cost
MOF	Ministry of Finance, China
MOH	Ministry of Health, China
MSDS	Material safety data sheet
MUC	Marginal user/depletion cost
MWR	Ministry of Water Resources, China
NBS	National Bureau of Statistics, China
NCEC	National Chemical Emergency Centre, UK
NCWCD	Northern Colorado Water Conservancy District, U.S.
NDRC	National Development Reform Commission, China
NFPF	National Forest Protection Project
NGO	Nongovernmental organization
NH ₃ -N	Ammonia nitrogen
NIWA	Nanjing Institute for Water Resources and Hydrology
NPC	National People's Congress, China
O&M	Operations and maintenance
OECD	Organisation for Economic Co-operation and Development
PES	Payment for ecosystem services
POPs	Persistent organic pollutants
PPP	Public-Private Partnership
PSB	Public Security Bureau, China
RBMC	River Basin Management Commission
RMB	China yuan renminbi
RMP	Risk management plan
SAWS	State Administration for Work Safety, China
SCCG	The State Council of the Chinese Government
SEA	Strategic Environmental Assessment
SEPA	State Environmental Protection Administration (now MEP)
SLCP	Sloping Land Conversion Program

SO ₂	Sulphur dioxide
TP	Total Phosphorus
TREM	Transport Emergency
TVIE	Township and village industrial enterprise
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WAB	Water Affairs Bureau
WB	World Bank
WHO	World Health Organization
WPPCP	Water Pollution Prevention and Control Plans
WPPCL	Water Pollution Prevention and Control Law
WRI	World Resources Institute
WTP	Willingness-to-pay
WUAs	Water user associations



Executive Summary

For years, water shortages, water pollution, and flooding have constrained growth and affected public health and welfare in many parts of China. Northern China is already a water-scarce region, and China as a whole will soon join the group of water-stressed countries. The combined impact of the widening gap between water demand and limited supplies and the deteriorating water quality caused by widespread pollution suggests that a severe water scarcity crisis is emerging.

China's leadership is aware of the worsening water situation, and is committed to transforming China into a water-saving society. The 11th Five-Year Plan (2006–10) sets a number of policy goals and priorities for water resource management, such as (a) adopting a more unified or better coordinated management system; (b) shifting from supply-side to demand-side management; (c) integrating river basin management with regional management; and (d) establishing a preliminary system of water rights trading.

To date, however, the increasing scarcity of water resources has not been effectively managed. Many national and local water resource management and water pollution control plans have not been fully implemented and many targets, including water pollution investment targets, have not been achieved. The economic costs of water pollution and scarcity are high. Water pollution poses a serious threat to public health and causes major economic and environmental losses, estimated by the Chinese government at the amount equivalent to about 1.7 percent of GDP or more in 2004.

OBJECTIVES AND SCOPE OF THIS REPORT

This report reviews China's water scarcity situation, assesses the policy and institutional requirements for addressing it, and recommends key areas for strengthening and reform. It is a synthesis of the main findings and recommendations from analytical work and case studies prepared under the World Bank Analytical and Advisory Assistance (AAA) program entitled "Addressing China's

Water Scarcity: From Analysis to Action.” These studies focus on several strategically important thematic areas for China where additional research was needed, as identified by the research team and advisory group based on a review of pressing issues. These areas are governance, water rights, pricing, ecological compensation, pollution control, and emergency response.

The approach has been to evaluate Chinese and international experience to identify policy and institutional factors that have proven effective in promoting the adoption of water conservation and pollution reduction technologies. The research was based on literature reviews, qualitative and quantitative policy analyses, household surveys, field trips, and case studies to develop feasible recommendations for a plan of action based on realities on the ground.

CHINA'S EMERGING WATER CRISIS

China's water resources are scarce and unevenly distributed. China's renewable water resources amount to about 2,841 km³/year, the sixth largest in the world. Per capita availability, however—estimated at 2,156 m³/year in 2007—is only one-fourth of the world average of 8,549 m³/year and among the lowest for a major country. While China as a whole is facing serious water stress, its problems are made more severe by the fact that its water resources are unevenly distributed, both spatially and temporally.

China's water resources availability varies greatly over space. The South, with average rainfall of over 2,000 mm/year, is more water-abundant than the North, where rainfall only averages about 200–400 mm/year. Per capita water availability in northern China is only 757 m³/year, less than one-fourth that in southern China, one-eleventh of the world average, and less than the threshold level of 1,000 m³/year commonly defined as “water scarcity.”

The temporal pattern of precipitation further intensifies the uneven spatial distribution of water resources. With a strong monsoonal cli-

mate, China is subject to highly variable rainfall that contributes to frequent droughts and floods, often simultaneously in different regions. While precipitation generally declines from the southeastern coast to the northwestern highlands, it varies greatly from year to year and from season to season. In the Hai and Huai basins, for example, river flows fall to 70 percent of their averages one year in four and to 50 percent one year in twenty. Dry years tend to come in succession, accentuating the water problem.

China's Water Productivity Is Low

China's water productivity of \$3.60/m³ is low in comparison with the average of middle-income (\$4.80/m³) and high-income (\$35.80/m³) countries. This gap is largely due to differences in the sectoral structure and efficiency of water consumption.

Water productivity in agriculture, which accounted for 65 percent of total water withdrawals, is the lowest of all sectors, due to extensive waste in irrigation systems, and suboptimal allocation among crops and between different parts of the same river basin. Only about 45 percent of water withdrawals for agriculture are actually used by farmers on their crops. In industry, which accounts for 24 percent of total water withdrawals, the water recycling level is 40 percent on average compared to 75–85 percent in developed countries.

A major contributor to China's low water productivity is its very inefficient water allocation system. A recent study of the Hai basin has found that water productivity, as reflected by the economic value of water (EVW) in different uses, ranges from 1.0 yuan/m³ in paddy irrigation to 12.3 yuan/m³ in vegetable fields, 21.3 yuan/m³ in manufacturing, and 33.7 yuan/m³ in the services sector. The magnitude of these differences in an extremely water-short region is indicative of a serious lack of market consciousness in the water allocation process.

China's water scarcity is aggravated by extensive pollution. Over the past three decades,

despite great efforts to control it, water pollution has increased, spreading from the coast to inland areas and from the surface to underground water resources. Total wastewater discharges have steadily risen to 53.7 billion tons in 2006. Domestic wastewater discharges have surpassed industrial discharges since 2000, and have become the most important pollution source. It was not until 2007 that the rising trend of water pollution discharges began to show a sign of reverse, as total 2007 COD discharges were reported to be 3.14 percent less than in 2006. However, the water pollution situation is still very serious. A major contributing factor is that only 56 percent of municipal sewage is treated in some form, versus 92 percent of industrial discharges.

Water pollution incidents also represent a serious threat. They overwhelm the already fragile water environment, contaminate downstream drinking water for millions of people, and severely threaten public health and the quality of life.

As a result of continuing pollution, the water quality of most of China's water bodies has been extensively degraded. In 2004, of all 745 monitored river sections, 28 percent fell below the Grade V standard (that is, unsafe for any use), and only 32 percent met Grade IV–V standards (that is, safe for industrial and irrigation uses only). Of 27 major monitored lakes and reservoirs, fully 48 percent fell below Grade V standards, 23 percent met Grade IV–V standards, and only 29 percent met Grade II–III standards (safe for human consumption after treatment).

The extent of pollution aggravates the scarcity of water. At present, approximately 25 km³ of polluted water are held back from consumption, contributing to unmet demand and groundwater depletion. As much as 47 km³ of water that does not meet quality standards are nevertheless supplied to households, industry, and agriculture, with the attendant damage costs. A further 24 km³ of water beyond rechargeable quantities are extracted from the ground, which results in groundwater depletion.

Water Scarcity and Pollution Entail Substantial Costs

The most important costs relate to the health risks associated with polluted drinking water sources. Over 300 million people living in rural China have no access to safe drinking water. The economic cost of disease and premature deaths associated with the excessive incidence of diarrhea and cancer in rural China has been estimated, based on 2003 data, at 66.2 billion yuan, or 0.49 percent of GDP.

Water scarcity is also undermining the capacity of water bodies to fulfill their ecological functions. Due to excessive withdrawals, even a minimum of environmental and ecological flows cannot be ensured for some major rivers in North China. To compensate for the deficit of surface water, North China has increasingly relied on groundwater withdrawals, often in excess of sustainable levels. Such overexploitation has resulted in the rapid depletion of groundwater reservoirs, leading to the lowering of water tables, the drying up of lakes and wetlands, and land subsidence in many cities.

The World Bank's *Cost of Pollution in China* study estimated that the water crisis is already costing China about 2.3 percent of GDP, of which 1.3 percent is attributable to the scarcity of water, and 1 percent to the direct impacts of water pollution. These estimates only represent the tip of the iceberg. They do not include the cost of impacts for which estimates are unavailable, such as the ecological impacts associated with eutrophication and the drying up of lakes, wetlands, and rivers, and the amenity loss from the extensive pollution in most of China's water bodies. Thus, total costs are undoubtedly higher.

A PLAN OF ACTION FOR ADDRESSING WATER SCARCITY

As outlined above, the major factors underlying the emerging water crisis point to the need for China to reform and strengthen its water resource management framework. In line with the

broad strategy of developing a market economy, the focus of the reform needs to be on clarifying the role of and relationships between government, markets, and society; improving the efficiency and effectiveness of water management institutions; and fully embracing and using market-based instruments as much as possible.

On this basis, the following thematic areas were selected for attention: (a) improving water governance; (b) strengthening water rights administration and creating water markets; (c) improving efficiency and equity in water supply pricing; (d) protecting river basin ecosystems through market-oriented eco-compensation instruments; (e) controlling water pollution; and (f) improving emergency response and preventing pollution disasters. The main findings and recommendations are summarized below. The combined set of recommendations, summarized in a table in the final chapter of this report, represents an action plan for addressing China's water scarcity.

IMPROVING WATER GOVERNANCE

To address the growing complexity of water resource management, China is moving from a traditional system with the government as the main decision-making entity toward a modern approach to water governance that relies on (a) a sound legal framework, (b) effective institutional arrangements, (c) transparent decision making and information disclosure, and (d) active public participation.

An Effective Water Governance System Has to Be Built on a Sound Legal Basis

China has made much recent progress in improving its legal framework. Even so, the effectiveness of the legal framework for water resource management is unsatisfactory, as evidenced by the growing seriousness of water-related problems, including rampant water pollution nationwide. Its main weaknesses and areas for improvement are:

Lack of mechanisms and procedures

Existing laws and regulations are usually focused on principles and lack mechanisms and procedures for enforcement, such as supervision, monitoring, reporting, evaluation, and penalties for noncompliance.

Incomplete legal system

The coverage of the existing legal framework is still limited. For example, the Water Pollution Prevention and Control Law requires that the state establish and improve the compensation mechanism for ecological protection of the water environment, but there are no national laws or regulations to support it. Neither is there a law on water rights and trading.

Ambiguities and conflicts between legal provisions

Some laws contain ambiguities. For example, the Water Law does not clearly define the authority of local governments and river basin management commissions (RBMCs). Such ambiguity in the provisions causes a vacuum of authority and weakens the effectiveness of the legal system.

Existing Institutions Are Fragmented and Uncoordinated

China's water resource management system is characterized by extensive fragmentation, both vertical and horizontal. Horizontally, at every level of government several institutions are involved in water management, with frequent overlaps and conflicts of responsibilities. This unwieldy system has increased the administrative cost of coordination among different institutions and undermined the effectiveness of water management.

The water management system is also vertically fragmented. It is mainly built upon the administrative boundaries of different levels of government rather than at the river basin level. Each level of government has its own focal points and priorities. This makes the management of

transboundary rivers—most of China’s rivers—very difficult.

China has established RBMCs for its seven large rivers as subordinate organizations of the Ministry of Water Resources. However, these commissions have limited power and have no representatives from the affected local governments in the basin. As a result, it is difficult for the RBMCs to coordinate with the provinces/municipal administrations and other stakeholders in river basin management.

Transparency Is Limited

Transparency means that the public can have better access to information on water resources, policies, and institutions on water-related issues and water-related behaviors of various stakeholders. The Chinese government has been aware of the importance of transparency and made efforts to increase the openness of public administration, but as of now, information on water quality and quantity, water users, and polluters remains inaccessible to the public and to government agencies outside of the sector.

The legal definition of what information should be disclosed to the public is not clear, so that many organizations or enterprises refuse to disclose water-related information in the guise of protecting state or business secrets. Finally, the citizens’ right of access to information is not emphasized in the laws, so that although several regulations on information disclosure have been promulgated, they are not yet implemented well because of weak supervision by the government and the public.

Public Participation Is Very Low

Public participation is helpful to tailor policy to local situations, to maximize the social welfare and utility of resources use, and to protect vulnerable groups. Major forms of public participation in water management in China are (a) public opinion surveys; (b) public hearings; (c) experts’ assessment/reviews of development plans and

programs; and (d) stakeholder coordination. But actual public participation is still very low, which is attributable to limited awareness by government agencies and the general public regarding the potential for public participation in water management, lax legal requirements and supervision, and legal barriers to the registration and participation of NGOs, which should be expected to play a very active role.

Recommended Actions

Amend and improve existing water-related laws and regulations

Given the vagueness and even contradictions of existing laws and regulations, the NPC should review and revise existing water-related laws, with particular attention to the enforcement issue and integrated water management.

Improve law enforcement

Improving law enforcement is the number one priority to make the legal framework useful and effective. A series of actions need to be taken:

Implementation procedures: Detailed implementation procedures should be stipulated in all water-related laws and regulations to make existing laws and regulations operational and enforceable.

Strengthened supervision and inspection: Supervision and inspection by the national and local congresses and administrative branches should be strengthened.

Public participation: The public should be empowered to help monitor and track down violators and supervise local agencies responsible for law enforcement, and public-private partnerships should be encouraged by laws and regulations.

Establish a national-level organization for integrated water management

One option is to establish a State Water Resources Commission as a coordinating and steering organization on water-related affairs across

the country at the highest level of government. This commission will serve as a high-level water policy-making body, much like the newly established State Energy Commission headed by the premier. Another option would be to merge major water-related duties currently under different government agencies (namely MWR, MEP, MOA, MHURC, and MLR) and establish a new super ministry to implement unified management of water quantity and quality, surface water and groundwater, water resource conservation and use, and water environmental protection.

Convert RBMCs into intersectoral commissions

The existing RBMCs for the seven major rivers should be converted into true intersectoral and intergovernmental “commissions” with representatives from relevant line agencies and local governments, instead of being subordinates of MWR. In the long run, RBMCs should be made independent of MWR and accountable to the State Council directly.

Make public information disclosure a compulsory obligation of the government, companies, and relevant entities

Public information disclosure requirements should be incorporated into all major development strategies, policies, regulations, and operational procedures. The information must be accessible for the public and concerned groups/communities and be made available through multiple channels.

Build a strong legal foundation for public participation

The rights of public participation should be emphasized in relevant laws to empower the public. In such laws as the Water Law and the Environmental Protection Law, articles should be added to explicitly grant rights of participation in water management to the public. Three rights need to be clearly defined: (1) the right of access to information, (2) right of participation in deci-

sion making, and (3) right to challenge water-related decisions by the government.

STRENGTHENING WATER RIGHTS ADMINISTRATION AND CREATING WATER MARKETS

The allocation of water rights and the establishment of water markets can improve the economic efficiency of water use in China and help resolve water shortages. China has been establishing a water rights administration since 2000, and has made remarkable progress in some pilot-ing areas. A preliminary framework of laws, regulations, and institutions on water rights has been developed at the national level. Additional actions are needed to deepen water rights administration and develop water markets.

Water Allocations Exceed Sustainable Levels

At present, there is a general lack of consideration and provision for environmental water requirements, with the result that for many surface water bodies and underground aquifers, water withdrawals are far in excess of sustainable levels. In some instances, water has been set aside for the environment, but these volumes are not allocated on a sound scientific basis. This poses a threat to the long-term health and sustainability of the water resources in question.

Water Rights Are Still Unclear and Unenforceable

Establishing clear, enforceable rights is an essential first step toward the creation of water markets. At present it is not always clear who holds the right and what the right entitles the holder to. There are few rules in place that protect against changes to water rights and no clear provisions dealing with what happens when a right is adversely affected.

Water Rights and Allocations Need to Be Based on the Evapotranspiration Approach

Past water management in China, based on water abstraction only, has encountered only limited success because the saved water was used to irrigate more land; that is, more water was consumed and less water returned to the surface and underground water systems. Recent advancements in remote sensing and geographic information system (GIS) technologies have made it feasible to manage water resources in terms of the amounts of water actually consumed through evapotranspiration (ET). The portion consumed through ET is the consumptive use that is lost and not available for users downstream. In contrast, the portion that returns to the surface or underground water systems is still available for other users downstream. ET technology thus makes it feasible for China to adopt a more scientific approach for its water rights allocation and administration.

Water Rights Administration and Trading Need to Be Strengthened

China still has a distance to go in establishing a well-functioning water rights administration system. First, water rights and water rights trading represent a relatively new concept for water resources management in China, and require reforms in institutions and policies that have been traditionally based on “command-and-control” regulation. Second, implementing tradable water rights requires improvements in the monitoring and information system for decision making and the enforcement of regulations. Third, there is no precedent for implementing tradable water rights in a large developing country like China, with its unique physical, economic, and social background. It is a challenge, but international experience and pilot projects support tradable water rights as a promising approach for China to pursue.

Recommended Actions

Use water resources allocation plans as the basis for water rights

Water resources allocation plans should be developed—first at the basin level, then at the regional level—as the basis for allocating water within a basin. Plans should set a cap for total water abstraction permits in the plan area and clearly identify the water available for abstraction, the amounts of water consumed, and the amounts that must be returned to the local water system.

Recognize ecological limits of water resources

Water resource allocation plans should recognize the requirements of the in-stream environment for water. Water should be set aside for this purpose, recognizing the importance of different parts of the flow regime for different parts of the ecosystem.

Water withdrawal permits need to be clearly specified and implemented

Permits must be specified in volumetric terms and need to be linked to the initial allocation of water established in the water resource plan. The total amount of water withdrawal permits should be limited to the maximum allowable amount based on sustainable water use with sufficient consideration of environmental uses and new water uses.

Strengthen water rights administration and provide certainty and security for holders of water rights

Water rights administration needs to be strengthened, with the conditions, procedures, rights, and obligations for water withdrawal, consumption, and return flows clearly specified. The process for granting water rights, and in particular for allocating water on an annual basis, should be clear and consistent. This will provide certainty and security for holders of water rights.

Adequate monitoring, reporting, and enforcement are part of effective water rights administration. Public participation, such as group participation through water user associations in rural areas, is critical to the success of water rights management.

Where feasible, an ET-based water resource management should be promoted

The ET approach focuses on actual water consumption and hence encourages more efficient use of water, increased return flows, and the adoption of more water-saving technologies. The ET approach can thus help improve the sustainability of the water resource system in both agricultural and urban areas. Governments should promote the ET-based water resource management, especially in water-stressed areas.

Adopt a step-wise approach to water trading

The sale or lease of water rights can be an effective approach for raising the productivity of and returns to water within and between sectors. But before trading starts, the entitlements of users under different levels of resource availability must be clearly defined. Once all stakeholders have gained experience in managing, monitoring, and observing rights, trading options can be explored, often starting with temporary trading in well-defined systems where infrastructure for delivery and monitoring is already in place.

IMPROVING EFFICIENCY AND EQUITY IN WATER SUPPLY PRICING

Traditionally, China's policies have focused on meeting the demand for water by increasing the supply rather than managing demand. An important factor contributing to the current water-scarcity crisis is the lack of effective water resource policies that focus on demand management and encourage efficient water use.

Water Pricing Can Be an Effective Means to Reduce Demand for and Improve the Economic Efficiency of Water Use

The central and local governments in China have recognized this, and allowed water tariffs to gradually rise since the early 1990s. Even so, repeated studies have shown that water and sewerage prices in China are still below the requirements for financial cost recovery and take little account of environmental and depletion costs. This has made it difficult for the water and sewerage utilities to adequately maintain their infrastructure, expand their service to outlying and poorer areas, and operate their infrastructure in a manner that meets environmental standards. Thus, the first step toward setting prices right should be to at least meet the utilities' financial performance requirements.

To Promote Efficient Water Use, Water Prices Also Need to Reflect the Marginal Opportunity Cost of Supply

Prices based on marginal opportunity cost (MOC)—which includes production, environmental, and depletion costs—would signal the full scarcity value of water to the consumer and induce the appropriate adoption of water-saving and efficiency technologies. Current tariff regulations in China already allow all of the components of marginal opportunity cost to be recognized and signaled to the consumer. Production costs are contained in the water development fee, environmental and depletion costs in the water resource fee, and waste disposal in the sewerage fee. But local authorities have been slow to fully implement the necessary tariff increases allowed by regulation, mainly as a result of concerns about the impact on the low-income population.

Equitable and Efficient Tariff Reform Is Feasible

Although often stemming from concern for the well-being of poorer households, low water tariffs have perverse consequences for income distribution. Results from household surveys show that the social impact of low water pricing on the poor is negative; they receive little or no benefit from the water price subsidies, but pay a high price for poor water supply services in terms of health impacts and the high cost of alternatives. On the other hand, tariff reforms can be designed to at least partially protect the poor from the impact of higher rates. Provided the increased revenues are used to extend the service infrastructure and improve the quality of service, a win-win solution can result. In China and other countries, three such approaches have been used: (1) increasing block tariffs (IBT), as already enshrined in Chinese regulations; (2) income support; and (3) price waivers for the poorest households.

Recommended Actions

Given the low efficiency of and high demand for water use, China should aggressively use pricing policy to manage water demand. This means that water tariffs, including wastewater treatment fees, have to continue increasing in the years to come. For pricing reform to be successful, the following recommendations are important.

Adopt a step-wise approach to tariff reform

The public should be fully informed of the problems of low service quality, indirect costs, inefficiency caused by underpricing or subsidization of water, and the importance of water tariff increases. Public hearings, consumer education, and transparency are necessary to overcome resistance to price reform, especially when existing service quality is poor.

Raise water tariffs to fully reflect its scarcity value

While the first step in price reform must be to fully achieve financial cost recovery, pricing of water and sewerage should follow the MOC approach and reflect the incremental costs of water and its disposal, including the costs of environmental damage in production and consumption and the opportunity costs of depletion. A system should be devised in which MOC estimates can be integrated into regional and national water management and economic planning systems so as to enhance the market consciousness of the allocation process while the trading system is being developed.

Address the social impact of tariff increases

The increasing block tariff approach, especially a two-tier tariff structure, is recommended for residential consumers. The first block should follow the WHO-recommended 40 liters per capita per day (i.e., about 5 m³ per month for a household of four), with the second block gradually increasing to full MOC. Other pricing or income support methods for the poor are encouraged to be adopted based on local political and economic circumstances. Water tariffs for commerce and industry should cover the full MOC.

Convert the water resource fee to a tax

The water resource fee, which is currently retained by local governments, provides little incentive for sustainable water resource development basin-wide or at the national level. The fee should be converted into a tax, the proceeds of which will be transferred to and appropriated by the central government. Such a conversion will provide a financial basis for the central government to facilitate more efficient water resource planning based on national priorities for water resource development and management. The funds of local water resource management programs should be de-linked from the revenue of water resource fees and

directly provided by central and local governments through their annual budgets.

PROTECTING RIVER BASIN ECOSYSTEMS THROUGH MARKET-ORIENTED ECO-COMPENSATION INSTRUMENTS

Addressing water scarcity requires protecting the sources of the water, especially the ecosystems in the upper reaches of river basins, such as forests, wetlands, and even agricultural lands. Both central and local governments are increasingly interested in the use of government transfers from public funds—under the name of ECMs—to protect ecosystems in the upper reaches of river basins. But the current approach relies on public financial transfers (mainly from the central government), and lacks a direct link between ecosystem service providers and ecosystem service beneficiaries. This raises some doubts about the long-term financial sustainability and efficiency of ECMs.

Payment for Ecosystem Services (PES) Offer a More Market-Oriented Approach

In a PES system, a market for environmental services is created whereby money is collected or reallocated from the beneficiaries who use environmental services (water consumers) and payments are made directly to those who provide these services (such as watershed land managers). PES offers a more market-oriented and self-financing alternative to the government-funded ECMs currently used in China.

PES Has Been Tested in Other Countries and Has Great Potential in China

PES has been developed and implemented in other countries with encouraging results and can be applied in China, as illustrated by the case

study of the Lashihai Nature Reserve in Lijiang City, Yunnan Province. While PES schemes are not a universal panacea, nor always easy to introduce, they should be treated as one step forward to enhance and complement existing efforts of ecosystem conservation in China.

Recommended Actions

Continue to expand the application of ECM

Given the urgency of protecting ecosystems in the upper reaches of river basins for water supply, China should continue to expand its ECM programs, especially when the ecosystem service providers and beneficiaries are distant from one another and their links cannot be explicitly defined, or where there are obvious poverty alleviation benefits.

Promote the piloting of PES

To improve the efficiency and effectiveness of ecological compensation and reduce the financial burden on governments, China should vigorously pilot more market-oriented approaches for ecological compensation, such as PES. It has much appeal in China and should be piloted and promoted, beginning with some small watersheds.

CONTROLLING WATER POLLUTION

The government has acknowledged the seriousness of water pollution and placed it at the top of pollution problems facing the country. Since the mid-1990s, COD reduction has been one of two major nationwide total emission control targets (the other is SO₂). Even so, total COD emissions have increased since the early 1990s, largely due to an increase in emissions of untreated municipal wastewater. In spite of over a decade of effort, it was not until 2007 that the rising trend in total COD discharges appears to have finally been reversed.

There Is Inadequate Investment in Water Pollution Control and a Large Amount of Wastewater Is Still Untreated

The investment shortfall contributed to the failure to meet pollution control targets—such as reducing COD discharge by 10 percent by the end of 2005—and to environmental deterioration. With insufficient investment, wastewater treatment capacity, including sewerage networks, has not expanded adequately, especially in small cities and townships. As a result, only 56 percent of the 53.7 billion tons of domestic wastewater discharged is treated in some form; the rest is still discharged without any treatment, offsetting the significant reduction in industrial pollution.

Many Water Pollution Prevention and Control Plans Have Failed to Achieve Their Objectives

China has prepared water pollution prevention and control plans at the national, local, and river basin levels. So far, many of these plans have failed to achieve their targets. For example, the Huai River basin was the first river basin in China to undertake a major planning effort for water pollution control. Evaluation of the first two five-year plans (1996–2005) found that the water quality and total emission control targets were not achieved. For instance, the 9th FYP's (1996) water quality target for 2000 was to achieve Class III for the entire main stream. However, by 2005, the water quality at 80 percent of monitoring sites in the basin was still at Class IV or worse.

Serious Water Pollution Is Attributable to Institutional and Policy Shortcomings

The effectiveness of pollution control is constrained by several issues: (a) poor law enforce-

ment and compliance; (b) failure to implement water pollution prevention and control plans; (c) lack of incentives for wastewater treatment; (d) a wastewater discharge control system undermined by problems with the issuance of permits, and their monitoring and enforcement; (e) lack of integrated river basin management and weak local commitment to pollution control under the influence of local and sectoral interests; (f) increasing and unchecked pollution from townships and nonpoint sources; and (g) insufficient and spatially imbalanced investment in wastewater treatment.

A Number of Issues Deserve Greater Scrutiny

Some of these issues include carefully defining the objectives of the Water Pollution Prevention and Control Law; providing more reliable and complete information on pollution sources; emphasizing the linkage between water pollution and unsafe drinking water sources; integrating pollution control measures, especially the use of permit systems; strengthening the deterrent function of current legislation and enforcement systems for managing water pollution; promoting routine pollution prevention over after-incident treatment; and addressing the relationship between the polluter-pays principle and government responsibility at the regional and national level, especially in those areas where governments have some responsibility due to their past activities.

Recommended Actions

The key to controlling and solving serious water pollution in China is the strengthening of law enforcement to improve compliance by industries and other polluters. The government has to use all available means—legal, institutional, and policy—and, through them, mobilize the public and motivate the private sector to ensure full compliance with all pollution control requirements. Specific recommendations are provided below.

Improve pollution control planning

Water pollution control planning in river basins should be improved, with the introduction of more realistic and tangible targets. Pollution control should not be regarded as the final target, but the way to achieve a clean and healthy water environment. This requires a long-term, integrated, but progressively targeted strategy for the protection of water quality. The financing, implementation, monitoring, and evaluation mechanisms should be well-embedded in the plans.

Unify and strengthen the pollution monitoring system

Better monitoring capability is required for the whole range of measures required for effective pollution control. The current segmented water monitoring system—involving MEP, MWR, and MHURC—has to be reformed. In the short term, the systems should be better coordinated, with a unified set of monitoring criteria and procedures for releasing water quality information in one channel. In the medium term, the different monitoring systems can be consolidated and managed by a third entity independent of any single ministry.

Strengthen the wastewater discharge permit system

To be effective, the wastewater discharge permit system should be built on a more solid legal basis, with a special administrative regulation issued by the State Council. The issuing of permits has to be technically sound and based on environmental quality, with daily maximum levels of discharge specified in order to achieve ambient targets. It should target key pollutants first and aim to control the total pollution load within the allowed pollution carrying capacity of the environment.

Increase reliance on market-based instruments

Pollution control efforts should take full advantage of market mechanisms to overcome market

failures in pollution reduction. Economic incentive measures (such as the pollution levy and fines) have to be rigorously enforced to provide a strong incentive for polluters to comply with emissions standards and other environmental requirements. The upper limits of maximum fines specified in current laws should be increased. Furthermore, the system of trading of water discharge permits should be gradually introduced in watersheds to improve the economic efficiency of wastewater treatment.

Enable litigation for public goods

The litigation system should be used to give more protection to the public interest. The law should encourage or require local governments on behalf of the public to initiate lawsuits against polluters and demand full compensation for damage to public goods—for example, to ecosystems—where damage to individuals is hard to identify. For significant cases, MEP itself might be the plaintiff.

Control rural pollution

Attention should be given to addressing rising water pollution in small towns and rural areas. The regulation of industrial and municipal sources in small towns and rural areas should be carried out by local EPBs and supervised by MEP. With regard to wastewater, sewage treatment in small towns should be promoted through the introduction of cost recovery policies, selection of efficient technologies, and the reuse of treated water for irrigation.

Increase financing for market gap areas

There are several areas where market-based approaches cannot be expected to effectively address, for which the central government needs to earmark special budgets with which to finance water pollution prevention and control. These areas include: (1) transprovincial pollution control and management, (2) important ecological regions and water sources, (3) dealing with accidents affecting international water bodies, and

(4) other issues with a national dimension that cannot be properly managed at the local level.

IMPROVING EMERGENCY RESPONSE AND PREVENTING POLLUTION DISASTERS

Despite some successful recent cases of environmental emergency response, the high frequency of serious pollution incidents and their associated costs in China support the need for continued reform and strengthening of existing institutions for environmental pollution emergency prevention and response. Current practice in emergency management still suggests that the main focus of local governments has been on mitigation after an incident. But prevention of incidents by strict enforcement of appropriate policies and regulations is typically a more cost-effective approach and should be emphasized. A situation analysis shows that the problem is attributable to various factors, ranging from weak legal and institutional arrangements, lack of incentives, and poor chemical management systems to inadequate on-site coordinating, monitoring, and reporting.

Based on lessons from the international experience, the basic elements of an effective prevention and response system, as already developed and implemented in many developed countries, include (a) a shift from mitigation to a focus on risk assessment, prevention, and planning; (b) enhancing the preparedness of first responders; (c) rigorous implementation of the polluter-pays principle to shift financial responsibility for the costs of potential disasters to polluters, (d) the establishment of chemical information management systems to track the flow of toxic chemicals and provide the necessary information for a quick and effective response if an accident occurs, and (e) effective public information systems to provide timely information in the event of an emergency.

Recommended Actions

Shift from mitigation to prevention and planning

Environmental protection and work safety agencies should be the competent authorities to approve the adequacy of environment and safety risk assessment, applying a thorough risk management approach that focuses on both prevention and mitigation of the impacts of chemical incidents. All high-hazard plants—regardless of age—should be subject to risk assessment and be required to prepare an emergency response plan.

Enhance preparedness

First responders should be well trained for handling chemical incidents and equipped with the mandate and resources to contain pollution releases. The National Chemical Registration Center and its regional offices should establish a unit, independent from enforcement divisions, to provide 24-hour technical support to the emergency services on the properties and appropriate responses to specific chemical releases from a safety and environmental perspective.

Establish an environmental disaster fund through the implementation of the polluter-pays principle

An environmental disaster fund with sufficient revenue to support such activities as information management, training, and clean-up for environmental incidents should be established. Funds could be raised through an increase in the pollution levy and/or the introduction of environmental taxes on toxic chemicals. In addition, increased fines for pollution accidents to cover the cost of clean-up and compensation should be considered another source for the fund.

Establish a chemical management information system

The central government should establish and maintain comprehensive inventories of all chemicals and pollution sources containing information

consistent with international standards. The function and effectiveness of the two existing systems developed by SAWS and MEP separately should be reviewed. Inventories should be consistent, comprehensive, and easily used in public emergency prevention and response. A comprehensive labeling system for chemicals should be established and applied to all parts of the production, storage, and transportation process.

Strengthen monitoring and public information

In the event of an incident, local environment and safety authorities should establish appropriate additional monitoring to assess the impact on the health and safety of the local communities and the environment. Investigation findings should be reported to the central authorities, and a mechanism established to share lessons learned and introduce new legally binding practices and procedures if necessary. The public has the right to be informed of the final investigation results.

ISSUES FOR THE FUTURE

While this report has addressed a number of critically important issues relating to water resource management in China, much work remains to be done. The various studies identified a number of areas where further work is required. Some of these issues for the future—relating to agricultural water, climate change, and strategic assessment and economic analysis for river basin plans and programs—are highlighted below.

Water Efficiency, Food Security, and Rural Development

The case studies have revealed great variations in the economic value of water by sector and by region, low economic efficiency of agricultural water use, and poor cost-effectiveness of underground water withdrawal in North

China. Although the general direction should be to raise water-use efficiency by reducing demand for water by the agricultural sector, progress is complicated by and associated with various issues involving the rights and well-being of the rural population, national food security, agricultural sector protection, and poverty alleviation. The central issue is how to reduce rural poverty and secure the nation's food supply while at the same time improving the efficiency of water use. This issue will require further study.

Climate Change Adaptation

Global warming caused by human activities can be one of the biggest threats to the natural environment and human well-being. The scarcity and vulnerability of China's water system can be negatively affected by climate change, and remedial and adaptation measures need to be taken to ameliorate these effects. How to fully take into account climate change impacts and mainstream adaptation measures in the institutional and policy reform of water resource management in China is an issue for further investigation.

Ecological and Economic Studies of River Basins

Effective application of water management measures—such as water pricing, water allocation and water rights administration, ecological compensation, and water quality management in a river basin—all depend on good analysis and understanding of the ecosystems and the economic value of competing water uses, such as agriculture, energy, municipal water supply, and flood control in the river basin. In many cases, the important analytical work remains to be done. Developing a sophisticated analytical system—using advanced economic, geographic, and ecological tools—is required for sound policy making.

Development Strategies, Policies, and Plans and Their Long-Term Impacts on Water Scarcity

China's Environmental Impact Assessment Law, effective in 2003, required strategic environmental assessments (SEAs) for regional and sectoral development plans. These include land use, water resource management, and water pollution control plans for river basins. However, such SEAs have rarely been carried out due to the lack of knowledge, expertise, and capacity of planning agencies and local environmental bureaus and research institutes. As a result, the long-term impacts of these plans on water scarcity conditions and the natural environment are in question. This situation has to be changed.

CONCLUDING REMARKS

There is no doubt that China is facing a major challenge in managing its scarce water resources to sustain economic growth in the years ahead. This is a daunting task for the Chinese leadership, but past experience in China and in other countries provides some lessons as to the way ahead. Of course, China is unique in many ways, and will have to adapt techniques and policies developed elsewhere to suit its own circumstances. But there are grounds for optimism; the Chinese, who have demonstrated immense innovative capacity in their successful program of economic reform, can and should take another bold move in reforming the institutional and policy framework to make it become a world leader in water resource management.



Introduction

BACKGROUND

For years, water shortages, water pollution, and flooding have constrained growth and affected public health and welfare in many parts of China. Given continuing trends in economic and population growth, as well as the current pattern of industrialization and urbanization, the pressures on the country's water resources are bound to increase. The impact of growing water demand—combined with limited supplies and the deteriorating water quality caused by widespread pollution—suggests that a severe water scarcity crisis is emerging if no decisive actions are taken soon.

China's per capita natural freshwater resources amounted to 2,156 m³ in 2007, and are expected to decline to 1,875 m³ as its population rises to a projected peak of 1.5 billion by around 2033.¹ In North China, the amount is already much lower, at about 700 m³ per person, and the amount of exploitable water is much smaller. The scarcity is greatest in the Hai River basin, with 120 million inhabitants, including Beijing and Tianjin, which has only about 300 m³ per person. Based on standard definitions, North China is already a water-scarce region, and China as a whole will soon join the group of water-stressed countries.² Specifically, about 400 of China's 660 cities are reportedly short of water; of those, 108 cities, including megacities like Beijing and Tianjin, are facing serious water shortages.³

In addition to scarcity, China's water resources are poorly managed. They are generally characterized by inefficient and outdated practices, unsustainable groundwater depletion, excessive water pollution, and extensive degradation and destruction of aquatic ecosystems. In 2006, China's total annual discharge of municipal and industrial wastewater reached 53.7 billion tons, of which only 56 percent had some form of treatment.⁴ Although the treatment rate has steadily increased in recent years, there is still a huge amount of wastewater discharged directly to the environment without any treatment. Nonpoint pollution, mainly from fertilizer and pesticide runoff and livestock

waste, represents an increasing and essentially uncontrolled factor. As a result, water quality remains a serious concern, especially in northern China due to the shortage of water flows to dilute pollution loads.

The costs of water scarcity and pollution are high. Water pollution poses a serious threat to public health and causes major economic and environmental losses. A recent study (World Bank 2007a) estimated the cost of water scarcity associated with water pollution at 147 billion yuan, or about 1 percent of GDP, and the cost of health-related impacts in rural areas at 1.9 percent of rural GDP in 2003. MEP estimated the cost of environmental degradation caused by water pollution in 2004 at about 1.7 percent of GDP. Surface water overexploitation has resulted in the drying up of lakes and wetlands, as well as insufficient environmental flows, including outflows to the seas. Groundwater overexploitation is leading to the annual lowering of water tables and the eventual exhaustion of groundwater reservoirs, as well as extensive subsidence in many major cities.

China's leadership is aware of the worsening water shortage, and is committed to transforming China into a water-saving society. This is expressed in recent development plans, decrees, and circulars. For instance, the 11th Five-Year Plan (FYP) (2006–10) for National Social and Economic Development sets the goal that water consumption for agricultural irrigation is to remain constant, and puts stress on water-saving technology innovation in water-intensive sectors to reduce water consumption per unit of industry-added value by 30 percent. The State Council's Guidelines on Deepening Reform of the Economic System (2005) specified that the government would address China's water scarcity by (a) reforming resource pricing systems, (b) expanding the collection of user fees for water resources, (c) strengthening the implementation and supervision of water tariffs and sewerage charges, (d) studying the establishment of a national system of water rights, (e) improving

the water exploitation permit system, (f) exploring the possibility of establishing water markets, (g) piloting a compensation system for transfer of water rights, and (h) gradually adopting market mechanisms for optimal allocation of water resources.⁵ The Government of China (GoC) has been actively seeking technical assistance from the international community to strengthen its policy and institutional framework for water resource management.

OBJECTIVES AND SCOPE

The objective of this report is to provide an overview of China's water scarcity situation, assess the policy and institutional requirements for addressing it, and recommend key areas for strengthening and reform. The report synthesizes the main findings and recommendations from analytical work and case studies prepared under a World Bank-funded Analytical and Advisory Assistance (AAA) program entitled "Addressing China's Water Scarcity: From Analysis to Action." Components of the AAA program are summarized in Box 1.1. The target audience for this synthesis report includes officials of relevant agencies, state leaders, interested professionals, and the general public.

The scope of water scarcity issues in China encompasses both qualitative and quantitative aspects. The qualitative aspects—protecting the sources of water supply—include environmental and ecological services required to ensure adequate water for the protection of wetlands, lakes, and environmental flows; water pollution management; and groundwater protection. The quantitative aspects—improving the efficiency of water use—include demand management measures (such as water pricing, permits, water rights, and trading); compensation for ecological conservation and services; social affordability; and improvements in water conservation and productivity.

Within this broad scope, the study focuses on several thematic areas that are strategically

BOX 1.1 The World Bank’s Analytical and Advisory Assistance Program—“Addressing China’s Water Scarcity: From Analysis to Action”

To seek international assistance in strengthening water resources management, several Chinese ministries requested the Bank’s analytical and advisory assistance, particularly in water policy and institutional reforms and the sharing of international experience. In response to the request, the World Bank launched an Analytical and Advisory Assistance (AAA) project—the China Water AAA—in fiscal 2006.

The broad objective of the China Water AAA is to assist the Chinese government to develop, adopt, and implement policy and institutional reforms needed to more effectively address China’s water problems. Building on a large number of existing and ongoing studies on water issues in China and on international experience, the China Water AAA concentrates on helping the responsible agencies develop and implement policy and institutional reforms needed to improve the sustainable management of the country’s water resources. The major tasks of the AAA were undertaken in three phases—diagnostic evaluation, thematic studies, and synthesis of recommendations.

In light of the magnitude of water issues and the limited resources and time available, the AAA program did not intend to be a comprehensive study, but focused on selected areas where more analysis was needed to improve the understanding of policy and institutional issues, and to recommend specific actions to address them. In relation to the earlier studies supported by the Bank and others, the main value added by this AAA program has been in (a) filling gaps in our understanding of strategically important water issues, and (b) engaging key government agencies, especially high-level policy makers and other stakeholders, to raise awareness of these issues and build a consensus on priority actions.

The AAA benefits from the participation and support of various Chinese and international institutions, including research institutes, universities, and civil society groups, and the U.K. Department of International Development (DFID), which provided both technical and financial support.

important and feasible for China. These areas—identified by the research team based on a review of pressing issues and government priorities—include water institutions and governance, water rights, the economic valuation of water, water supply pricing and social affordability, watershed ecological compensation, and water pollution control and emergency prevention. Other important areas, such as water use in agriculture, and water utilities’ regulation and performance, were omitted because they have been covered in previous work. Some relevant studies conducted by the World Bank are described in Box 1.2.

Case studies and reviews of international experience have been carried out around each theme in order to develop policy recommendations based on realities on the ground. The case studies cover the economic valuation of water in the Hai River basin, the Songhua River toxic chemical spill

incident, willingness-to-pay (WTP) and water tariff reform in Chongqing, water tariff reform and income impacts in Beijing, water rights in the Hai River basin, and the ecological compensation mechanism in Lijiang City of Yunnan Province. To diagnose the problems of plan implementation, we evaluated water pollution control planning in the Huai River basin. A set of background papers on international experience was also produced. A list of case studies and reports is provided at the end of the report.

CONCEPTUAL FRAMEWORK AND APPROACH

The conceptual framework in Figure 1.1 identifies the main water issues, water resource management components, and the interaction

BOX 1.2 Recent Water Resource Management Studies at the World Bank

Water resource management in China has been the subject of considerable attention by international development institutions. This study, which elaborates on selected topics, complements several reports and publications issued by the World Bank in recent years.

Several of these reports have addressed strategic and policy issues related to environmental management and water resources management. For example, *Clear Water, Blue Skies: China's Environment in the New Century* (World Bank 1997) estimated the costs of water pollution and the benefits of an adequate water supply in terms of productivity and health and set out general policies for sustainable use of water resources, with much emphasis on the polluter-pays principle. More recently a report entitled *Cost of Pollution in China: Economic Estimates of Physical Damages* (World Bank 2007a) estimated environmental damage costs for air and water pollution at 5.8 percent of GDP.

Much of the analytical and policy work done in the World Bank has focused on the allocation of water among competing water uses, particularly the institutional and economic means of addressing this issue. The *Agenda for Water Sector Strategy for North China* (World Bank 2002b), a comprehensive analytical study of water resource management, covered water scarcity, flooding water for agriculture, water pollution, groundwater, and water management institutions in the Huang-Huai-Hai River basins of the North China Plain, the dominant agricultural area of the country. The report outlined an action plan and provided an indicative assessment of investment needs.

China, Air, Land, and Water—Environmental Priorities for a New Millennium (World Bank 2001a) also dealt extensively with water resource management and water pollution. This study formed the basis for the World Bank's *Water Resources Assistance Strategy for China* (World Bank 2001b). Key findings stemming from this work included the importance of institutional reform, including the development and enforcement of detailed policies/regulations and management. Much emphasis was given to improved multipurpose basin management, as well as water rights issues and economic incentives, such as pricing of irrigation and municipal water and enforcement of the polluter-pays principle. Such findings were reinforced in *China Water Quality Management: Policy and Institutional Considerations* (World Bank 2006a).

Alongside its China-specific policy analysis, the World Bank has continued to develop policy recommendations on a worldwide basis, with considerable attention paid to the agriculture sector—the major water user in most countries. Comprehensive treatment of this topic is to be found in the report *Re-engaging in Agricultural Water Management: Challenges, Opportunities and Trade-offs* (World Bank 2005b).

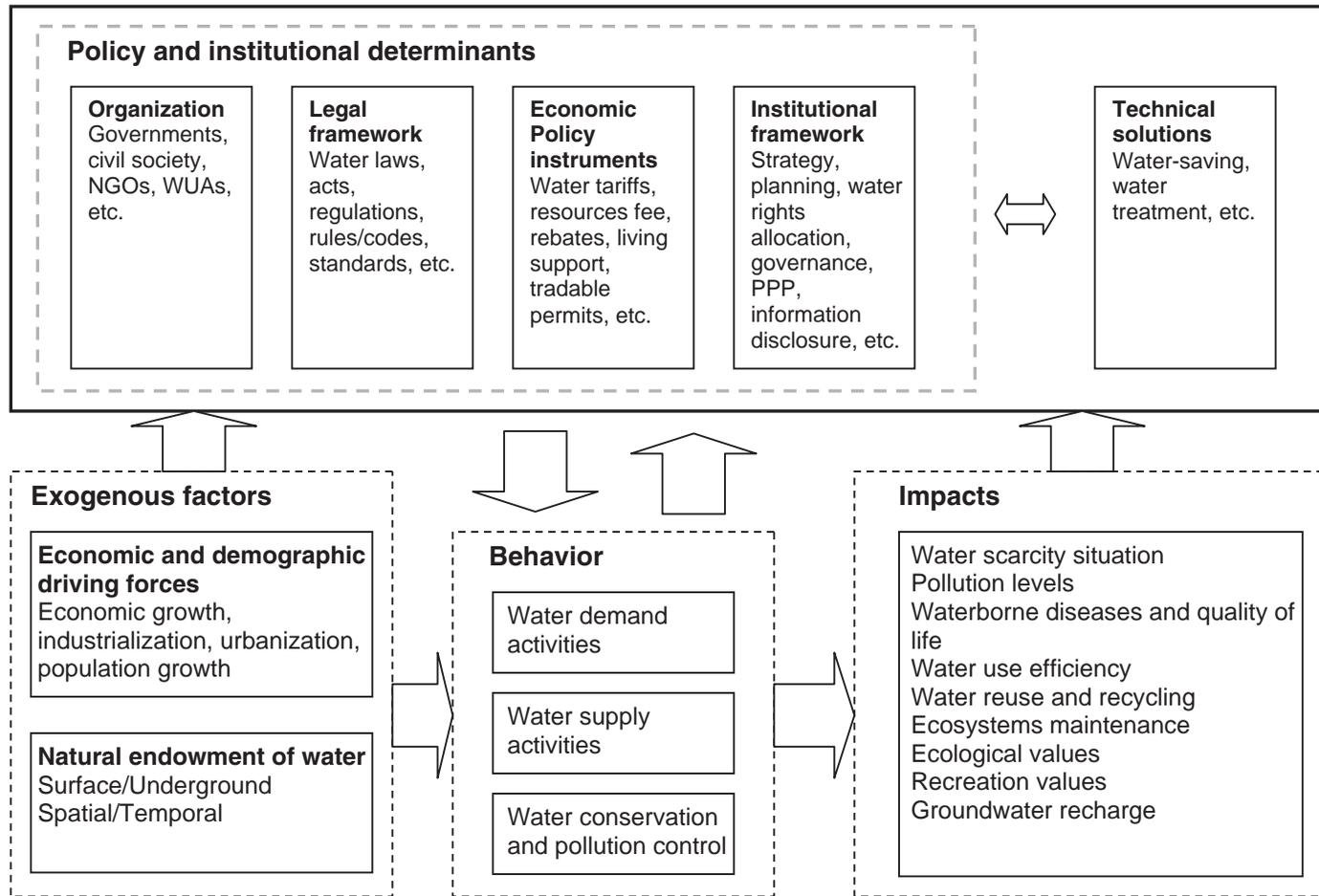
As in the case of agriculture, pricing and other strategic issues for urban water and sanitation have traditionally been addressed in the context of individual projects, as well as in a growing number of research and policy papers. *Addressing China's Growing Water Shortages and Associated Social and Environment Consequences* (Shalizi 2006) addresses the interface between property rights and water pricing. The importance of cost recovery and other policy, regulatory, and institutional issues for urban water utilities was also addressed in *Stepping Up: Improving the Performance of China's Urban Water Utilities* (World Bank 2007b). The focus of this report is fairly narrow, since it does not fully consider the implications of increasing water scarcity or environmental costs for water pricing, and in particular on how efficient pricing can be reconciled with the need to ensure adequate service for poor households.

between them, using a pressure-state-response framework.

In this study, external economic and demographic conditions—such as population, economic growth, industrialization, and urbanization—are largely exogenous, and so is the distribution of water resources, which is

largely determined by precipitation and runoff patterns. For example, the supply of water is determined by existing rainfall patterns. Thus climate change and its impacts, while admittedly human-induced, are treated as exogenous for the purposes of this study. In addition, given the current state and economics of sea-

FIGURE 1.1 Water Resource Management



Source: Authors.

Note: PPP = public-private partnership.

water desalination and artificial rainmaking technologies, they can only be expected to play a minor role in enhancing China's freshwater resources. The demand for water is driven by economic and demographic forces that, for the purposes of this study, are treated as exogenous.

Balancing the supply and demand for water will essentially depend on behavioral choices that determine the efficiency of water use and the extent of pollution. In other words, technology, investment, and operational decisions made by farmers, enterprises, and other water users and polluters are based on a calculus that takes all costs and benefits into account, to the extent that they (the economic actors) are aware of them and are given the correct incentives to do so.

Water resource management has policy, institutional, and technical dimensions. Although technologies such as those for water-saving and pollution control are critical to water management, they are not highlighted in the analysis. Rather, this study focuses on the policy and institutional framework for water resource management, which has a major influence on decisions made by water users and polluters. For example, the design of specific water and effluent pricing mechanisms can greatly influence the costs and benefits of alternative water saving, treatment, recycling, and reuse technology choices and stimulate their adoption (or not), with attendant impacts on future evolution of water-use efficiency and pollution control.

This study further identifies organizations, the legal framework, policy instruments, and the institutional framework as four major elements of water resource management. These are treated as determinant variables in the analysis, since the government can influence their design and operation. Organizations include governmental bodies, civil society, grass-roots associations, and NGOs. The legal framework includes water laws, acts, regulations, rules, and standards. Policy instruments include economic incentives—such as prices, taxes, subsidies, and tradable permits—as well as regulatory instruments. The institutional

framework covers a wide range of institutional measures, from planning to governance.

Given this conceptual framework, the study seeks to evaluate Chinese and international experience with water resource management and water pollution control in order to identify policy and institutional models that have proven effective in promoting the adoption of water conservation and pollution reduction technologies. The research used a mix of methods, including literature reviews, qualitative and quantitative policy analyses, household surveys, field trips, and case studies. Surveys on water use and willingness to pay at the household level were conducted by research teams in case studies in Chongqing City, the Huai River basin, the Hai River basin, and Lijiang City, Yunnan. Detailed policy analyses were conducted for each thematic area, including evaluation of the implementation of water plans in representative regions.

The study has taken a cross-sectoral, multi-stakeholder approach through collaboration and partnership with various government agencies, research institutes, and donor agencies. Some of the case studies and thematic research directly involved World Bank teams responsible for lending projects in Chongqing, Yunnan, and Shandong provinces, and supported the preparation and implementation of those projects. Outside the Bank, studies were done in partnership with relevant central and local government agencies, top research Chinese institutes and universities, and NGOs. The study also built on synergies with programs of other Chinese and international groups and benefited from a strong partnership with the DFID China Program and the participation of international consulting service groups in Italy, Japan, and other countries.

OUTLINE OF THE REPORT

The report contains ten chapters. Following this introductory chapter, Chapter 2 reviews the water scarcity situation in China, from water shortages to water pollution and external driving forces.

Chapter 3 examines water resource management in China, focusing on institutional and policy issues and possible areas of improvement. Chapters 4 to 9 then discuss selected areas of water resource management and make policy recommendations. Chapter 4 discusses governance issues, with policy recommendations relating to legal frameworks, organizations, information disclosure, and public participation. Chapter 5 discusses water rights administration and trading. Chapter 6 addresses water supply tariff reform, emphasizing the need to recover environmental and depletion costs and to protect the poor. Chapter 7 promotes market-based ecological compensation mechanisms in river basins by introducing a new market-based approach of payments for ecosystem services. Chapters 8 and 9 address water pollution control and the prevention of water pollution incidents, respectively. Chapter 10 contains concluding remarks.

Endnotes

1. The per capita number for China in 2007 is calculated based on data available from the 2007 *Little Green Data Book* published by the World Bank. The per capita number for 2033 is calculated by dividing China's total freshwater resources, which, is 2812.502 km³, according to the *Little Green Data Book*, by the projected population peak of 1.5 billion by 2033, which is available from the State Population Development Strategy Report, published by the National Population and Family Planning Commission of China in 2007 and available at http://www.chinapop.gov.cn/gxdd/t20070111_172058513.html.
2. UNDP, UNEP, the World Bank, and the World Resources Institute define water stress as annual water availability of 2,000 m³/person or less, and water scarcity as 1,000 m³/person or less. See Shalizi 2006.
3. See Chinese Academy of Hydraulic and Hydropower Research 2004.
4. The wastewater discharge rate is reported in SEPA 2007. The treatment rate is an official figure in the report of the Implementation of the 2006 National Plan of Economic and Social Development submitted by the National Development and Reform Commission (NDRC) to the National People's Congress (NPC) at the 5th Plenary of the 10th NPC on March 5, 2007. The treatment rate may reflect the installed wastewater treatment capacity rather than the actual treatment, which is likely lower due to the lack of sewage networks and funds for operation and maintenance in many cities.
5. Please see the State Council document at http://news.xinhuanet.com/newscenter/2005-04/17/content_2841603.htm.

Water Scarcity in China

Current Situation

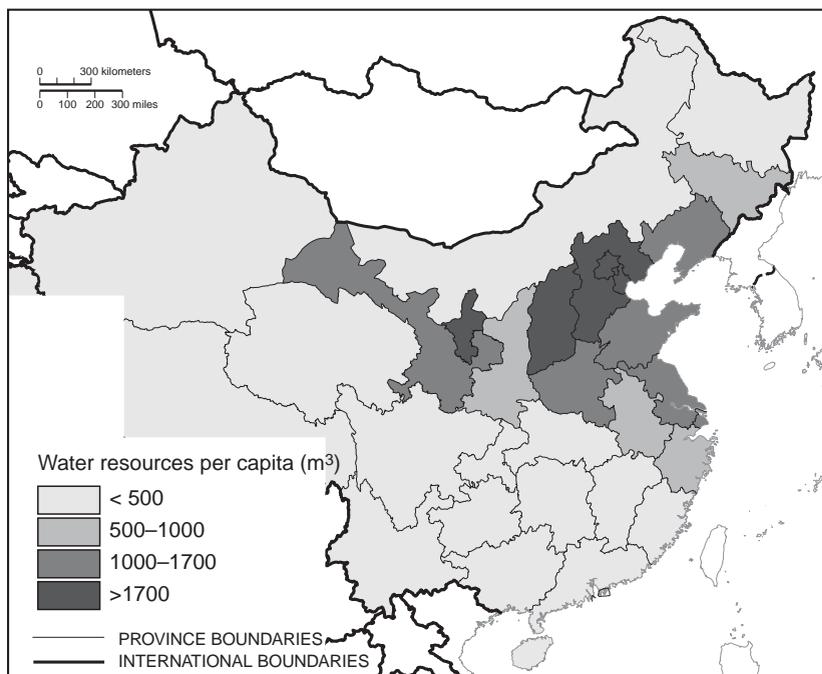
This chapter provides an overview of water scarcity in China and its long-term implications for sustainable development. It first discusses China's natural endowment of water, and points to its uneven distribution in spatial and temporal terms as an important contributing factor in the nation's severe water scarcity, particularly in northern China. The next sections discuss the extent of water pollution, which exacerbates water scarcity, and the environmental, economic, and social impacts of water scarcity, which undermines the long-term sustainability of development. The chapter then examines such external factors as economic growth, industrialization, urbanization, and population growth, which drive the increasing demand for water. While these factors are clearly subject to policy influence, they will be treated as exogenous for the purposes of this study.

SPATIAL AND TEMPORAL DISPARITIES

China's total annual renewable water resources amount to about 2,812 km³, the sixth largest in the world. Its annual per capita freshwater resources, however—about 2,156 m³ in 2007—are among the lowest for a major country.¹ In 2005, China's total consumption withdrawals were 563 km³. Surface water accounted for 81.2 percent of withdrawals, groundwater for 18.4 percent, and 0.4 percent came from other sources.² While China as a whole is a water-stressed country, the severity of the problem is greatly worsened by the uneven distribution of the resource, both spatially and temporally.

Water availability in different parts of China varies greatly due to characteristics of its climate and topography (Figure 2.1). Overall, southern China is much more water abundant than the northern part. This spatial disparity does not match the distribution of China's population, arable land, and productivity. For example, in 2000 southern China (the Yangtze River basin and areas to its south) accounted for 80.4 percent of the nation's naturally available water resources, 53.5 percent of its population,

FIGURE 2.1 Spatial Distribution of Annual per Capita Water Resources in China



Source: The World Bank (2007a).

35.2 percent of its arable land, and 54.8 percent of its GDP. Northern China accounted for only 19.6 percent of naturally available water resources, 46.5 percent of the population, 64.8 percent of the arable land, and 45.2 percent of China’s GDP (Liu 2002).

In a few important basins, water scarcity is even more serious than for North China as a whole (Table 2.1). In the Huang (Yellow)-Huai-Hai river basins (the so-called 3-H basins), 34.7 percent of China’s population has access to only 7.6 percent of China’s naturally available water resources. The annual per capita level of naturally available water resources in the 3-H area ranges from 358 m³ in the Hai-Luan basin to 750 m³ in the Huang basin, far below the “scarcity” level of 1,000 m³ as defined by international organizations.³ In the Hai River basin, where Beijing and Tianjin are located, only 1.5 percent of China’s water resources

are available to support 10 percent of the total population and 11 percent of the total arable land.

The temporal pattern of precipitation further intensifies the uneven spatial distribution of water resources. With a strong monsoonal climate, China is subject to highly variable rainfall that contributes to frequent droughts and floods, often simultaneously in different regions. In the Yangtze River basin, there has been a severe flood roughly every 10 years for the past 2,000 years. While precipitation generally declines from the southeastern coastline to the northwestern highlands, annual precipitation varies greatly from year to year and from season to season. In the Hai and Huai basins, for example, river flows fall to 70 percent of their averages one year in four and to 50 percent one in twenty, and dry years tend to come in succession, accentuating the water problem (Berkoff 2005).

TABLE 2.1 Spatial Distribution of China's Water Resources and Other Social Variables

Basin	(1) Mean Annual Surface Runoff (km ³ , %)	(2) Groundwater (km ³ , %)	(3) Total Annual Water Resources ^a (km ³ , %)	(4) Population (millions, %)	(5) Arable Land (million hectares, %)	(6) Annual per Capita Water Resources (m ³)
<i>North</i>	334.3 (12.3)	168.9 (20.3)	405.4 (14.4)	520.5 (44.4)	57.4 (59.5)	778.9
Song-Liao	165.3 (6.1)	62.5 (7.5)	192.8 (6.9)	113.2 (9.6)	19.5 (20.2)	1703.2
Hai-Luan	28.8 (1.1)	26.5 (3.2)	42.1 (1.5)	117.6 (10.0)	10.8 (11.2)	358.0
Huai	74.1 (2.7)	39.3 (4.7)	96.1 (3.4)	190.5 (16.2)	14.7 (15.2)	504.5
Huang	66.1 (2.4)	40.6 (4.9)	74.4 (2.6)	99.2 (8.4)	12.4 (12.9)	750.0
<i>South</i>	2260.8 (83.4)	591.7 (69.3)	2276.6 (80.9)	627.4 (53.5)	33.5 (34.8)	3628.6
Yangtze	951.3 (35.1)	246.4 (29.7)	961.3 (34.2)	402.5 (34.3)	22.9 (23.8)	2388.3
Pearl	468.5 (17.3)	111.6 (13.5)	470.8 (16.7)	141.5 (12.1)	6.5 (6.7)	3327.2
Southeastern	255.7 (9.4)	61.3 (7.4)	259.2 (9.2)	65.1 (5.6)	2.4 (2.5)	3981.6
Southwestern	585.3 (21.6)	154.4 (18.6)	585.3 (20.8)	18.3 (1.6)	1.7 (1.8)	31983.6
Inland	116.4 (4.3)	86.2 (10.4)	130.4 (4.6)	24.7 (2.1)	5.4 (5.6)	5279.4
TOTAL	2711.5 (100)	828.8 (100)	2812.4 (100)	1172.6 (100)	96.4 (100)	2398.4

Sources: Columns (1–3) adapted from Ministry of Water Resources and Electric Power of China. 1997. "Use of Water Resources in China" (cited in UN Economic and Social Commission for Asia and the Pacific (ESCAP). 1997. "Study on Assessment of Water Resources of Member Countries and Demand by User Sectors: China—Water Resources and Their Use." Bangkok: UN. Columns 4 and 5 are from Nanjing Institute for Water Resources and Hydrology (NIWA) and China Institute of Water Resources and Hydropower Research (CIWRHR). 1998. "Water Demand and Supply in China." Beijing: China Water and Power Press.

a. The sum of water resources from surface water and groundwater may exceed the total water resources by the amount of overlap between them, since surface water interacts with groundwater, with the river base flow formed by groundwater and part of groundwater recharge coming from percolation of surface water.

Climate change is also aggravating water scarcity. Over the past 100 years, inter-regional differences in precipitation have increased, with rainfall gradually declining in North China at rates of 20–40 mm/decade, and rising in South China at rates of 20–60 mm/decade. Over the past 20 years, main stream water flows have declined by 41 percent in the Hai River basin, 15 percent in the Huang River basin, 15 percent in the Huai River basin, and 9 percent in the Liao River basin (NDRC et al. 2007). According to the *National Report on Assessment of Climate Change*—which was jointly issued in December 2006 by six governmental institutions, including the Ministry of Science and Technology and the Chinese Academy of Sciences—it is estimated that average nationwide temperatures will increase by 1.3 to 2.1°C by 2020, 1.5 to 2.8°C by 2030, and 2.3 to 3.3°C

by 2050, as compared to 2000. While the total annual precipitation will increase to some extent, higher evaporation together with spatially uneven distribution of the precipitation will certainly worsen the already serious water scarcity situation, especially in North China. For the 3-H basins, the current water shortage—about 30–40 km³ per year (NDRC et al. 2007)—is projected to rise to 56.5 km³ by 2050 unless effective measures are taken to reduce demand and to augment supply (World Bank 2002b).

WATER POLLUTION

The scarcity of water in China is aggravated by extensive pollution from industrial, domestic, and agricultural sources. Over the past three decades, despite great efforts to control it, water pollution has increased, spreading from inland

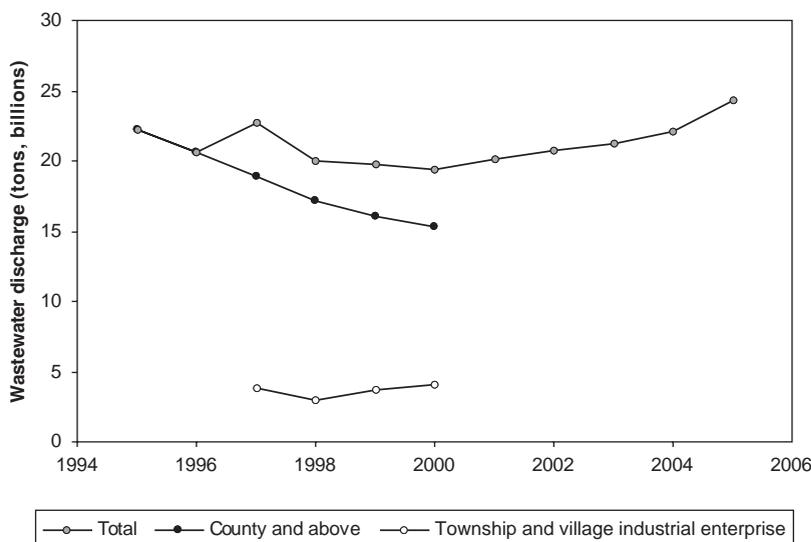
water bodies to inshore coastal areas, and from surface waters to groundwater resources. Total wastewater discharges have steadily risen to 53.7 billion tons in 2006, with COD discharges and NH₃-N discharges amounting to 14.28 million and 1.41 million tons, respectively (SEPA 2007b). It was not until 2007 that the rising trend of water pollution discharges began to show a sign of reverse, as total 2007 COD discharges were reported to be 3.14 percent less than in 2006. However, the water pollution situation is still very serious due to the high volume of untreated wastewater discharged to the environment.

Following a decreasing trend during the period from 1995 to 2000, industrial wastewater emissions increased annually during 2000–05 (Figure 2.2). This increase is attributed to an increase in wastewater discharges from township and village industrial enterprises (TVIE) that offset a decrease in wastewater discharges from county and above-county-owned enterprises.⁴ Although the proportion of total wastewater discharges that meet pollution emission standards is increasing,

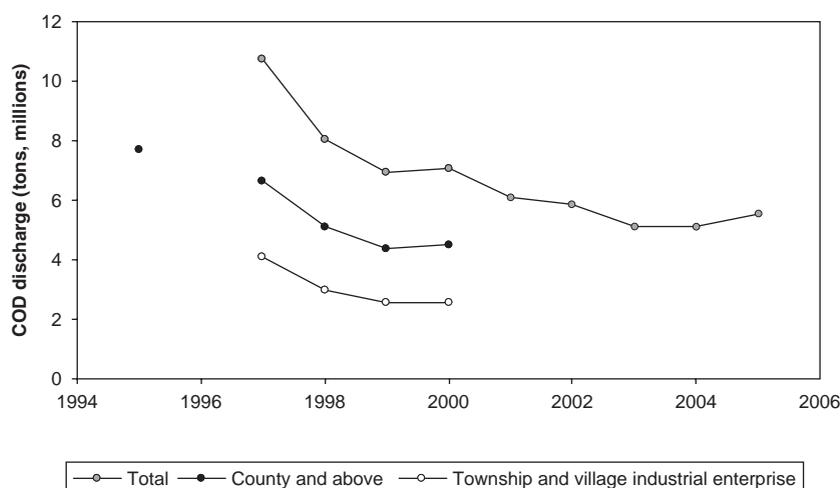
wastewater from TVIEs is still largely discharged without treatment.⁵ Industrial COD discharges, which decreased in 2001–04 due to an increasing share of industrial wastewater that is treated (from 85.2 percent in 2001 to 90.7 percent in 2004), also increased slightly in 2005 (Figure 2.3) (*China Statistical Yearbook 2006*). However, with the rapid growth of domestic and nonpoint pollution discharges, the share of industrial wastewater in total water pollution has decreased. As of 2005, only 11 percent of organic pollutants (biochemical oxygen demand [BOD]), 4 percent of total nitrogen (TN), and 2 percent of total phosphorus (TP) pollution in China were attributable to industrial wastewater discharges (World Bank 2006a).

Domestic wastewater discharges have surpassed industrial discharges since 1999, and have become the most important pollution source (Table 2.2). A major contributing factor is that only 56 percent of municipal sewage is treated in some form. With lagging growth in wastewater treatment facilities, including sewerage, about

FIGURE 2.2 Industrial Wastewater Discharge, 1995–2005



Source: China Statistical Yearbook (various years).

FIGURE 2.3 Industrial COD Discharge, 1995–2005

Source: China Statistical Yearbook (various years).

20 billion m³ of untreated wastewater per year is directly discharged into water bodies. In 2005, domestic sources accounted for 52 percent of BOD, 69 percent of TN, and 2 percent of TP discharges.

Nonpoint pollution (NPP), primarily related to agricultural activities such as fertilizer and pesticide run-off from farmland and infiltration of livestock waste, has long been out of control and is becoming an increasingly important source. Over

the 1978–2004 period, fertilizer applications in China increased fivefold, and pig, sheep, and “other livestock” (including cattle, horses, donkeys, and camels) production increased by 54 percent, 86 percent, and 62 percent, respectively. These trends contributed greatly increased nutrient flows into water bodies, and accelerated the eutrophication of many of China’s lakes, such as Dianchi, Lake Chao, and Lake Tai (World Bank 2006a). By 2005, nonpoint pollution accounted

TABLE 2.2 Wastewater and Pollutant Discharges, 2000–05

Year	Wastewater (tons, billions)			Chemical Oxygen Demand (tons, thousands)			Ammonia Nitrogen (tons, thousands)		
	Total	Industrial	Domestic	Total	Industrial	Domestic	Total	Industrial	Domestic
2000	41.52	19.42	22.09	14450	7045	7405	1252	413	839
2001	43.29	20.26	23.03	14048	6075	7973	1288	421	867
2002	43.95	20.72	23.23	13669	5840	7829	1297	404	893
2003	46.00	21.24	24.76	13336	5119	8217	1330	422	908
2004	48.24	22.11	26.13	13392	5097	8295	1495	522	973
2005	52.45	24.31	28.14	14141	5547	8594	-	-	-

Source: NDRC et al. 2007.

for an estimated 37 percent of BOD, 27 percent of TN, and 45 percent of TP discharges in China.⁶

Water pollution incidents represent a serious threat for water resources. According to the *China Statistical Yearbook*, there were 752 water pollution-related incidents in 2004 and 693 in 2005. These numbers are probably on the low side because polluters and some local officials tend not to report environmental accidents. In recent years, some major water pollution incidents occurred, including the well-known Songhua River pollution incident in November 2005, which interrupted drinking water supply to millions of households. Other major recent examples include the release of toxic smelting waste into the Bei River (in the Pearl River basin) in December 2005; the release of cadmium-containing wastewater into the Xiang River (in the Yangtze River basin); and a diesel-oil spill into the Huang (Yellow) River in January 2006. These incidents have badly damaged the already fragile water environment, contaminated downstream drinking water supplies for tens of thousands of people, and severely threatened public health and the quality of life.

As a result of continuing pollution, the water quality of most of China's water bodies has been extensively degraded. In 2006, of all 745 monitored river sections, 40 percent met the grades I–III surface water quality standard (that is, water that is safe for human consumption after treatment), 32 percent met grades IV–V standards (that is, safe for industrial and irrigation use), and 28 percent failed to meet grade V+ (that is, unsafe for any use). Of 27 major monitored lakes and reservoirs, only 29 percent met the grades I–III standard, 23 percent met grades IV–V standards, and 48 percent failed to meet grade V+ (SEPA 2007b). Water quality in China's lakes and reservoirs is characterized by accelerated eutrophication as a result of excessive nutrient loads from both point and nonpoint sources. Overall, 57.5 percent of the 40 main freshwater lakes—including Lake Tai, Lake Chao, and Dianchi—have become eutrophic and hypertrophic (Table 2.3).

Since the early 1990s, overall water quality in China does not seem to have changed much, with increases in the shares of both good quality and poor quality river sections, and a decrease in the share of medium quality sections (Figure 2.4). However, regional trends were quite different, with significant improvements in the South, except for some rivers (Figure 2.5, right), contrasting with some deterioration in the North (Figure 2.5, left). At the river basin level, the percentage of poor quality sections increased in all five major northern rivers between 2000 and 2004, while all rivers—except the Yangtze in southern China—experienced increases in the proportion of water classified as good quality for the same period (Figure 2.6).

In spite of these differences, water quality degradation is also a threat to water supply in southern China, where many cities face a supply crisis due to heavy pollution. Shanghai is a good example. Located downstream of the Yangtze River and the Lake Tai basin, Shanghai is seriously impacted by both upstream and local water pollution. According to data from the local environmental protection bureau, only 1 percent of its surface water meets the standard for drinking water (grades I–III), while the percentage of poor quality water (worse than grade V) is as high as 68.6 percent. Zhejiang Province faces the same problem; that is, an abundance of water that is unusable rather than unavailable.

Groundwater is also polluted by wastewater discharges from industrial, municipal, and agricultural sources. In about 50 percent of all regions, shallow groundwater is polluted. In about 50 percent of the cities, groundwater is suffering from quite serious pollution.⁷

ENVIRONMENTAL AND SOCIAL IMPACTS AND ECONOMIC LOSS

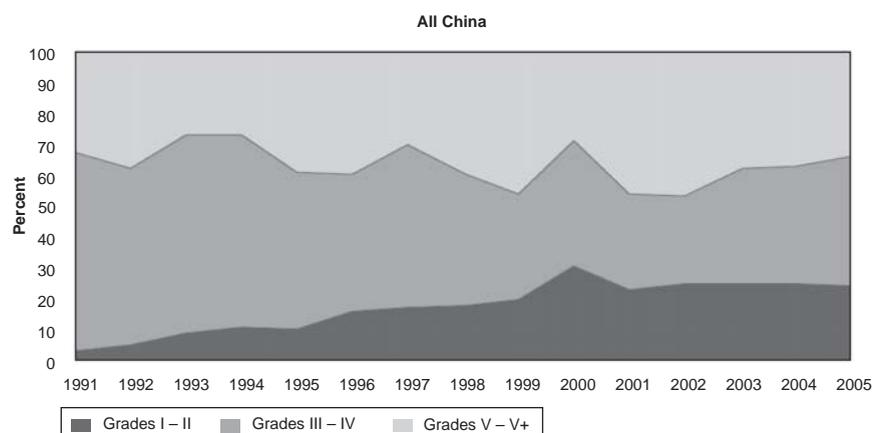
Water scarcity and extensive pollution entail substantial environmental and social impacts and economic losses, which threaten sustainable development.

TABLE 2.3 Current Trophic Level of Lakes and Reservoirs in China

Lakes	Year	Water Quality Parameter		Trophic State
		Total Phosphorous (mg/liter)	Total Nitrogen (mg/liter)	
Five Big Lakes				
Poyang	2000	0.102	0.862	Mesotrophic-eutrophic
Dongting	2001	0.336	0.89	Eutrophic
Tai	2001	0.126	3.24	Eutrophic
Hongze	2004	0.103	1.906	Eutrophic
Chao	1999	0.193	2.96	Eutrophic
Urban Lakes				
Cibi (Dali)	2003	0.016	0.39	Mesotrophic
Xi (Hangzhou)	2003	0.17	3.06	Eutrophic
Dong (Wuhan)	2001	0.125	2.5	Eutrophic
Xuanwu (Nanjing)	2003	0.478	3.5	Eutrophic
Gantang (Jiujiang)	2003	0.24	1.73	Eutrophic
Nan (Changchun)	2003	0.529	5.45	Eutrophic
Lu (Guangzhou)	2003	0.22	3.04	Eutrophic
Xi (Huizhou)	2003	0.124	0.83	Eutrophic
Haixihai (Dali)	2003	0.033	0.28	Mesotrophic
Reservoir				
Miyun	1990	0.018	0.115	Mesotrophic
Dahuofang	1988–91	0.06	1.09	Mesotrophic-eutrophic
Yuqiao	1999	0.14	2.5	Eutrophic
Guanting	2000	0.047	2.92	Eutrophic
Shanzai	2001	0.05	0.27	Mesotrophic-eutrophic

Source: Jin et al. 2005.

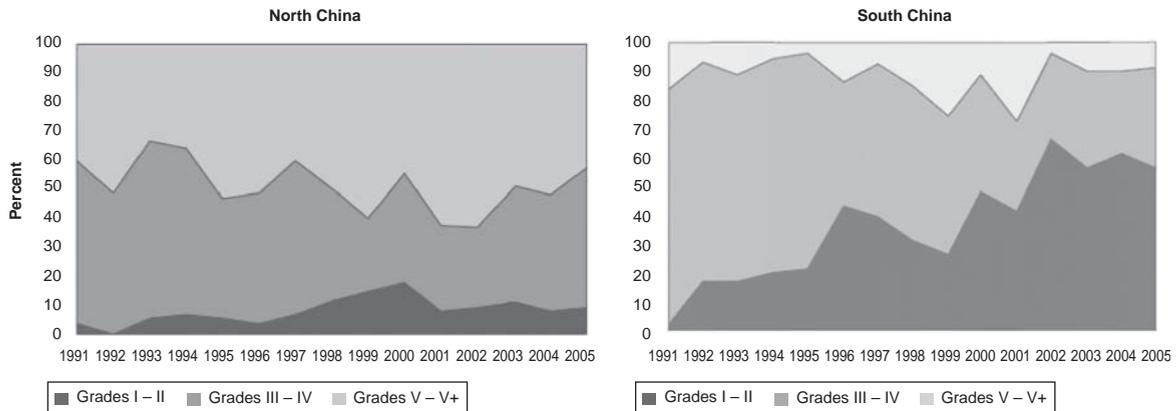
FIGURE 2.4 Trends in Water Quality at Monitored River Sections in China, 1991–2005



Source: World Bank (2006a).

Note: Grades I–III refer to water that is safe for human consumption after treatment; grades IV–V refer to water that is safe for industrial and irrigation use; and grade V+ refers to water that is unsafe for any use.

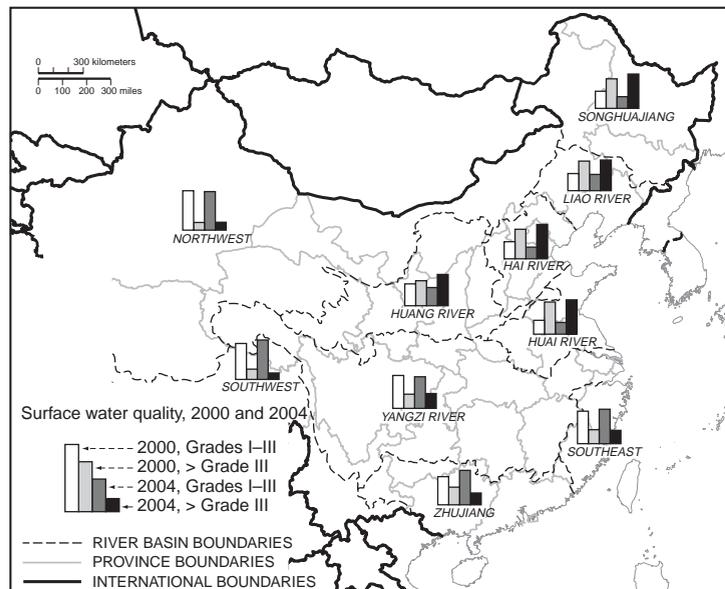
FIGURE 2.5 Trends in Water Quality Changes at Monitored River Sections in North and South China, 1991–2005



Source: World Bank (2006a).

Note: Grades I–III refer to water that is safe for human consumption after treatment; grades IV–V refer to water that is safe for industrial and irrigation use; and grade V+ refers to water that is unsafe for any use.

FIGURE 2.6 Surface Water Quality, 2000 and 2004



Source: World Bank 2006a.

Water scarcity is undermining the capacity of water bodies to fulfill their ecological functions. Due to excessive withdrawals, even a minimum of environmental and ecological flows cannot be ensured for some rivers in northern China. For example, water withdrawal rates in the Huang River can reach up to 90 percent in dry years, with the river running dry before reaching the sea (WRI 2001). In some years in the 1990s, water flows at the deltas of the Hai and Huang (Yellow) rivers averaged about 15 km³ less than the amount required to transport silt and to maintain estuarine and coastal environments (World Bank 2002b). The duration of low flows in these rivers increased from 40 days in the early 1990s to 200 days in 1997. In recent years, the situation has improved because of relevant policy actions such as the Regulation on Water Volume Control for the

Huang River, which has been enforced since August 1, 2006.

Excessive pollution also results in groundwater depletion. As much as 24 km³ of water beyond rechargeable quantities is extracted from the ground, leading to a lowering of water tables and eventual exhaustion of groundwater reservoirs, as well as extensive subsidence in many cities. In northern China in 2005, 63.3 percent of water supply was from surface water, and 36.3 percent (over one-third) from groundwater, equivalent to withdrawal rates of 47.1 percent and 53.5 percent, respectively (Table 2.4). In the Hai River basin, groundwater accounted for 66.7 percent of water supply and was being withdrawn from the aquifer at a rate of 95.5 percent. To compensate for the deficit of surface water in meeting demand, northern China has increasingly relied on groundwater.

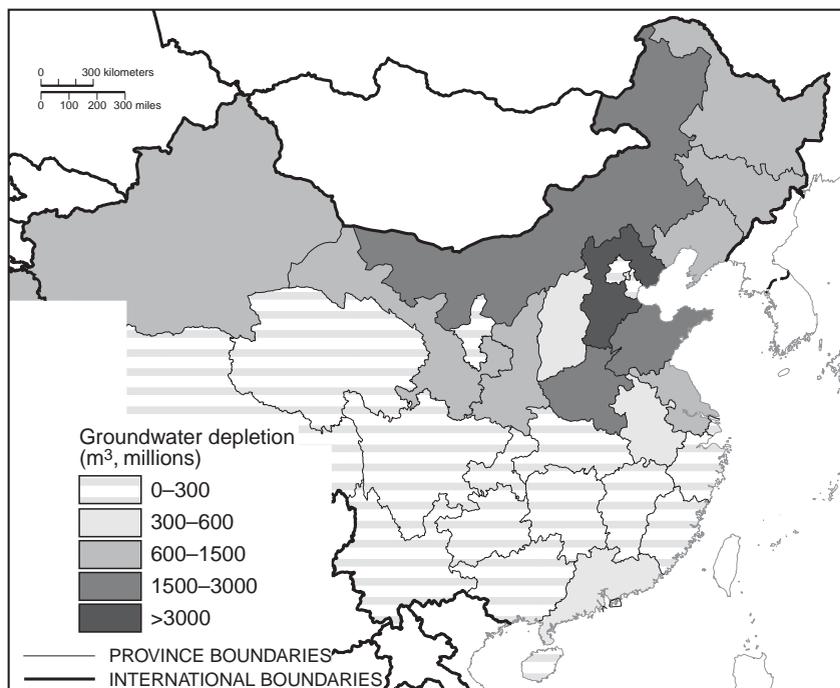
TABLE 2.4 Water Supply and Renewable Water Resources in China, 2005

Basin	Water Supply (km ³ , %)			Average Annual Renewable Water Resources (km ³)			Intensity of Water Use (%)		
	Surface	Ground-water	Total	Surface	Ground-water	Total ^a	Surface	Ground-water	Total
<i>North</i>	157.6 (63.3)	90.4 (36.3)	249.1 (100)	334.3	168.9	405.4	47.1	53.5	61.4
Song-Liao	30.4 (53.4)	26.4 (46.4)	56.9 (100)	165.3	62.5	192.8	18.4	42.2	29.5
Hai-Luan	12.3 (32.3)	25.3 (66.7)	37.9 (100)	28.8	26.5	42.1	42.7	95.5	90.0
Huang (Yellow)	24.5 (64.2)	13.3 (34.9)	38.2 (100)	66.1	40.6	74.4	37.1	32.8	51.3
Huai	38.5 (70.8)	15.8 (29.0)	54.4 (100)	74.1	39.3	96.1	52.0	40.2	56.6
<i>South</i>	299.6 (95.3)	13.5 (4.3)	314.3 (100)	2260.8	591.7	2276.6	13.3	2.3	13.8
Yangtze	175.6 (95.3)	8.0 (4.3)	184.2 (100)	951.3	246.4	961.3	18.5	3.2	19.2
Pearl	83.0 (95.0)	4.1 (4.7)	87.4 (100)	468.5	111.6	470.8	17.7	3.7	18.6
Southeast	31.2 (96.0)	1.2 (3.6)	32.5 (100)	255.7	61.3	259.2	12.2	2.0	12.5
Southwest	9.9 (96.9)	0.3 (2.9)	10.2 (100)	585.3	154.4	585.3	1.7	0.2	1.7
Northwest	52.0 (84.3)	9.6 (15.5)	61.7 (100)	116.4	86.2	130.4	44.7	11.1	47.3
TOTAL	457.2 (81.2)	103.9 (18.4)	563.3 (100)	2711.5	828.8	2812.4	16.9	12.5	20.0

Sources: Water supply data is from CAS (2007) for year 2005. Data on average annual renewable water resources is from a comprehensive assessment of national water resources by the Nanjing Institute of Hydrology and Water Resources in 1995–96.

a. Surface water and groundwater are interrelated, and therefore, the total amount of water resources may be smaller than the sum of surface water and groundwater.

FIGURE 2.7 Groundwater Depletion by Province (million m³)



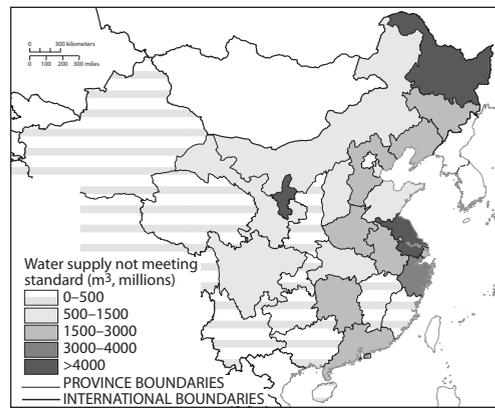
Source: Adapted from World Bank (2007a), which was originally from Ministry of Water Resources.

Such excessive overexploitation of groundwater resources (Figure 2.7) has resulted in the lowering of water tables and the rapid depletion of groundwater reservoirs. For example, the annual sustainable supply of groundwater in the Hai River basin is estimated at about 17.3 km³, while withdrawals were 26.1 km³, which indicates an annual overextraction as high as 8.8 km³. As a result, deep groundwater tables have dropped by up to 90 meters, and shallow groundwater tables by up to 50 meters (World Bank 2002b). In Beijing, groundwater tables have dropped by 100 to 300 meters (World Bank 2002b).

The depletion of groundwater resources is contributing to the drying up of lakes and wetlands and an increase in groundwater salinity, which occurs when seawater intrudes or when declin-

ing groundwater resources are substituted by brackish water that often lies between the shallow and deep groundwater tables (Zhu 2006). In some locations, intrusion of brackish water has been monitored at a rate of 0.5 to 2 meters per year for the past 20 years (Foster et al. 2004). Sea water intrusion has occurred in 72 locations along coastal provinces, covering an area of 142 km² (World Bank 2002b).

When groundwater is depleted, the aquifer is compacted, causing the land above it to subside. Subsidence of up to several meters has been observed in cities like Beijing, Tianjin, Taiyuan, Shijiazhuang, and Shanghai, causing damage to buildings and bridges, and even the collapse of construction projects (Shalizi 2006). Direct impacts of subsidence include reduced capacity

FIGURE 2.8 Polluted Water Supplies in China

Source: Adapted from WB (2007a) with data from the Ministry of Water Resources.

for flood protection and waterlogging in urban areas due to less effective drainage (World Bank 2002b). The compaction of groundwater aquifers also destroys their storage capacity, and with it their ability to serve as a strategic reserve for dry years. In some areas, the destruction of aquifers is already worsening the impact of droughts and desertification.

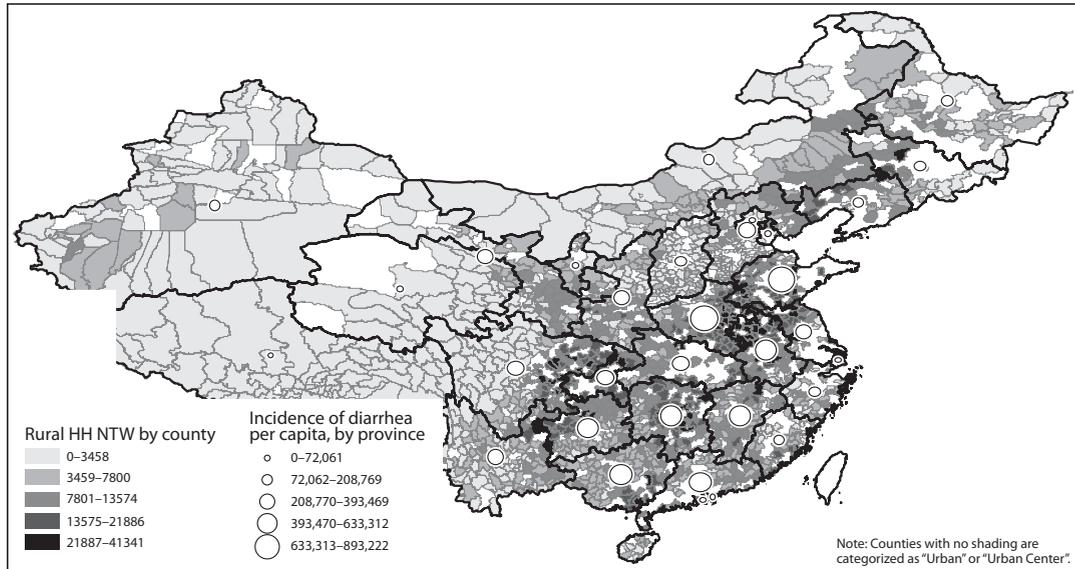
Water scarcity and water pollution have important social impacts. The most important relates to the health risks resulting from polluted drinking water sources. According to a national survey, about 25 percent of over 1,000 source areas of drinking water nationwide do not meet the national standard (Sheng 2005). In rural areas, about 300 million people rely on unsafe drinking water, of which 190 million drink water with unhealthy levels of hazardous materials, 63 million with high concentrations of fluorine, and 38 million with salty water (Sheng 2005). Figure 2.8 shows polluted surface and groundwater supplies for domestic use. During 2000–03, 47 m³ of water that did not meet the Grade III standard (of being safe for human consumption after treatment) were used for water supply, which was close to 10 percent of the average national

domestic water supply (World Bank 2007a). Some studies found significant correlations between the level of coliform bacteria in drinking water and the incidence rates of diarrhea, and between the integrated water quality index (IWQI) and incidence rates of typhoid/paratyphoid and diarrhea for both men and women (Pan and Jiang 2004). The lack of access to piped water has been associated with a 26 percent increase in diarrhea in children under five years of age (Figure 2.9). As Figure 2.10 shows, the mortality rates for liver and stomach cancer in China are well above the world average, while the mortality rates for liver, stomach, and bladder cancer were highest in rural areas.

The social impacts of water pollution become most prominent during pollution emergencies. This is exemplified by the Songhua River incident and the more recent water crisis in Wuxi City (Box 2.1).

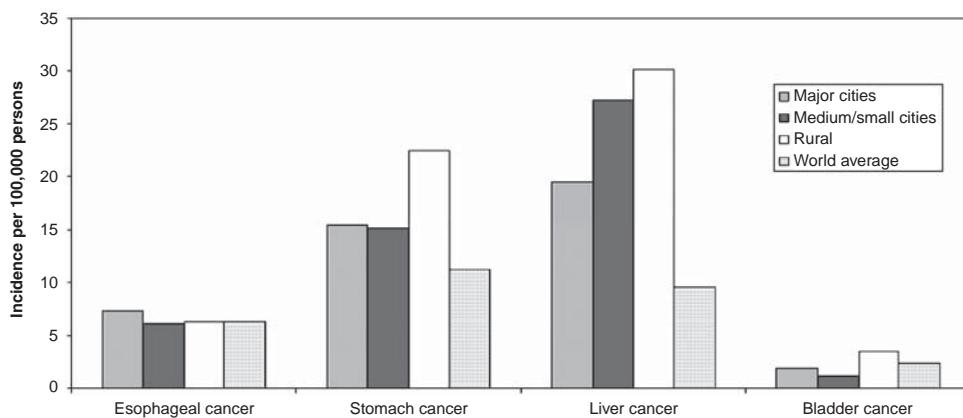
Water scarcity and pollution have caused tremendous economic losses in China. The economic cost of the disease and deaths associated with the excessive incidence of diarrhea and cancer in rural China has been estimated, based on 2003 data, at about 66.2 billion yuan, or

FIGURE 2.9 Rural Households with No Access to Piped Water and Diarrhea Incidence



Source: World Bank (2007a).

FIGURE 2.10 Mortality Rate for Cancer Associated with Water Pollution (1/100,000) in China, 2003 (world Average in 2000)



Source: World Bank 2007a.

BOX 2.1 Water Crisis in Wuxi in 2007

Wuxi, a typical city in eastern China, has long relied on Lake Tai as its source for water supply. Since the 1980s, rapid industrialization and urbanization have accelerated the eutrophication process of Lake Tai, which historically has been a major recipient of abundant agricultural fertilizer, pesticides, and livestock wastes. In May 2007, there was a sudden large-scale algae bloom, resulting in an intolerable odor in the local public water supply. Approximately 70 percent of local water supply became unusable, severely affecting the water use of 2 million people.

about 0.49 percent of GDP. These costs are underestimated, since they do not include many health impacts associated with water pollution, such as those associated with chemicals known to cause cancer but without sufficient data to determine a dose-response relationship (World Bank 2007a).

Another important cost results when wastewater (that is, water below Grade V standards for irrigation) is used to irrigate crops. About 4.05 million hectares, or 7.4 percent of the nation's irrigated lands, are irrigated with polluted water; two-thirds of this land are in northern China. This leads to reduced harvests, poor quality crops, and degraded quality soils. The economic loss attributed to these impacts has been estimated at about 61.3 billion yuan, equivalent to about 0.46 percent of GDP in 2003.

Water pollution also has an important impact on fisheries. Fishery losses due to acute pollution accidents amounted to over 4.3 billion yuan in 2003. While not insignificant (this figure is equivalent to 0.03 percent of GDP), these figures greatly underestimate the total fishery loss due to pollution, since chronic pollution costs are not included in the estimate and are likely to be much higher (World Bank 2007a). There are also major impacts on aquatic, coastal, and marine ecosystems, which are not included in the estimate.

In addition to direct impacts, pollution compounds the scarcity of water. This imposes significant costs on all productive sectors, especially agriculture. China depends on 55 million hectares of irrigated lands for about 80 percent of total grain output. Of these, about 20 million hectares are suffering from water deficiency, and an additional 7 million hectares cannot be irrigated at all, largely because of a shortage of 25 km³ of polluted water that cannot be used. The economic cost of water held back from supply has been estimated at 85.4 billion yuan, or about 0.64 percent of GDP, based on a scarcity value of water from 2.1 to 5.2 yuan/m³ (He and Chen 2005). The economic cost of groundwater depletion has been estimated at 92.3 billion yuan, equivalent to 0.69 percent of GDP, based on the scarcity value of water (World Bank 2007a).

Overall, water scarcity is constraining the long-term sustainability of development. The above estimates suggest that the external cost of water already amounts to about 2.3 percent of China's GDP, of which 1.3 percent is attributable to the scarcity of water, and 1 percent to the direct impacts of water pollution. These estimates only represent the tip of the iceberg. They do not include costs where data are unavailable, such as the avoidance and treatment costs incurred by individual households and enterprises; the ecological impacts associated with eutrophication and the drying up of lakes, wetlands, and rivers; and the amenity loss of extensive pollution in most of China's water bodies. Thus, the actual cost can be much higher.

EXTERNAL DRIVING FORCES OF WATER PROBLEMS

While natural conditions are important, China's water resource issues can be largely attributed to human-related activities. The increasingly serious water problems are embedded in the process of development and transformation in China over the past three decades. Such factors

as economic growth, industrialization, urbanization, and continuous population expansion constitute the driving forces of China's water problems.

Since the late 1970s, when China began its economic reform and opening-up, it has been among the fastest growing economies in the world, with an average annual growth rate of more than 9 percent (*China Statistical Yearbook 2006*). Its economy, however, remains largely based on extensive use of natural resources. Partly because of China's low water productivity—at \$3.6/m³, lower than the average of middle-income (\$4.8/m³) and high-income (\$35.8/m³) countries (World Bank 2007d)—such rapid economic growth has led to a rapid increase in water demand. Rapid growth has also led to serious pollution via the ineffective control of wastewater discharges, especially those from urban and agricultural sources.

China's urban population accounted for 44.9 percent of the total by the end of 2007, compared to 17.9 percent in 1978. Urbanization generally contributes to higher efficiency of water use, but these increased efficiencies are only achieved if the urban public services infrastructure, including water supply and wastewater treatment, is expanded in tandem with demand. However, only 56 percent of urban domestic wastewater was treated in 2006 (NDRC 2007c), and 200 cities had no treatment at all (SEPA 2007c). Given such a lag in the supply of urban wastewater sewerage and treatment infrastructure, China's increased urbanization has increased the flow of untreated wastewater discharges, with the attendant pollution impacts.

Another factor is the continuous growth of population. In spite of strict family planning policy measures implemented to control population growth since the mid-1970s, China's population increased from 962.59 million in 1978 to more than 1.31 billion in 2006 (*China Statistical Yearbook 2007*). Given the low water-use efficiency and lagging wastewater treatment

infrastructure, the growth in population directly contributed to an increase in water demand and serious water pollution.

At the regional level, there is a widening gap between the eastern coast and western/inland (upper reaches of most rivers) areas of China, posing a challenge for water resources and water quality management in river basins. In China, the wealthiest provinces and cities are all located along the eastern coast, which are the lower reaches of most rivers, while the upper reaches tend to be in the poor provinces in the West. The economic gap between the western and eastern regions has widened during the past 10 years. For instance, in 2006 the per capita GDP of eastern China reached RMB 25,400 yuan, nearly 2.5 times that in western China. The regional gap and inequality means that those less developed provinces located in upper reaches have few financial resources and incentives to invest in water resources management and water pollution control, which worsens the water situation in the lower reaches.

While debate over the sustainability of China's rapid growth continues, the momentum of this growth—and its attendant consequences—is not likely to slow down. The process of urbanization will also continue, with the share of urban population likely to reach 55 to 60 percent by 2020. The population itself will also keep growing and peak at 1.5 billion around 2033. Driven by these forces, under a business-as-usual scenario (i.e., with a continuation of the existing water pricing regime), total water demand in China is projected to increase from 563.3 km³ in 2005 to 653.5 km³ (a 16 percent increase) in 2030. The increase is largely driven by industrial and municipal demands, which will increase 42 km³ and 40 km³ on the level of 2000, respectively, while agricultural demand will decrease 10 km³. Compared to the levels in 2000, this scenario suggests that by 2030 water demand will increase by 6.7 percent in the Hai River basin, 10 percent in the Huai River basin, and 50 percent in Songhua Jiang basin (Table 2.5).⁸

TABLE 2.5 Projected Water Demand

		Total Demand (km ³)			Per Capita Demand (m ³)		Shares by Sectors (%)					
							2000			2030		
		2000	2030	increase	2000	2030	Municipal	Industry	Agriculture	Municipal	Industry	Agriculture
River Basins	Songhuajiang	35.2	51.7	16.5	559	689	9	22	69	9	20	71
	Liao	19.6	22.7	3.1	356	355	13	18	69	20	25	55
	Hai	40.2	42.9	2.7	312	262	13	17	70	21	21	58
	Huang	43.7	48.1	4.4	397	364	7	14	79	13	19	68
	Huai	65.1	71.6	6.5	332	320	10	16	74	18	20	62
	Yangtze	193.9	223.9	30.0	454	451	10	29	61	15	33	52
	Southeast Rivers	33.9	33.8	-0.1	471	367	12	26	62	20	34	46
	Pearl	79.2	81.0	1.8	492	405	13	20	67	20	29	51
	Southwest Rivers	10.6	13.6	3.0	530	544	8	3	89	14	6	80
	Northwest Rivers	59.8	64.2	4.4	2062	1646	2	3	95	4	3	93
Regions	6 Northern Regions	263.6	301.2	37.6	453	432	8	14	78	13	17	70
	4 Southern Regions	317.6	352.3	34.7	467	433	12	25	63	17	31	52
	Nationwide	581.2	653.5	72.3	461	432	10	20	70	16	24	60

Endnotes

1. See data from AQUASTAT, a global information system on water and agriculture developed by FAO.
2. Chinese Statistics Yearbook 2006. Beijing: China Statistics Press.
3. Including the UNEP, UNDP, World Bank, and the World Resources Institute.
4. China Environmental Yearbooks show TVIE wastewater discharge only for the years 1997–2000, which tended to be increasing.
5. China Environmental Yearbooks indicate an increasing rate of wastewater discharged by county and above county-owned enterprises that meets the discharge standard over the years 1995–2000. The wastewater discharges from TVIEs, however, are likely to be excluded from the trend even though no detailed data have been reported in the statistics yearbooks since 2001.
6. Zhou, Shengxian. 2006. “Speeding up Facilitating Historical Transition and Creating a New Situation of Environment Protection.” A speech at the 2006 Meeting of Director-Generals of Local EPBs across China, April 18, 2006.
7. See http://news.xinhuanet.com/newscenter/2004-03/22/content_1378785.htm.
8. China Sustainable Development Strategy Study Group of the Chinese Academy of Sciences. 2007. *China Sustainable Development Strategy Report 2007—Water: Governance and Innovation*. Beijing: Science Press.

Water Resources Management in China

An Overview of Determinant Variables

This chapter reviews the system and practice of water resource management in China. The first section points out technically viable and economically feasible water-saving and cleanup options available to address water scarcity, and highlights the potential influence of institutional and policy determinants in improving water resource management. The second section examines the Government of China's commitments, major plans, and actions to address water scarcity. It then discusses the existing institutional issues and policy failures in water management as causes of water scarcity in China, indicating areas for improvement. These are the elements of the water management system whose design and operation the government can control to influence water-related activities and behaviors. They are treated as determinant variables for the purposes of this study.

TECHNICAL SOLUTIONS ARE AVAILABLE AND ECONOMICALLY FEASIBLE

While the emerging water crisis is serious, there are many technically and economically feasible options to address it by improving the productivity of water use and reducing pollution. China's water productivity is low in comparison with other countries. That suggests a significant potential for China to reduce its water demand without slowing down its pace of development. The water productivity gap between China and other countries is largely due to differences in the structure and efficiency of water consumption, and should improve with the gradual evolution of the economy's sectoral structure. For example, the agriculture sector, which accounted for 65 percent of freshwater withdrawals, saw its share of GDP decline from 25 percent in 1989 to 13 percent in 2005. Over the same period, industry increased its share of GDP from 43 percent to 48 percent, and services from 32 percent to 40 percent, while consuming only 23.4 percent and 1.7 percent respectively of water withdrawals (MWR 2005).

Water productivity in agriculture is the lowest of all sectors. This is largely due to extensive waste in irrigation systems, as well as suboptimal allocation among crops and between different parts of the same river basin. The extent to which water is wasted is difficult to estimate with accuracy. One estimate is that due to the poor management of irrigation canals, only 50 percent of water from primary canals is actually delivered to fields (Xu 2001). The water that reaches the fields is not used efficiently by local irrigation managers and farmers; it is estimated that 20 to 30 percent is wasted. Only about 40 percent of water withdrawals for agriculture are actually used by farmers on their crops (Wang et al. 2005).

Water productivity in industry is also low by international standards. China's paper producers, for example, consume about 400 to 500 tons of water per ton of paper, compared to consumption of less than 200 tons of water in OECD countries. The largest steel mills use about 60 percent more water to produce a ton of steel than the combined average of the United States, Japan, and Germany, while water consumption by smaller firms is as much as five times higher than in those developed countries. This may be due to differences in the structure of production, as well as low levels of water recycling. About 40 percent of industrial water is recycled, compared to 75 to 85 percent in developed countries. If China's industry could improve its water utilization efficiency to that level, it could reduce its raw water consumption withdrawals by two-thirds (SEPA Policy Research Center 2006).

China's urban water utility distribution network losses are among the highest in the world, averaging around 50 to 75 m³/day per km of network. This is twice the leakage rate in Brazil and Russia, and more than ten times the rate in the United Kingdom. Among the lowest performing utilities, average leakage rates are around 150 m³/day/km. Many pipelines are old and need rehabilitation, and many newer pipelines built prior to 1990 were constructed with poor quality materials and substandard construction methods. A

major underlying cause has been the utilities' limited ability to support the maintenance and rehabilitation of these pipelines (World Bank 2007b). The leaks account for about 18 percent of total urban water supplies on average, or about 1.5 percent of China's total water withdrawals.

Finally, the cleanup of pollution will substantially contribute to addressing the scarcity of water. As mentioned in Chapter 2, approximately 25 km³ of polluted water is held back from consumption, contributing to unmet demand and groundwater depletion. As much as 47 km³ of water that does meet quality standards is nevertheless supplied to households, industry, and agriculture, with the attendant costs. A further 24 km³ of water beyond rechargeable quantities is extracted from the ground and causes groundwater depletion. Altogether, the cleanup of pollution could make nearly 100 km³/year of additional surface water available for consumption or environmental uses, equivalent to 18 percent of China's total freshwater withdrawals (World Bank 2007a).

The expanded use of water savings and cleanup options is economically feasible, especially in water-scarce North China. A recent study estimated the scarcity value of water to range from 2.1 to 5.2 yuan/m³ (He and Chen 2005). The value differs between river basins, with the highest values obtained in the Yellow, Huai, and Hai basins, where water is scarcest. An ongoing study of the Hai basin has found that the economic value of water ranges from 1.0 yuan/m³ in paddy irrigation to 12.3 yuan/m³ in vegetable fields and 21.3 yuan/m³ in manufacturing.

For China as a whole, the scarcity value of water is determined by the incremental cost of additional supplies. For coastal areas such as the Hai basin, including Tianjin and Beijing, a ceiling on the scarcity value of water is provided by the cost of producing desalinated water, which has fallen dramatically in the past two decades. Recently built large-scale plants in many countries produce freshwater for \$0.45 to \$0.50/m³ (equivalent to 3.4 to 3.8 yuan/m³) using reverse

osmosis technology (U.S. National Research Council 2004). China has a history of desalination projects dating back to 1958. More than 20 seawater desalination plants are planned or in operation, with a cumulative capacity of 30,000 m³/day and a production cost of 4–7 yuan/m³.¹ Another indicator of the scarcity value of water is the unit cost of the South-North Water Transfer Project, which is about 7–8 yuan/m³.²

Overall, a wide range of water-saving and pollution abatement technologies is available and economically feasible for China, and some have already been adopted to a limited extent. But the rate of adoption has been insufficient to balance the supply and demand of water and effectively address the water quality issues that have contributed to the emergence of the water crisis. The creation of an enabling environment, including institutional and policy reforms that will accelerate the adoption of these technical solutions, should lie at the heart of any strategy to address China's water scarcity.

GOVERNMENT COMMITMENTS, PLANS, AND IMPLEMENTATION

China's leadership is well aware of the severity of its water problems, and has committed to the creation of a water-saving society. The importance of water resources management has been recognized and is considered a policy priority in action plans of the Chinese government. For example, the 9th Five-Year Plan (FYP) (1996–2000) for National Social and Economic Development set sustainability as the guiding principle for socioeconomic development, and put stress on strengthening water resource development (SCCG 1996). In the aftermath of the 9th FYP, the government developed a medium- and long-term national plan to balance water supply and demand (NIWRH and CIWRHR 1998). Based on a number of studies dedicated to water resources management, the MWR (1998) published China Agenda 21. This was followed by a series of action plans for the management of river

basins and lakes, including the Yangtze River (1998), Huai River (1998), Huang River (1998), Hai-Luan River (1998), Song-Liao River (1998), Pearl River (1998), and Lake Tai (1998).

The 10th FYP (2001–05) highlighted again the importance of improving water resources management in achieving sustainable social and economic development (SCCG 2001). It identified the actions needed, including establishing a rational water resource management system, setting up rational pricing mechanism, adopting water conservation technologies and measures, facilitating the development of water efficient industries, strengthening water pollution prevention and control, and raising the public awareness of water conservation.

The 11th FYP (2006–10) sets a number of policy goals and priorities for water resources management in line with the guiding principle of “scientific development” and the general goal of achieving a “harmonious society.” The 11th FYP stresses the need for improving water resources management by adopting a more unified or better coordinated management pattern, shifting from supply-side to demand-side management, integrating river basin management with regional management, and establishing a preliminary system of water rights trading.

According to the 11th FYP, the total water consumption for agricultural irrigation is to remain constant, with the effective water-use coefficient expected to reach 0.5. For industrial sectors, especially water-intensive industries such as power plants, mining, and steel, the focus will be on development and innovation of water-saving technologies. The mandate target is to reduce water consumption per unit of industry-added value by 30 percent. For the urban sector, the focus will be on improving water-saving measures, including mandatory use of water-saving appliances; enhancing water recycling and reuse; and strengthening construction of water-saving infrastructure in public buildings and residential houses. Priorities set in the 11th FYP include water pollution control in major river basins

and regions such as the “three major rivers” and “three major lakes”; protecting the sources of drinking water supply; and regulating pollution discharge into major rivers and lakes. The plan also promotes construction of municipal sewage treatment facilities and generalization of wastewater charges, with a target of raising the wastewater treatment rate to 70 percent by 2010.

Based on the principles and goals set by the 11th FYP, the Chinese government developed the 11th Five-Year Plan of National Water Resources Development (FYPNWRD), setting specific objectives with action plans and measures to support them (Box 3.1).

In 2002, the Chinese government amended the Water Law passed in 1988 to establish a legal foundation for integrated water resource management and demand management. The amended 2002 Water Law enshrines the principles that everybody should have access to safe water, and that water conservation and protection are a priority. It

focuses on five areas of water resource management: (1) water allocation; (2) water rights and water withdrawal permits; (3) river basin management; (4) water use efficiency and conservation; and (5) protecting water resources from pollution.

As a response to increasingly severe water pollution, China amended its Water Pollution Prevention and Control Law, which was passed in 1984 and amended in 1996. Adopted by the Standing Committee of the NPC on February 28, 2008, the newly amended version provides more detailed measures for preventing and controlling water pollution from various sources, makes clearer specifications on the responsibilities of different stakeholders, and strengthens the legal liabilities for water pollution.

These plans and laws embrace efficiency, equity, and sustainability as universally accepted principles for water resources management. The Chinese government also strengthens such principles as (a) balancing between water resource uti-

BOX 3.1 China’s 11th FYP for Water Resources Development

Based on the 11th FYP, China developed the 11th FYP of National Water Resources Development to provide specific guidance on water resources development and management.

The 11th FYP of National Water Resources Development emphasizes that water is an important national strategic resource that is becoming increasingly scarce. The sustainable use of water resources to support sustainable social and economic development will be an important mission of the government for the 11th FYP period.

The plan summarizes achievements in water resource development and reform during the 10th FYP period and lays out guiding principles and a vision for the reform of water resources development and management. It promotes actions in the following fields: (a) improving water resource development; (b) strengthening construction and management of water projects; (c) increasing investment; (d) deepening reforms; (e) improving management of water resources within the legal framework; (f) enhancing the capacity of disaster prevention and response; and (g) protecting and saving water resources.

The plan sets specific objectives with action plans for water resource development and management and reform. In regard to water resource development, it focuses on the construction of water works and technological innovation for securing water supply and drinking water safety, enhancing flood control and disaster mitigation, and improving water saving and conservation. In regard to water resource management, it proposes such actions as reform of the management system, establishing a water rights trading and administration system, introducing quantity control and quota management, shifting to integrated river basin management, setting up mechanisms for water financing, strengthening water conservation in rural areas, and improving water pricing. It also lists major measures to support its implementation, including setting up financial mechanisms, defining authorities and responsibilities of government institutions, improving accountability, conducting research and staff training, and enhancing public participation in water resource management.

lization and conservation; (b) planning as a whole for and balancing between various uses and demands of various users; (c) integrating increasing sources of water supply and saving water, with water saving as the priority; (d) putting pollution control first; and (e) integrating basin-based water management with administrative boundary-based water management.

These plans reflect the strong commitment of the Chinese government to address the nation's water problems, prevent the emergence of a water crisis, and provide guidelines for policy making at both the central and local levels. However, these plans are not always fully implemented, and not all the planned objectives can be achieved. For example, since the mid-1990s, the Chinese government has pledged to carry out large-scale water pollution prevention and control in the key polluted basins of three rivers and three lakes over two successive five-year periods. However,

by the end of the 10th Five-Year Plan for Environmental Protection (FYPEP), the objectives of water pollution control were not achieved, in spite of substantial investment (Table 3.1). A recent case study of the Huai River basin, the most heavily polluted in China, identifies a few reasons why the extensive water pollution prevention and control programs of the 9th and 10th FYP periods have not achieved their objectives of reducing major pollutants such as COD (Box 3.2; see also Box 8.1 in Chapter 8).

EXCESSIVE FRAGMENTATION OF THE WATER MANAGEMENT SYSTEM

Despite the recent trend of combining various water-related agencies into a more unified water bureau in some city governments and converting government-owned water utilities into corporations, China's water resource management system

TABLE 3.1 Performance in Meeting the 10th FYPEP Targets for Water Pollution Control

Sector/Region	Chemical Oxygen Demand (tons, million)			Ammonia Nitrogen (tons, thousands)		
	2000 Base	2005 Target	2004 Actual	2000 Base	2005 Target	2004 Actual
Total	14.45	13.00	13.39	18.3	16.5	13.3
Industry	7.05	6.47	5.10	7.8	7.1	04.2
Domestic	7.40	6.53	8.30	10.6	9.4	9.1
Rivers						
Huai	1.06	0.64	0.99	1.5	1.1	1.2
Hai	1.58	1.06	1.24	2.6	2.0	1.3
Liao	0.58	0.33	0.47	0.7	0.5	0.5
Lakes						
Tai	0.49	0.38	0.44	130.0 ^a	99.1 ^a	42.0 ^a
Chao	0.06	0.06	0.07	12.3 ^a	11.4 ^a	8.0 ^a
Dianchi	0.04	0.03	0.03	10.9 ^a	8.8 ^a	2.0 ^a
South-north						
Water						
Transfer	0.97	0.55	0.49	1.4	0.7	0.5
Three Gorges						
Reservoir	1.35	1.03	1.01	1.1	0.8	0.8
Bohai Sea	1.14	1.03	2.09	1.6	1.3	0.1
Beijing	0.19	0.13	0.13	0.4	0.3	0.2

Source: OECD (2007).

a. Total nitrogen is in ten thousand tons.

BOX 3.2 Case Study: Evaluating the Implementation of the Water Pollution Prevention and Control Plans for the Huai River Basin

The Huai River basin (HRB) is located between the Yangtze River basin and Yellow River basin, covering an area of 270,000 km² in Henan, Anhui, Jiangsu, and Shandong provinces. It is composed of two water systems, the Huai River to the south of the old Yellow River, with a catchments area of 190,000 km², and the Yishusi River to the north, with a catchments area of 80,000 km². The HRB's population was estimated at 168 million in 2003, accounting for 13 percent of the nation's total. Its GDP has increased from 421.48 billion yuan in 1994 to 1.05 trillion yuan in 2003. The urban population share increased from 13.02 percent in 1990 to 20.22 percent in 2003.

Since the end of the 1970s, the basin has witnessed booming growth in township and village enterprises, including paper production, alcohol distilleries, and food processing plants, which are highly water intensive and polluting. Since the introduction of large-scale pollution control in the Huai River in 1993, township industrial enterprises and others have grown by 1.5 times, and industrial output 14.5 times, over the 1978 levels. Enterprises, especially low-tech agro processing plants, grew rapidly. These small enterprises not only further aggravated the shortage of water resources in the basin, but also increased pressure on the environment, leading to frequent pollution incidents.

To address water pollution in the HRB, a series of Water Pollution Prevention and Control Plans (WPPCP) were made at the basin and provincial, city, and county levels by central authorities, local environmental protection bureaus (EPBs), and planning agencies.

Despite the great efforts to prevent and control water pollution, the planned goals for total pollutant discharge control and water quality have not been achieved, and the planned investment and treatment projects have not been fully implemented. There is still a long way to go to achieve the objective of controlling water pollution and improving water quality in the basin. The failure can be attributed to insufficient consideration of the complexity and difficulty of water quality improvements in formulating the plans; incomplete and even distorted information for pollution control planning; lack of monitoring systems to evaluate implementation of plans; policy failures in support of implementation of plans; and fragmented institutional systems for water resources management.

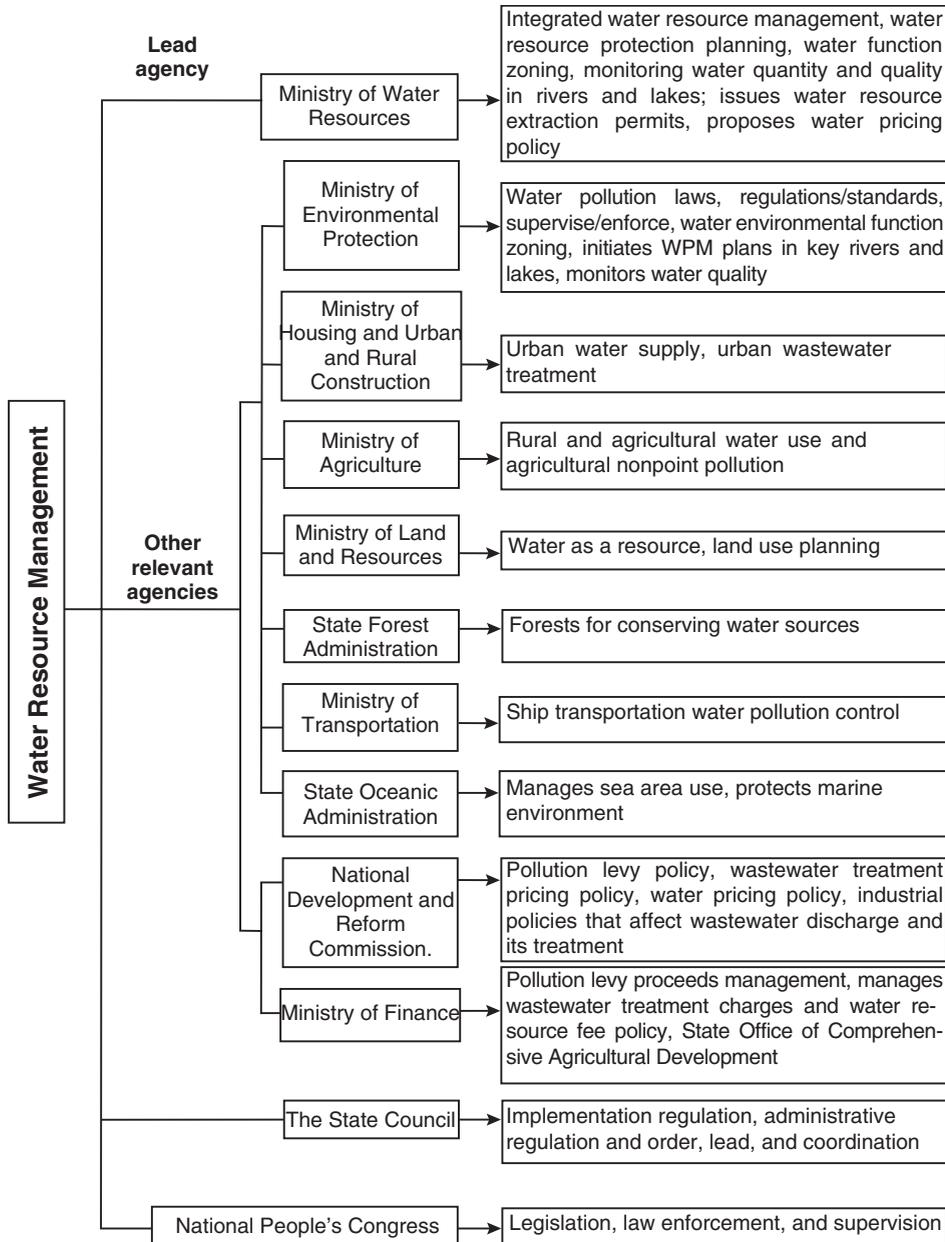
Source: Ma 2006a.

is characterized by extensive vertical and horizontal fragmentation. Horizontally, at every level of government several institutions are involved in water management. At the central level, the NPC and the State Council play an overarching role through enactment of laws/regulations and supervising their implementation and coordination. In addition, a dozen ministries/authorities are involved in various ways in water management: the Ministry of Water Resources (MWR), Ministry of Environmental Protection, State Oceanic Administration, Ministry of Housing and Urban and Rural Construction (MHURC), Ministry of Finance, Ministry of Agriculture (MOA), Ministry of Land and Resource, Ministry of Transportation (MOT), the State Forestry Administration, and National Development and Reform Commission (NDRC) (Figure 3.1).³ A common metaphor to describe the current system is that “nine dragons

manage the water.” Within this system, there are overlaps and conflicts in responsibilities, as the boundaries between institutional jurisdictions are not always clear. This unwieldy system has increased the administrative cost for coordination among different institutions and affected the effectiveness of water management.

For example, water quality and quantity management are separated from each other and put under MEP and MWR; that is, MWR is responsible for water allocation planning and water rights administration, whereas MEP is responsible for water pollution prevention and control. As a result, the planning process for basin-wide water quantity and quality management has mainly proceeded on two separate tracks, under the supervision of MWR and MEP, with the actual implementation in the hands of the local governments. This two-track system is replicated at the local (province,

FIGURE 3.1 Ministries and Authorities Involved in Water Resource Management



Source: Authors.

prefecture, county) level. Water resource bureaus at the provincial level and water affairs bureaus (WAB) at the municipal level, which are overseen by MWR and MHURC at the central level, are responsible for the administration of water rights, the planning and operation of water utilities, and the protection of water bodies on the basis of water function zones. Environmental protection bureaus (EPBs) overseen by MEP are responsible for issuing pollution permits, controlling pollution, and the protection of water bodies on the basis of environmental water zones.

Even the responsibility for water pollution prevention and control is broken down and put under different institutions. While MEP is responsible for prevention and control of pollution from industrial and municipal sources, MOA is responsible for nonpoint agricultural pollution control and MOT for ship transportation water pollution control. Consequently, for any given water body that receives pollution from various sources, the management of water quality would involve these institutions as well as MWR, because water quality is associated with water quantity: more water can create greater capacity to dilute more pollutants. That increases the difficulty and administrative costs in water quality management.

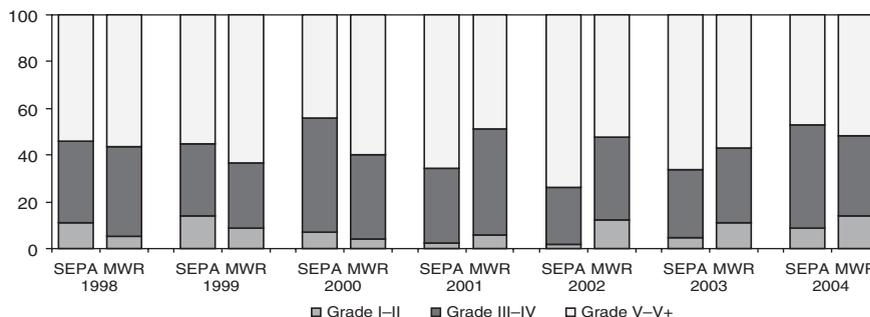
In addition, these institutions do not cooperate and coordinate with each other very well. For

example, both MWR and MEP monitor the water quality of major rivers, but each has its own monitoring stations and do not share its respective database on water quality information. As Figure 3.2 shows, MEP’s and MWR’s water quality data for the Huai River over the period of 1998–2004 are different.

Vertically, the water management system is also fragmented. The existing regime of water resource management is mainly based on administrative boundaries of different levels of government rather than at the river basin level. Each level of government has its own focal points and priorities. This makes the management of trans-boundary rivers difficult. Sector and basin-wide objectives, such as abating pollution, balancing upstream and downstream needs, and protecting aquatic ecosystems, tend to have relatively low priority among local authorities, who have an incentive to focus local resources on meeting local needs. For example, the benefits from pollution abatement and water savings in one province will be felt farther downstream. However, the majority of funding for pollution control and water-saving investments must come from local budgets (user fees or loans) with only a small share contributed by the central government.

China has established river basin management commissions (RBMCs) for its seven large river/

FIGURE 3.2 MEP and MWR Water Quality Data for Huai River, 1998–2004



Sources: China Statistical Yearbook (various years), MWR Statistical Yearbook (various years).

Note: Grades I–III refer to water that is safe for human consumption after treatment; grades IV–V refer to water that is safe for industrial and irrigation use; and grade V+ refers to water that is unsafe for any use.

lake basins (six river basin management commissions and the Lake Tai Basin Management Agency) as subordinate organizations of the MWR. These organizations have limited power. They are responsible for preparing basin-wide water allocation plans and providing technical direction and guidance to local governments within the basin. Regarding water quality management, RBMCs only have the authority to monitor water quality, but no authority over pollution control at the source. For instance, the Hai River Basin Management Commission is responsible for inter-provincial water allocation and flood control, while the responsibility for func-

tional control in most instances rests with the provincial, prefecture, and county governments within the river basin. However, these RBMCs have no representatives from the affected provinces and municipalities. As a result, it is difficult for them, as subordinate institutions of MWR, to coordinate with related provinces/municipalities and other stakeholders.

Given the nature of water resource management, a more integrated system would be more effective. Some developed countries like France and the United Kingdom are good examples in this regard (Box 3.3). The Chinese government is aware of the weaknesses of the existing fragmented

BOX 3.3 River Basin Agencies in France

In the early 1960s, several major French rivers had been declared “dead.” Levels of pollution from industry and agriculture were dangerously high. Native fish had disappeared, plant life was dying, and the water was unsafe for swimming. Today, the rivers and their surroundings have been rehabilitated. This dramatic change began with the recognition in 1964 of six river basins as the natural units for water resource management in France, and the creation of six river basin agencies to manage them accordingly. How was this done?

The six river basin agencies were established to implement basin-wide sustainable and coherent water management systems, with targets and standards defined by national laws and regulations to

- ensure the security of water supplies
- protect the ecological resources of the river environment
- improve the efficiency of the municipal water supply and wastewater treatment

The main tools included consensual agreements among all stakeholders and technical advice and financial support for water “owners”—mainly municipalities, industries, and farmers. The necessary financial resources came from water pricing and the enforcement of the consumer-pays principle for quantitative management and the polluter-pays principle for pollution control.

The water resource management plan and a master development plan were drawn up for each five-year period. The plans were proposed by a River Basin Committee (“Water Parliament”), which included all stakeholders. It was complemented by smaller plans, drawn up by local water committees at each subbasin level.

An important aspect was the introduction of a system of volume-based water use and effluent charges that fully reflected the treatment costs of specific pollutants (suspended solids, oxygen demand, nitrogen, phosphorus, soluble salts, hydrocarbons, and toxic metals) in each basin’s own wastewater treatment plants. Revenues were exclusively used to fund investment and operating costs of the treatment facilities and to provide financial incentives (below-market credits) for pollution abatement by industrial plants.

Since the program started, more than 500 new wastewater treatment plants have been built, increasing the previous municipal treatment efficiency by about 20 percent for the control of organic pollution and by more than 50 percent for the nutrients. The treatment of industrial discharges has increased by more than 30 percent. As a result, reports show a continuous improvement in the quality of rivers. The one exception is the continuing high level of nitrogen, more than 66 percent of which comes from nonpoint sources.

Sources: UNESCO (2003) and <http://www.lesagencesdeleau.fr/>.

system and is planning to initiate reforms to shift from fragmented management to integrated management. In his speech at the 17th National Congress of the CPC in October 2007, China's President Hu Jintao promoted institutional reform toward more integrated institutions. In the new round of governmental restructuring of the State Council initiated in March 2008, some ministries/agencies, such as Ministry of Personnel, Ministry of Labor and Social Security, were integrated. Therefore, a more integrated water management system is expected to be set up in the next few years.

POLICY FAILURES IN WATER MANAGEMENT

The most significant policy failures in China's water management include an underdeveloped system of water rights administration; an excessive focus on supply rather than demand management; an excessive reliance on administrative measures rather than market-based instruments; insufficient financing for pollution control; and low levels of pollution charges.

An Underdeveloped System of Water Rights Administration

A sound system of water rights administration based on clearly defined and tradable water rights is a prerequisite for more effective water resources management through market mechanisms. During the long period of the planned economy, there was no definition of water rights in China. It was only in the 1988 Water Law that legal stipulations were imposed on the ownership of water resources. Since 2000, China has formulated a series of laws/regulations and policy guidelines on water rights administration, including the amended Water Law in 2002 and MWR's 2005 Framework for Water Rights System Development. Based on these laws/regulations and policy guidelines, China has established a preliminary system framework of water rights administration

covering water allocation, water withdrawal, and water rights transfer. There are also pilots and experiments in water rights administration at the local, regional, and river-basin levels.

The system of water rights administration in China is far from mature. First, the initial rights of water ownership are not very clearly defined. According to the 2002 Water Law, all water resources (except those in ponds and reservoirs belonging to rural collectives) are owned by the state, and the State Council exercises the right of ownership on behalf of the state. In reality, the State Council has delegated water ownership rights to local governments under the supervision of MWR. MWR supervises water allocations through the RBMCs, which only have the responsibility to formulate water-use plans and allocate water for major cross-provincial rivers. For water bodies within provinces, municipalities, or counties, water is subject to allocation by administrative authorities of the relevant provincial, municipal, or county governments.

Second, under the current system, there is no link between the amount of water authorized for use and an overall water resources allocation plan based on water balance analyses at the river-basin level. While basin-wide water allocation plans are prepared by the RBMCs, water rights at the user level are administered by local governments, which are not represented in the RBMCs.

Third, the current water rights administration system does not cover all water users. The current water use rights in irrigation areas are allocated to intermediary organizations responsible for irrigation rather than to end users. Many users, especially farmers, withdraw water without permits, notably from underground aquifers, which are not regulated at all.

Fourth, despite provisions and principles for water rights transfers, there are no specific regulations on conditions, procedures, and operating guidelines for such transfers.

Finally, there are some technical barriers to effective water rights administration in China. For example, China lacks facilities for measur-

ing water use, especially groundwater use. Its current approach is entirely based on measuring water withdrawals from surface and groundwater sources, rather than “real” water use, in terms of the amounts of water consumed by crops and trees for evapotranspiration (ET), and taking account of water reflows after use. Recent advances in technology have made it possible for such an approach to be implemented, particularly for agricultural uses (Box 3.4).

Excessive Focus on Supply, Rather Than Demand Management

Lack of effective water resources policies that focus on demand management and encourage efficient water use is an important factor causing current water scarcity. Traditionally, China’s policies were more focused on meeting the demands for water by increasing supply rather than managing demand. In order to increase water supply to meet continuously growing demands from economic activities and domestic uses, China

built many reservoirs, dug wells to pump groundwater, built canals to transfer water, and more recently, plans to produce desalinated water. This focus on increasing supply without managing demand has contributed to over-withdrawal and inefficient use of water.

A greater focus on demand management, especially the use of prices to reflect the scarcity value of water and stimulate its more efficient use, would be appropriate. At present, water-use efficiency in China is quite low compared to many countries, and the price of water for many uses (domestic, agricultural, industrial) is also low compared to the scarcity value of water. In 2003, water use per unit of GDP was 4.5 times the level in developed countries, while water use per unit of industry-added value was 5 to 10 times the level of developed countries. The average crop productivity of water was 1 kg/m³, only half of the level of developed countries.⁴ Therefore, there is great potential for demand management to play an important role in effective water management in China.

BOX 3.4 Planning Scarce Water Resources Using Evapotranspiration Quotas

Recent advances in remote sensing and GIS techniques have made it feasible to manage irrigation water resources in terms of the amounts consumed by crops, trees, and weeds for evapotranspiration (ET), rather than water withdrawals from surface and groundwater sources. The portion consumed through ET is the “real” consumption that is lost to users downstream. The portion that returns to the surface or groundwater systems is still available for downstream uses, unless its quality has deteriorated to the point that the water cannot be reused, in which case this represents “real” losses.

In water-scarce areas, it is important to manage water resources in terms of net water consumption (ET) quotas. This approach encourages farmers to reduce the evaporation and transpiration that does not contribute to plant growth. For example, they will reduce evaporation by shifting toward dry-seeded species (from paddy), reducing waterlogged areas, irrigating when evaporation is lowest (at night instead of during the day), using moisture-retaining mulches, and replacing open canals and ditches with pipes. They may also reduce plant transpiration by weeding, using water-stress-resistant varieties, and fine-tuning deficit irrigation. Where excessive fertilizer and pesticides runoff is a problem, they will be encouraged to reduce nonpoint pollution, since return flows that are not reusable downstream will be deducted from their ET quota.

The Hai basin project in China will pilot water resources planning through the allocation of ET quotas. The objective is to increase the volume and value of agricultural production in the demonstration areas using a target ET amount. The target amount will be less than the current ET, and be gradually lowered until enough water is released to maintain environmental functions and avoid groundwater depletion; that is, until the existing water gap is closed. This goal can be achieved by gradually raising crop water-use efficiency and reducing nonbeneficial ET.

Source: The Development Research Center of the Ministry of Water Resources 2007a.

Excessive Reliance on Administrative Measures Rather Than Market-Based Instruments

Due to the long tradition of a planned economy and centralized power, China has mainly relied on administrative (“command-and-control”) measures rather than market-based instruments for water management. For example, market-based water pricing should be an important policy instrument for improving water resource allocation among different economic uses and for enhancing water-use efficiency. However, water prices in China are determined politically and by top-down administrative commands rather than by the market.

For example, the price of water for irrigation does not reflect the full cost of water supply, including operation and maintenance costs plus overhaul and replacement costs of water delivery systems. There are no extraction fees for the agricultural use of groundwater, and the only payment made is for the cost of energy for pumping (in the range of 0.08 yuan/m³ to 0.56 yuan/m³ in the Hai basin). In most irrigation districts, water fees are assessed on the basis of the size of a household’s irrigated area, encouraging vast water waste by farmers. When the cost of water is low or unrelated to the quantity used, the benefit from saving water is low. As a result, the current cost recovery approach to water pricing in the agricultural sector has not been effective in providing incentives to save water (Huang et al. 2006b).

The price of water for domestic use by urban households is lower than the production cost of water. For instance, water supply for households in Xi’an is priced at 1.6 yuan/m³, while the full cost is 5 yuan/m³, estimated by the local water affairs bureau (OECD 2007). Due to low water prices, expenditures by urban households on water currently account for only 1.2 percent of disposable income. This is lower than the level needed to provide an incentive for water-saving behavior.

An adjustment in water prices to more fully reflect its scarcity value would greatly stimulate the adoption of water-saving techniques. Recent studies have estimated price elasticities of water demand for the irrigation of grains in the range of –0.17 to –0.21, suggesting that a 100 percent increase in price would lead to a 17 to 21 percent reduction in water use (Huang et al. 2006b). These savings would largely result from the greater use of water-saving technologies such as border and furrow irrigation, alternate wetting and drying irrigation, field leveling, minimum tilling, plastic sheeting, drought-resistant varieties, surface and underground piping systems, and canal lining and sprinkler systems. Some of these technologies—such as plastic sheeting—have been reported to reduce water requirements by up to 90 percent (Blanke et al. 2006). These technologies are familiar in many parts of China, yet the extent of adoption is quite low, largely due to inadequate appreciation of the scarcity value of water, as well as lack of supportive institutional arrangements.

An increase in the price of water for industry and the domestic sector can also be expected to stimulate an increase in water-use efficiency, mainly through higher rates of water treatment to allow for its recycling and reuse.⁵ In recent decades, substantial advancements in wastewater treatment processes make it possible to effectively remove biodegradable material, nutrients, pathogens, and heavy metals from effluent streams so that the treated waters can be reused in a wide range of applications. Costs will vary. A recent survey of Chinese enterprises and wastewater treatment plants estimated that treatment costs range from 1.0 to 3.8 yuan/m³ for industrial uses, and from 0.8 to 0.9 yuan/m³ for domestic uses. Both are below the scarcity value of water, at least in North China (Table 3.2).

The results of a recent study on economic values of water (EVW) in different regions and sectors in the Hai basin well reflect both market and policy failures in water management in China. According to this research, which was

TABLE 3.2 Wastewater Treatment Cost for Major Industrial and Domestic Sectors

Sector	Treatment Cost (yuan/m ³)
Coal mining and washing	2.00
Food processing	3.20
Food manufacturing	1.95
Beverage manufacturing	1.65
Textile manufacturing	2.50
Paper and paper products manufacturing	2.50
Raw chemical materials and products	3.70
Petrochemicals	3.80
Medicines manufacturing	1.90
Chemicals manufacturing	3.70
Chemical fibers manufacturing	2.80
Non-metallic mineral products	2.65
Iron and steel smelting and pressing	3.50
Power generation and heating	2.00
Domestic wastewater	0.8–0.9

Source: CAEP 2006.

conducted in eight case study counties in the Hai River basin, the integrated EVWs in different sectors vary greatly, with those in service sector more than 7 times and 1.6 times as high as those in the industrial sector and agriculture (primary) sectors, respectively (Figure 3.3). If the market worked well, these differences would tend to be much smaller, since the sectors with higher EVWs would be able to purchase water from the sectors with lower EVWs, until the EVWs were more or less equalized, subject to differences in water quality and transmission costs. While some differences could be justified by policies for food security, their magnitude and persistence are still indicative of market failure or a serious lack of market consciousness in the water allocation process.

The adjustment of water prices can also be expected to drive a change in the structure of agricultural production to more fully reflect the

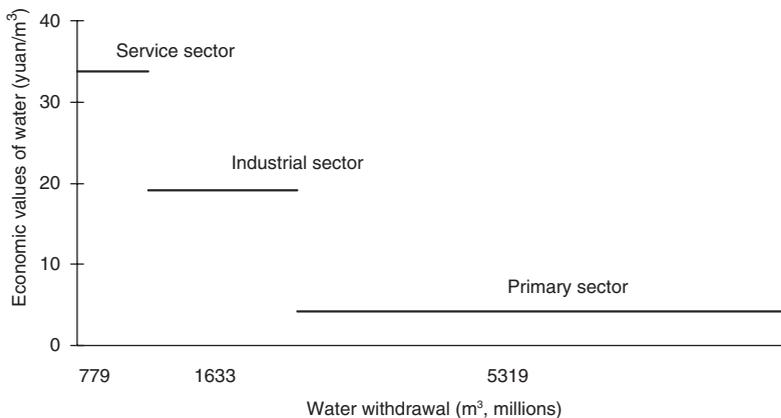
scarcity of water and increase water productivity. An indication of the direction of the structural changes is provided by an analysis of the amount of water embedded in each crop, the virtual water content (Table 3.3). From this analysis it is evident that as part of a strategy to balance the supply and demand of water, a country or region that is water scarce should increase its reliance on the import of commodities with high water content (for example, beef, pork, rice, and wheat), and apply its limited water resources to crops with low water requirements (for example, milk, maize, and potatoes).

Insufficient Financing for Pollution Control

In the last three five-year plan periods, investments in environmental protection accounted for only 0.68 percent, 0.81 percent, and 1.19 percent of China's GDP, respectively, which is insufficient to reach the expected level as originally planned (World Bank 2007a). Although investment in environmental protection in the 11th FYP period (2006–10) is expected to increase by 85 percent over the 10th FYP level, the growth rate is still below the GDP growth rate of 80 to 120 percent every five years (Ma 2006b). Moreover, the increase of investment in water pollution control has been lower than that for flood control, soil erosion control, and water resource allocation. Consequently, as acknowledged by the Chinese government, lack of investment as well as poor supervision has largely contributed to the failure to meet the nation's pollution control targets, such as reducing COD discharge by 10 percent during the period from 2001 to 2005, and to the deterioration of the environment.

China began to set up the targets of urban sewage treatment in the mid-1990s. It aimed to treat 25 percent of urban sewage by the end of the 9th FYP in 2000. The target went up to 45 percent by 2005 in the 10th FYP and 70 percent by 2010 in the 11th FYP. During the 9th FYP period (1996–2000), the total investment in

FIGURE 3.3 Integrated Economic Values of Water and Water Withdrawals in the Primary, Industrial, and Service Sectors in Eight Regions



Source: Chinese Academy of Hydraulic and Hydropower Research (2007).

sewerage networks and sewage treatment was RMB 60.27 billion yuan. Although the investment went up to 159.5 billion RMB yuan (including RMB 82.52 billion yuan for sewage treatment) during the 10th FYP period, this is still a relatively small spending item in the country’s total fixed-assets investment (Table 3.4). For example, road and bridge construction investment climbed to RMB 875.2 billion yuan during the 10th FYP, accounting for about 43 percent

of all urban fixed-asset investment, while sewage treatment accounted for only 4 percent (Comprehensive Financial Department, Ministry of Construction 2006). More importantly, while total urban pollution discharge kept on increasing, the percentage of investment in the drainage network and sewage treatment kept on decreasing during the 10th FYP period. Investment in the drainage network during the 10th FYP period was smaller than that of 9th FYP period.

TABLE 3.3 Virtual Water Content of Selected Products

Product	Liters of Water per kilo of Crop
Wheat	1,150
Rice	2,656
Maize	450
Potatoes	160
Soybeans	2,300
Beef	15,977
Pork	5,906
Poultry	2,828
Eggs	4,657
Milk	865
Cheese	5,288

Source: Adapted from Hoekstra (2003).

Although it was reported officially that the treatment rate went up to 45.6 percent by installed capacity in 2004 and then to 56 percent in 2006,⁶ the shortage of sewerage networks and funds for operation have been widely reported, causing a low operation rate. With insufficient investment, wastewater treatment facilities, including sewerage networks, have not been adequately built, especially in small cities and “established towns.” It is unlikely that the real treatment rate of urban sewage reaches 45 percent. After all, over half of wastewater is untreated and directly discharged into the water environment, offsetting the reduction in industrial wastewater discharge. The failure in achieving water pollution control goals has been well documented in the Huai River basin and other areas.

TABLE 3.4 Urban Fixed-Asset Investment during the 9th and 10th Five-Year Period (RMB billion yuan)

Year	Total	Sewage Treatment ^a		Drainage Network ^b		Road and Bridge	
		Amount	Percent	Amount	Percent	Amount	Percent
1996	94.86	–	–	6.68	7.04	12.61	13.29
1997	114.27	–	–	9.01	7.88	12.83	11.23
1998	147.76	–	–	15.45	10.46	16.1	10.90
1999	159.08	–	–	14.2	8.93	14.67	9.22
2000	189.07	–	–	14.93	7.90	14.24	7.53
1996–2000	705.04	–	–	60.27	8.55	70.45	9.99
2001	235.19	11.64	4.95	22.45	9.55	85.64	36.41
2002	312.32	14.41	4.61	27.5	8.81	118.22	37.85
2003	446.24	19.88	4.46	37.52	8.41	204.14	45.75
2004	476.22	17.45	3.66	35.23	7.40	212.87	44.70
2005	560.22	19.14	3.42	36.8	6.57	254.32	45.40
2001–05	2030.19	82.52	4.06	159.5	7.86	875.19	43.11

Source: Comprehensive Financial Department, Ministry of Construction (2006).

a. Data for sewage treatment investment in the 9th FYP period are unavailable.

b. Fixed-asset investment of drainage network is gained by subtracting fixed-asset investment of sewage treatment from that of drainage network. These two data are also from the *China Statistical Yearbooks*.

– = Not available.

Low Levels of Pollution Charge

In developed countries, polluters are often liable for the full cost of remediation and compensation. In China, although the country has implemented a pollution levy system since the 1980s, its pollution levy and penalties for noncompliance are low and not often prohibitive, and the

cost of causing pollution is low compared to international standards. The low levels of the pollution levy provide little incentive for industries to abate pollution and reduce pollution discharges. In many cases, it is cheaper for polluters to pay the levy than to take actions to abate or reduce pollution. Box 3.5 provides an example of a specific chemical plant.

BOX 3.5 Distorted Economic Incentive for Pollution Discharge

The financial trade-offs faced by a chemical enterprise in China that is required to meet discharge standards illustrate the distorted economic incentive for pollution control. The plant discharges 1,000 m³/day of wastewater with a pH of 10.8, with average 750mg/L COD, 180 mg/L anionic surfactants, 190mg/L BOD, and 330mg/L suspended solids. These pollutants exceed the Grade II wastewater discharge standards that the plant is required to meet. Based on the Collection and Management Provisions of Pollutants Discharge Fee (State Council, 2003 Order No. 31), the discharge fee for such noncompliant discharge should be 3.01 yuan/m³. On the other hand, should the enterprise choose to treat its wastewater prior to discharging, its investment is equivalent to a capital cost of 6.90 yuan/m³, not including operation cost, to which should be added a discharge fee of 0.17 yuan/m³ for the pollutants remaining in the treated and compliant wastewater. Thus, paying for the noncompliant discharge is much cheaper than building a WWTP.

Source: Louis Berger Group (2007).

SUMMARY

Many technically and economically feasible options are available to increase the efficiency of water use and reduce pollution. Their implementation, however, has been limited. This is mainly due to the country's weak institutional and policy framework for water resources management. The fragmented institutional arrangements and policy failures, which rely heavily on administrative instruments without the adequate use of market-based instruments, are important causes of ineffective water management. Therefore, institutional reforms emphasizing a more integrated management, and policy reforms emphasizing market mechanisms, would be important to improve water resources management and address China's water scarcity.

To assist China in improving its water resources management in line with that orientation, the following chapters of this report will focus on key areas where the design and operation of the institutional and policy framework can be improved to stimulate an increase in water-use efficiency and reduce pollution. Such areas include (a) strengthening key dimensions of water institutions and governance; (b) allocating and administering water rights, which is essential for the market to work; (c) setting prices right based on market mechanisms, while protecting the poor; (d) piloting market-based ecological compensation to achieve financially sustainable and natural conservation; (e) pro-

moting a system and measures to strengthen water pollution control; and (f) improving both emergency response and prevention to mitigate environmental disasters.

Endnotes

1. See China Economic Net. 2006. "Seawater desalination to relieve water shortage in China." *Insight* 2006-2-28-2006. Beijing. Available at: http://en.ce.cn/Insight/200602/28/t20060228_6217706.shtml.
2. See Hui Dian Market Research Network (July 22, 2005), Statement by MWR Vice Minister Zhai Haohui at 2005 Summit on China's Development to establish a resource-saving society. Available at: <http://freereport.3see.com/items/2005/07/22/3074.html>.
3. China undertook a new round of governmental restructuring in March 2008, in which the former State Environmental Protection Administration (SEPA) was transformed into the Ministry of Environmental Protection, the former Ministry of Construction into the Ministry of Housing and Urban and Rural Construction, and the former State Civil Aviation Administration into the State Civil Aviation Agency as a subordinate organization of the Ministry of Transportation. In Chinese terms, the number nine often means "multiple" instead of an accurate number.
4. China Water Development Report 2005.
5. Water reuse is the use of treated wastewater for general uses such as agricultural irrigation and industrial cooling. Water recycling is the reuse of effluent water within the same (industrial) plant, often after treatment.
6. According to the NDRC report on the implementation of the 2006 National Plan of Economic and Social Development submitted by the National Development and Reform Commission (NDRC) to the National People's Congress (NPC) in March 2007. See http://202.123.110.5/2007lh/content_553601.htm.

Improving Water Governance

For thousands of years, the Chinese people have been confronted with the challenges of controlling floods and fighting droughts caused by too much or too little water [in the nation's given natural conditions.] In response, they gradually developed a governing system and techniques for water management. The Dujiangyan Water Project, completed more than 2,200 years ago in the Min River basin of Sichuan Province, demonstrates the great efforts and wisdom of the Chinese people in coping with these challenges. However, traditional wisdom is insufficient for addressing current water issues, which are far more complicated than before.

As discussed in earlier chapters, the water issues currently faced by China are a result of interactions among several factors, both natural and man-made. Man-made factors have had by far the greatest impact. For example, the “sudden” burst of blue algae in Tai Lake in eastern China in May 2007, which contaminated the drinking water source and interrupted water supply to millions of residents in the city of Wuxi in Jiangsu Province, was a combined effect of unusual weather (higher temperature, less rainfall) and heavy pollution from the rapid economic industrialization and urbanization of the basin of Tai Lake over the past three decades. Due to the nature of water management and inter-dependence among various water problems, the opportunity for China to address its water issues lies more in human actions—more specifically, in good water governance.

This chapter focuses on water governance in China in more general terms. It begins with an overview of water governance in concept. The following four sections examine four major aspects of water governance in China: the legal environment, institutional arrangements, information disclosure and transparency, and public participation. Each section includes an overview of the current situation, points to areas for improvement, refers to relevant international experiences, and puts forward recommendations. To avoid repeating the discussion in previous chapters, the discussion of institutional arrangements is mainly focused on organizational arrangements without much elaboration on policy issues. The

final section concludes with recommendations for improving water governance in China.

THE CONCEPT OF WATER GOVERNANCE

Both governance and water governance are quite new concepts. In just the last 10 years or so, the two concepts attracted much attention and were used in studies and discussions among academicians and practitioners worldwide when it comes to public policy and public management. As a result, a number of definitions of these terms have been devised by various researchers and organizations, each with a somewhat different focus. According to UNDP (2003), governance covers the way in which power is exercised in the management of resources (natural, economic, and social) and broadly embraces the formal and informal institutions by which authority is exercised. It is related to the broader social system of governing as opposed to the narrower perspective of government as the main decision-making political entity. Thus the essential elements for good governance include (1) openness, transparency, and accountability; (2) fairness and equity in dealing with citizens; (3) efficient and effective services; (4) clear and transparent laws and regulations; (5) consistency and coherence in policy formation; (6) respect for the rule of law; and (7) high standards of ethical behavior (OECD 1997).

In line with the general definition of governance, UNDP defines water governance as the range of political, social, economic, and administrative systems that are in place to develop and manage water resources and the delivery of water services at different levels of society (UNDP 2006a). Good water governance depends on a number of factors, including (1) strong policy, legal, and regulatory frameworks; (2) more effective implementing organizations; (3) a civic determination to improve water governance; and (4) appropriate investment (World Bank 2006b). Some researchers identify other principles for effective water governance, such as (1) openness and transparency; (2) inclusiveness and effective

communication; (3) coherence and integration; (4) equity and ethics; (5) accountability; (6) efficiency; (7) responsiveness; and (8) sustainability (Rogers and Hall 2002).

These definitions of water governance suggest that the three main pillars of water governance are the legal framework, institutional arrangements, and civil society. The legal framework covers all the water-related laws and regulations that (1) define water property rights and necessary environmental and technical standards; (2) establish instruments for implementing the rights and achieving the standards, including decision-making and planning instruments, implementing instruments, and monitoring and evaluation instruments; (3) create an institutional system for water governance; and (4) set up enforcement procedures. The institutional arrangements for water governance include all governmental entities that have direct executive responsibilities related to water, their authorities and duties, the inter- and intra-department relationships established by the laws, and the processes and mechanisms of their operation.

Lastly, civil society, as the third pillar of water governance, reveals itself through many varied channels and forms. Public participation is one of the features of civil society involvement, which in turn differentiates water governance from traditional water management by government. Therefore, good water governance depends on the well-coordinated efforts of all stakeholders—including governmental organizations at all levels, relevant business communities, the public at large, and NGOs—working within a sound legal framework.

THE LEGAL ENVIRONMENT FOR WATER MANAGEMENT

Over the past two decades, China has made much progress in improving its legal framework for water management, both in legislation and in enforcement of laws/regulations. The existing framework includes relevant stipulations in the Constitution as the primary source of legality

and authority. At the second level are national laws and their implementation guidelines, such as the Water Law, Water Pollution Prevention and Control Law, Water and Soil Conservation Law, Flood Control Law, and Fishery Law. The third level of legislation includes national and sectoral administrative regulations on water, such as the Regulation of River Channels, and the Regulation of Flood Prevention; and local regulations and rules that have played a critical role in regional water management.¹ Within this framework, the Water Law promotes an administrative structure for water resources that integrates river basin management with regional administrative management, and recognizes the legal status and responsibilities of river basin management organizations.

While strengthening legislation for water management, China has also made efforts to strengthen law enforcement. The NPC and relevant ministries/authorities at the central level of government inspect the implementation and enforcement of laws and regulations on a regular basis. Some authorities such as MWR and SEPA make scheduled or unscheduled performance evaluations to improve the enforcement of laws and regulations. In 2006, the establishment of five Regional Environmental Supervision Centers in China (as subordinated offices of SEPA) was a new attempt to strengthen enforcement of environmental laws, including those related to water pollution management. In the 11th Five-Year Plan for Environmental Protection, one of the major tasks is to establish a comprehensive system for environmental law/regulation enforcement and supervision. In the newly amended Water Pollution Prevention and Control Law promulgated in February 2008 and effective on June 1, 2008, stricter penalties against noncompliers are added to enhance law enforcement.

Areas for Improvement

Despite the progress described above, the effectiveness of the legal framework for water resource management is unsatisfactory. Overall, law

enforcement in this area has been lax in China, as evidenced by the nation's serious water-related problems, including rampant nationwide water pollution dramatized by the algae outbreak in Tai Lake. Many studies (Chinese Academy of Sciences 2007; China Institute of Water Resources and Hydropower Research 2007) have pointed out that the legal framework leaves much room for improvement. Its main weaknesses and areas for improvement are summarized below.

Weak law enforcement

Law enforcement is a real problem in China, not only in the area of water pollution control, but also in broader areas like water exploitation and conservation. Ineffective law enforcement can be attributed to three main factors:

1. Lack of mechanisms and procedures. Existing laws and regulations usually are focused on principles and lack mechanisms and procedures for enforcement, such as supervision, monitoring, reporting, evaluation, and imposition of penalties against violators. As mentioned above, the newly amended Water Pollution Prevention and Control Law includes stricter penalties against non-compliers. However, without more detailed guidelines for implementing the law and profound reform of the law enforcement system, effective implementation of those measures remains a question.
2. Inadequate institutional arrangements. The central government relies on local government agencies in law enforcement. In some cases, when local governments feel that enforcement could cause losses in local economic growth and local tax revenue, they tend to hinder law enforcement or take a passive attitude toward enforcement. Insufficient resources available for enforcement agencies also result in weak governmental enforcement capacity.
3. Lack of transparency and participation. Lack of transparency and relatively low levels of public participation have led to poor public

supervision, contributing to weak law enforcement. In this regard, China can learn good practices of law enforcement from other countries (for example, see Box 4.1 regarding experiences in the United States).

Incomplete legal system

The coverage of the existing legal framework is still limited. For example, while the Water Pollution Prevention and Control Law requires that the state establish and improve compensation

BOX 4.1 The U.S. Experience in Promoting Law Enforcement

The Clean Water Act (CWA) in the U.S. has various stipulations on violations and penalties, such as: (i) "Any person who violates a permit condition or order of the EPA Administrator shall be subject to a civil penalty not to exceed \$25,000 per day for each violation;" (ii) "In determining the amount of a civil penalty the court shall consider the seriousness of the violation or violations, the economic benefit (if any) resulting from the violation, any history of such violations, any good-faith efforts to comply with the applicable requirements, the economic impact of the penalty on the violator, and such other matters as justice may require"; and (iii) "Any person who knowingly makes a false statement in any report or who knowingly falsifies any monitoring device shall, upon conviction, be punished by a fine up to \$10,000 or imprisonment for no more than 2 years or both."

The following three examples illustrate how these provisions are applied:

Example 1. United States v. Roll Coater, Inc. 21 ELR 21073 (S.D. Ind. 1991). Roll Coater is a coil coating company accused of emitting "unsatisfactorily treated effluent" into the City of Greenfield's wastewater system. The District Court for the Southern District of Indiana calculated the statutory maximum penalty under § 309(d) to be \$52,945,000. However, §309(d) also includes mitigating factors, which eventually lessened the fine to \$2,093,456 because the firm needed time to test out new treatment technologies.

Example 2. United States v. Smithfield Foods, Inc. 972 F. Supp. 338 (E.D. Va. 1997). Smithfield Foods is a large pig slaughtering and processing operator. For years it discharged waste into the Pagan River in Virginia in violation of its permit. The court calculated the economic benefit to Smithfield of noncompliance with the CWA to be \$4.2 million. Citing statutory factors such as the frequency and severity of Smithfield's violations and their impact on water quality, Smithfield's history of violations, and the inadequate compliance efforts, the court increased the penalty to \$12.6 million (or 7.2 percent of the maximum penalty). 191 F.3d 516 (4th Circuit, 1999).

Example 3. Exxon Valdez Oil Spill Prince William Sound, Alaska. The U.S. and Alaska brought a lawsuit against Exxon under CWA 311(f) for injury to natural resources to recover costs of clean-up and restoration following an 11-million-gallon crude oil spill in 1989. Exxon spent \$2 billion on clean-up. 10/8/1991 Consent Decree—compensation for fishermen and businesses of at least \$900 million. Fishermen and businesses that suffered injury also sought punitive damages. The trial court jury awarded punitive damages of \$5 billion. The federal appellate court, *In re Exxon Valdez*, 270 F. 3rd 1215 (9th Circuit, 2001), reduced this to \$2.5 billion. On 10/29/07, the U.S. Supreme Court agreed to review the appropriateness of punitive damages under CWA and federal maritime law.

There are also many other means of promoting compliance and enforcement in the U.S., such as: (1) media—newspapers or TV report on corporate pollution, often based on information supplied by citizen groups; (2) banks loaning money to a corporation or municipality may want evidence that a company is in compliance with environmental laws; (3) government contracts may require that a company be in compliance with all environmental laws; (4) disclosure by corporations of legal proceedings in financial documents filed with the U.S. Securities and Exchange Commission (SEC); (5) Item 101 of SEC regulation requires a company to disclose the material effects that compliance with federal, state and local environmental laws may have upon its capital expenditures, earnings, and competitive position; (6) A firm must disclose any material administrative or judicial proceedings arising under environmental laws. 17 CFR § 229.103.

Source: Tripp 2007.

mechanisms for ecological protection of the water environment in drinking water source areas and upstream of rivers, lakes, and reservoirs by instruments such as payment transfers, there are no supporting national laws or regulations in support of ecological compensation in river basins. Neither is there a law on water rights and trading. There are few laws to specify the procedure of making and enforcing water-related laws and policies, contributing to ineffective law enforcement, as mentioned above. In addition, while there are some general rules and regulations in place requiring an overall plan and integrated utilization for water resources, there is no specific regulation on master plans for management of cross-boundary rivers and lakes.

Ambiguous legal provisions

Some laws contain ambiguities. For example, the Water Law does not clearly define the authority of the local governments and the river basin management organizations. Neither does it clearly demarcate the authority of environmental protection agencies versus the role of water administrative organizations in aspects of water management, such as water quality monitoring. The Water Pollution Prevention and Control Law defines the responsibilities and duties of local government in water environmental protection, but does not provide financial arrangements for local governments assuming the responsibilities. Such ambiguity in the provisions causes a vacuum of authority and weakens the effectiveness of the legal system.

Conflict between legal provisions

Some laws tend to serve the interests of certain sectors instead of national interests. In some areas, these sectoral laws contradict each other. This is partially due to the “sector-based” legislative process, in which a ministry or administrative entity of the central government is normally entrusted with the drafting of a law or regulation on a subject within its jurisdiction. Because of the weak capacity of the NPC for legislation on some special subjects (due to lack of expertise and poor consultation) and poor coordination between dif-

ferent ministries/entities in the drafting of the law, it is not unusual that such a law adopted by the NPC may represent sectoral interests and conflict with other laws drafted by other line ministries or authorities. For instance, before it was amended recently, the Water Pollution Prevention and Control Law (Article 18) stipulated that water resource protection agencies in river basins are responsible for monitoring and evaluating surface water quality and reporting to SEPA and MWR. However, the Water Law (Article 32) requires that the water bureaus of the local governments above the county level and river basin organizations be responsible for monitoring water quality in water function zones and report to local governments and environmental protection agencies.

Recommendations for Legal System Reforms

Based on this discussion, we offer several recommendations.

Developing an action plan for improving the legal framework

China is currently in the process of a broad reform targeted to strengthen the rule of law. The actions to improve the legal framework for water management should keep pace with this overall process. While it is unrealistic to have the legal framework perfected within a short period, an overall plan and road map for improving the legal environment should be worked out. In the short term, the emphasis should be on improving the integration and coordination of various water-related laws and regulations—especially the Water Law and the Water Pollution Prevention and Control Law—to avoid contradictions and conflicts. In the long run, it should aim to establish a comprehensive water management legal system to cover the remaining areas of water resource management.

Improving law enforcement

Improving law enforcement is the number one priority to make the legal framework useful and

effective. As stipulated in the State Council's *Compendium of Implementation for Fully Promoting Law-Based Administration* promulgated in 2004, a series of actions need to be taken:

1. Implementation procedures: Detailed implementation procedures should be stipulated in all water-related laws and regulations to make existing laws and regulations operational and enforceable. For example, detailed guidelines for implementing the Water Pollution Prevention and Control Law should be developed, and the existing systems of total pollutant control and pollution emission permits should be improved.
2. Strengthened supervision and inspection: Supervision and inspection by the national and local congresses and administrative branches should be strengthened. Adequate budget and personnel for such inspection and supervision should be provided by law so that the local agencies responsible for law enforcement can be independent of local authorities.
3. Public participation: The public should be empowered to help monitor and track down violators and supervise local agencies responsible for law enforcement. Public-private partnerships should be encouraged by laws and regulations.

Overcoming sectoral and local interests in the process of legislation

The current legislative process has undermined the quality of laws and regulations. The *Compendium of Implementation for Fully Promoting Law-Based Administration* has reiterated the importance of developing sound and effective procedures for legislation. One option is to strengthen the role of the People's Congresses at different levels in preparing laws and regulations, with a special emphasis on reviewing and evaluating draft laws/regulations by experts and various stakeholders as an indispensable step in the process of legislation. Another is that different ministries/entities should take a more coordinated and integrated approach in

preparing water-related laws/regulations through a coordinating mechanism set up in the State Council, so that any water-related law or regulation is reviewed and accepted on a consensus basis by all relevant ministries/entities before it is submitted to the Congress for deliberation and approval. In addition, public participation such as public hearings should be required and implemented as an important step in the legislative process.

Amending and improving existing water-related laws and regulations

Given the vagueness and even contradictions of existing laws and regulations, the NPCs should carry out a careful review of all existing water-related laws. The laws and regulations should be revised, also taking into account the enforcement issue and integrated water management. For the Water Law, it should more clearly define the authorities, responsibilities, and coordination mechanism for different administrative organizations such as MWR, MEP, RBMCs, and relevant organizations at the local level. It should also clarify the linkages between all these organizations; clarify the status, responsibilities, operational mechanisms, and process of river basin management organizations; and require a stakeholder participation mechanism at the basin level. For other water-related laws and regulations, amendments are needed to make them consistent with the Water Law and the newly amended Water Pollution Prevention and Control Law.

Providing a legal basis for RBMCs with the active participation of local governments

The role of RBMCs in planning, allocation, and development of water resources should be legally specified, preferably in primary legislation. Given the important role of local governments in water resource management, their participation as a member of the RBMC in planning and implementation should be required by law. Realizing that it may take some time to enact such a law or legal provision, China should start with feasibil-

BOX 4.2 River Basin Management Legislation in the United States: The Case of the Susquehanna River Basin

The Susquehanna River, the sixteenth largest river in the United States, runs through populous areas in the states of New York, Pennsylvania, and Maryland. It is classified as a navigable waterway by the federal government. The Susquehanna River basin, though still relatively wild and partially undeveloped, experienced a period of environmental negligence. The river was polluted, its water resources overexploited.

Because the river runs through three states, there was clearly a strong need for coordinating the efforts of the three states, together with the federal government. The parties agreed to establish one management system to oversee the use of water and related natural resources throughout the basin. This collaboration also led to the drafting of the Susquehanna River Basin Compact.

The compact, as adopted by the Congress of the United States and the legislatures of New York, Pennsylvania, and Maryland, was signed into law on December 24, 1970. It provides the management mechanism to guide the conservation, development, and administration of the water resources of the river basin. Under the compact, the Susquehanna River Basin Commission (SRBC) was established as the agency to coordinate the three states and federal government.

The federal and local governments have since then worked closely to solve the problems in the Susquehanna River basin. Strict laws have been introduced to prohibit point-source pollution, regulate mining, and control erosion.

Source: <http://www.srbc.net/>.

ity studies and pilots at the local level. As part of this process, it is useful to examine international experience in river basin legislation and management (see Box 4.2).

INSTITUTIONAL ARRANGEMENTS FOR WATER RESOURCE MANAGEMENT

The UNDP's *Human Development Report 2006* (UNDP 2006b) concludes that the global crisis of freshwater supply is essentially a public management crisis, which in turn is primarily the result of an improper and incomplete public management system and slow reform progress. That statement fits the case of China. As discussed in chapter 3, for China there are many economically feasible technical options available to increase the efficiency of water use and reduce pollution that would contribute to addressing its water issues. However, because of its weak water management system, these options have only been adopted and implemented to a very limited extent. In line with lessons from global experience, it is expected that their wider implementation will have to be supported by improved institutional arrangements for the various levels of government in China.

Areas for Improvement

As discussed in Chapter 3, a major weakness is the excessively fragmented water management system. Horizontally, too many agencies are involved in water management along sectoral lines, with only vague boundaries separating their responsibilities. This has not only led to overlapping responsibilities, but also to inconsistent and sometimes conflicting policies made by different agencies with weak coordination among them. From a vertical perspective, water management is tied to administrative boundaries. Within the five-tiered administrative structure (national, provincial, municipal, county, and township), most water-related institutions respond to only a single level, with no relationship to the levels above or below. Each administrative unit (provinces, municipalities, counties, etc.) is responsible for making and implementing policies within its jurisdiction, mostly based on its own interest and priorities without enough attention to their impacts on the integrity of water resources and the whole river basin. Ironically, although China has a rather centralized power structure, the central government's policies are often resisted or ignored by

local governments responsible for their implementation. Efforts to deal with externalities and the characteristics of water resources as a public good tend to end in failure.

Other areas for improvement discussed in Chapter 3 include (1) an underdeveloped system of water rights administration, particularly the vague definition of water ownership that has hampered the implementation of market mechanisms; (2) an excessive focus on supply rather than demand management, which contributes to the low efficiency of water use and increased pressure on water resources; (3) an excessive reliance on administrative measures rather than market-based instruments, which not only burdens the administrative capacity of the government and raises their administrative costs, but also distorts the allocation of water resources; (4) insufficient public financing for water pollution control, especially when compared to the economy's rapid growth and accompanying water pollution, which contribute to the difficulty of reducing overall pollution levels; and (5) low levels of pollution charges and resource pricing, which fail to provide incentives for pollution reduction and resource saving.

International Experience in Institutional Arrangements

Most countries are faced with water issues in one way or another and have been making efforts to address them. In terms of institutional arrangements, while practices of different countries vary

greatly, some can be shared by many countries (Box 4.3).

Since the 1990s, in response to the complex water problems they are facing, more and more countries have adopted a more systematic and integrated approach to water management to consider water supply, pollution control, agriculture, hydropower, flood control, and navigation together. For example, the European Commission promulgated the Water Framework Directive (WFD) in 2000 (Box 4.4) and set up a common integrated approach, making integrated river-basin planning and management compulsory for its member states and candidate countries. The U.S. Clean Water Act also adopts an integrated approach, shifting from the conventional strategy of pollution control from project to project, from source to source, and from pollutant to pollutant to a new strategy of integrated, river-basin-based pollution control.

In line with this integrated approach, governmental institutions for water management have been arranged or restructured in several countries. Two features are common in these governmental arrangements. First, at the national level, water management duties are assumed by one or two institutions. For example, in the UK, the Environmental Agency (EA) is the leading central administrative body with responsibility for long-term water resource planning and the duty to conserve, augment, redistribute, and secure the proper use of water. In France, major agencies at the national level responsible for water resource management

BOX 4.3 Three Models of Water Resource Institutions in Europe

Model 1: River-basin (watershed)-based management systems. In the UK and France, these have centralized administrations; in Spain, a semi-federal administration. The scope of these entities is defined by the geographical boundaries of a river basin, whose water resources they manage in coordination with different interests along the entire river basin.

Model 2: Administration-boundary-based systems. Adopted in many countries, the scope of these entities is defined by administrative regions within which they coordinate with relevant agencies on the integrated management of the water resources.

Model 3: Coordinating model in the Netherlands. A combination of the above two, focusing on coordinating and balancing the interests of the administrative regions and the whole river basin.

BOX 4.4 The EU Water Framework Directive

Early European water legislation began in 1975 with a “first wave” of standards for rivers and lakes used as sources of drinking water and culminated in 1980 with a set of binding quality targets for drinking water. A second wave of water legislation followed in 1991 with the adoption of the Urban Waste Water Treatment Directive, which provided for secondary (biological) wastewater treatment, and the Nitrates Directive, addressing water pollution by nitrates from agriculture. It was completed in 2000 with the adoption of the EU Water Framework Directive. Some of the key elements of this directive are:

- (1) A single system of water management: river basin management. The best model for a single system of water management is management by river basin—the natural geographical and hydrological unit—instead of according to administrative or political boundaries.
- (2) Coordination of objectives: good status for all waters by a set deadline. There are a number of objectives. The key ones are (a) general protection of the aquatic ecology, (b) specific protection of unique and valuable habitats, (c) protection of drinking water resources, and (d) protection of bathing water, all of which must be integrated for each river basin.
- (3) Coordination of measures. The aim is to coordinate the application of measures at the community level to tackle particular pollution problems, key examples of which are the Urban Waste Water Treatment Directive and the Nitrates Directive.
- (4) Public participation. There are two main reasons for an extension of public participation: balancing the interests of various groups, and to underpin enforceability.
- (5) Getting the prices right. The aim is to set water prices at levels adequate to act as an incentive for the sustainable use of water resources in order to reflect the true costs of the environmental objectives.

Sources: Gislév 2007; see also http://ec.europa.eu/environment/water/water-framework/index_en.html.

are the Environment Ministry and the National Water Committee. The Environment Ministry is responsible for protection, management, and upgrading of aquatic environments and river systems, water quality, programming, and coordination of state intervention in relevant sectors. The National Water Committee, chaired by a member of the Parliament and composed of representatives of the National Assembly and the Senate and of important institutions and national federations, plays a key role in national water policy and in drafting legislative and regulatory texts. In Singapore, the Ministry of Environment and Water Resources was established in 2002 through the merging of the former Public Utilities Board (PUB), which used to be responsible for water resources and supply only, and the former Ministry of Environment, which used to be responsible for sewage treatment and the sewerage system. As part of the Ministry of Environment

and Water Resources, the restructured PUB’s responsibilities have been extended and now include sewage treatment and reuse, flood control, and the sewer system, in addition to water resources and supply.

The other feature is that water management is based on river basins instead of boundaries of administrative jurisdictions or sectors, and specific organizations based on river basins are set up for water resource management. For example, the UK Environment Agency has eight regional offices corresponding to the eight big river basins in England and Wales. France has set up a river basin committee and water agency in each river basin, both involved in the preparation of the Water Resources Development and Management Master Plan, and supervised by the Ministry of the Environment. In the United States, the Environmental Protection Agency has ten regional offices; each covers several states and one or more

entire river basins that cross several state jurisdictions. The U.S. also set up some river-basin-based water commissions as interstate institutions to address cross-state water management issues. Typically, members of these commissions include representatives of the federal government, state governments, and other stakeholders. In addition,

the concept of integrated river-basin management has been increasingly adopted by governments of many countries (Box 4.5).

These experiences of other countries in institutional arrangements for water management provide useful information for China to improve its water governance.

BOX 4.5 Integrated River Basin Management

Since the 1990s, the experience of water governance in various countries has led to a broad international consensus that the best solution for water issues lies in drafting overall plans to manage water-related affairs at the river-basin level. This process, known as integrated river basin management (IRBM), came to prominence after the 2002 Earth Summit in Johannesburg, South Africa. IRBM has been implemented in EU countries, the United States, Canada, South Africa, and elsewhere.

IRBM is a process of coordinating the management and development of water, land, biological, and other resources within a river basin so as to maximize economic and social benefits in an equitable way, while at the same time conserving freshwater ecosystems, species, and resource services for people.

IRBM is not a simple amalgamation of existing management of water, soil, biological, and other aspects. It moves away from the former practice of separated regional and sectoral administration and features the following:

- A river basin is an ecosystem that cannot be split into isolated sections. IRBM can help understand the cycles of evolution, development, and change to river basin ecosystems and adapt their management to fit with the natural order by using ecosystem approaches to manage water, soil, and other natural resources basin-wide.
- In terms of management objectives, IRBM tries to balance economic development, social progress, and ecological and environmental protection to maximize the economic, social, and environmental benefits throughout a river basin. This could be achieved through the active participation of stakeholders, and coordination between different governmental agencies. Strict environmental standards, as well as pressure on local governments from both the central government and the public, can also play significant roles.
- IRBM administrative targets focus on water and water resources, aiming for systematic management of water resources, the water environment, land resources, and aquatic ecosystems. This could help solve the conflicts between governmental agencies regarding water resource management, water environmental management, as well as land resources management.
- IRBM involves a combination of structural and nonstructural measures, with special care taken when adopting irreversible measures to harness a river basin. It advocates management approaches that cut across sectoral and jurisdictional boundaries and the use of legislative, administrative, economic, planning, and scientific and technologic instruments in a comprehensive fashion.
- IRBM emphasizes management processes that include the active participation of stakeholders. The involvement of stakeholders in management, planning, and policy making, as well as many other basin-level affairs, is essential for the success of IRBM.

IRBM has not been easy to implement in either developed or developing countries. This is especially the case for China with its fast-growing economy. The first steps toward implementing IRBM should be to define the rights, responsibilities, and obligations of the relevant stakeholders; discuss how to enhance information sharing, communication, and coordination between and among them in order to reach consensus on IRBM; and jointly seek the best solutions to these basin-level issues.

Source: Wang et al. 2007.

Recommendations for Organizational Reform

Focusing on the areas for improvement in institutional arrangements for water management in China discussed above, and based on international experience, our recommendations are as follows:

Shifting to a new paradigm of water management

The traditional approach to water management, fragmented along sectoral and regional lines, can exacerbate water problems rather than address them. China should make a shift from the current paradigm to a new paradigm of integrated water management. That suggests a profound reform, ranging from restructuring government organizations, to improving legal frameworks, and to developing innovative policy instruments.

Strengthening coordination among existing agencies and organizations

As water involves so many stakeholders, even in countries adopting the integrated approach, there are still many institutions and organizations involved in water management. For example, 17 organizations at the federal level are involved in groundwater management in the U.S. In China—given the reality of the multiple-tier government structure and multiple agencies at each tier involved in water management—in the short run it is more important and feasible to first strengthen coordination among those agencies by establishing a proper coordinating mechanism. Regular inter-agency consultation, compulsory information sharing, cross review and endorsement of relevant policies and plans, and joint policy making are components of the coordinating mechanism.

Restructuring governmental organizations for integrated water management at the national level

There are several options. One option is to establish a State Water Resources Commission as a coordinating and steering organization on water-

related affairs across the country at the highest level of government. It should be chaired by the premier or a vice premier, and its members would be heads of all water-related ministries/agencies at the central level. Its major missions would be to direct the development of a national water strategy, examine long-term plans for water development, allocation, and use, and coordinate all water-related ministries/agencies to avoid policy inconsistency and conflicts before they are implemented. This commission will serve as a high-level water policy-making body, much like the newly established State Energy Commission headed by the premier. At the ministry level, an option would be to merge major water-related duties currently put under different government agencies (namely MWR, MEP, MOA, MOC, and MLR) and establish a new super ministry to implement unified management of water quantity and quality, surface water and groundwater, water resource conservation and use, and water environmental protection.

Establishing and reshaping river basin commissions

China should establish river basin commissions for all major rivers and lakes that run across different provinces/municipalities. Specific provisions should be added to the Water Law and other laws/regulations to provide legal status and clarify the authorities/responsibilities of the new type of RBMCs. Since the existing RBMCs for the seven major rivers in China, as subordinates of MWR instead of real “commissions” as they should be, do not have enough power or representatives from local governments, they should be reshaped. In the short run, as organizations on behalf of the central government, RBMCs could consider the involvement of representatives from MEP. In the long run, they should be made independent of MWR and accountable to the State Council directly. Their governing board should include representatives from both the central government and provincial/municipal governments to ensure

appropriate accountability for basin-wide water resources management.

TRANSPARENCY AND INFORMATION DISCLOSURE

Transparency is one of the essential elements of good governance and a basic prerequisite for public participation in public management. In terms of water management particularly, transparency means that the public can have better access to information on water resources, policies, and institutions on water-related issues and water-related behaviors of various stakeholders.

Current Status

The Chinese government has been aware of the importance of transparency to good governance and made efforts to increase the openness of public administration. In the Compendium of Implementation for Fully Promoting Law-Based Administration promulgated in 2004 by the State Council, administrative agencies are required to open to the public all governmental information except that related to state secrets, business secrets, or personal privacy. In 2005, the Guidance for Further Enforcing Openness of Administrative Affairs (GFEOAA) was promulgated. In April 2007, the Government Information Disclosure Regulation (GIDR)—which was promulgated by the State Council and took effect on May 1, 2008—defines the range of government information, sets methods and procedure for information disclosure, designs dispute resolution mechanisms, and provides specific provisions on performance supervision.

Following these important official documents by the State Council, the MWR issued GFEOAA for Water Management in June 2005, and MWR's Provisional Regulation on Openness of Administrative Affairs in May 2006. These two documents define the scope of information that should be disclosed to the public and various forms of information disclosure, ranging from

official bulletins and public hearings to web-based channels. The Regulation of Hydrology, issued in 2007, focused on water quality monitoring and also set requirements on information disclosure.

SEPA also issued official documents to enhance information disclosure. The Provisional Regulation on Public Participation in Environmental Impact Assessment, promulgated in 2005, defines the scope of information that project organizations should make available to the public, as well as forms of disclosure and time limits for disclosure. MEP's Environmental Information Disclosure Decree, which was put into effect on May 1, 2008, makes it a compulsory responsibility for enterprises and governments to disclose their important environmental information to the public.

In addition to these regulations by central governmental agencies, local governments have also promulgated regulations and policies to promote water-related information disclosure. Reports on the state of large river basins have been delivered on an annual basis to provide information on water conditions and management in whole river basins. As a result, the public has better access to water-related information, and the administration of water issues is much more transparent than before.

Areas for Improvement

Even with the progress above, especially in policy making for enhancing transparency, the openness of public administration in water management is still limited in China. Major areas for improvement are summarized below.

Limited disclosure of information on water

Most of the information that existing regulations require to be made open to the public is on government organizations in charge of water affairs and their responsibilities and behaviors. Information on water itself—including water quality and quantity and such causal factors as water

users and pollution sources—is not emphasized enough. In reality, such information is not only inaccessible to the public, but also inaccessible to other governmental organizations outside those sectoral or local government organizations. It is not unusual that a specific organization responsible for water management has kept the information it collected and does not share it with other organizations. As a result, each organization has its own database, and the information issued is not consistent. This is illustrated, for example, by the different water quality data for the Huai River reported by MEP and MWR shown in Figure 3.2 in Chapter 3.

Ambiguity of terms leading to noncompliance in information disclosure

In some existing regulations, the definition of what information should be disclosed to the public is not clear enough. As a result, some organizations take advantage of the vagueness of the regulations and refuse to disclose water-related information. For example, the current regulations require that all information except that related to state secrets, business secrets, or personal privacy should be open to the public. However, there is no clear definition of what information relates to state secrets or business secrets. Thus, some organizations or enterprises refuse to disclose water-related information in the name of protecting state secrets or business secrets.

Incomplete legal system for information disclosure

The citizens' right of access to information is not emphasized properly in formal laws. For example, there are very few clauses on information disclosure in the Water Law and the newly amended Water Pollution Prevention and Control Law. In the existing regulations on information disclosure, the provisions on the procedure of information disclosure are not detailed and very few provisions are provided for measures against noncompliers. The Environmental Information Disclosure

Decree provides for a punishment for nondisclosure, with a maximum fine of 100,000 yuan (less than \$14,000), but that is too low to be an effective incentive. Besides, current laws do not specify how to provide compensation for the losses caused by noncompliance with information disclosure requirements. In addition, although several regulations on information disclosure are promulgated, they are not implemented well because of weak supervision by both the government itself and the public.

International Experience in Enhancing Transparency and Information Disclosure

As information disclosure is essential to good water governance, many countries, especially developed countries, attach importance to it and have enacted substantial legal measures to enhance it.

In 1990, the EU adopted the Directive on the Freedom of Access to Information on the Environment, which promotes environmental information disclosure (Box 4.6). In 1998, the EU signed the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (the Århus Convention), which was put into effect on October 30, 2001. In this convention, the right of access to information is regarded as one of three pillars of public participation in environmental management. In 2003, the EU issued a new Directive on Public Access to Environmental Information, which took effect on February 14, 2005. As a binding document for all member states, the directive grants the public a right of access to environmental information, provides for a broader definition of environmental information, and establishes a deadline of one month (reduced from the previous two) for public authorities to supply the information requested. It also clarifies the circumstances under which authorities may refuse to provide information. Access to information shall be

BOX 4.6 EU Directive on the Freedom of Access to Information on the Environment

The main EU legal instrument on access to environmental information is the Directive on the Freedom of Access to Information on the Environment adopted in June 1990. The directive makes it clear that:

- Providing a general right of access to information, rather than a more specific right of access to environmental information, is preferable.
- Access to information should be a right. Exceptions to this right of access should be interpreted narrowly and used only in exceptional circumstances.
- The time limits for the provision of information should be short—weeks or days rather than months.
- Fees for the provision of information should be reasonable and well known to the requester.
- Continuing awareness building and training of officials is crucial in building a good access-to-information system.
- The public should be informed about what information is available and the means for obtaining that information.
- The appeals process should be inexpensive, and decisions on appeals need to be speedy.

Source: Resources for the Future (2001), <http://www.rff.org/documents/RFF-RPT-pubaccess.pdf>.

granted if the public interest served by the disclosure outweighs the interest served by a refusal. The directive grants the public the right to challenge acts or omissions of public authorities relating to requests for environmental information and specifies review procedures for that. Following these EU directives, the member states revised or made laws/regulations to enhance information disclosure.

In the United States as early as 1979—in laws such as the Clean Water Act, the Resource Conservation and Recovery Act, and the Safe Drinking Water Act—the Environmental Protection Agency promulgated regulations setting minimum regulatory requirements and suggested information, notification, and consultation responsibilities as program elements for public participation. It required that each agency should provide the public with information on continuing policy, program, and technical issues at the earliest practicable time. For controversial issues or significant decisions, each agency is required to provide one or more central depositories of reports, studies, plans, and other documents in a convenient location, such as public libraries.

Recommendations for Actions to Enhance Transparency

To protect the citizens' right of access to information on public affairs, facilitate public participation in water management, and prevent the public from harm by water emergencies, it is crucial for China to take actions to enhance the transparency of the government and water-related information disclosure. Major actions recommended are summarized below.

Make public information disclosure a compulsory obligation of the government, companies, and relevant entities

The government should be fully committed to using the information disclosure approach in water resource management. Public information disclosure requirements should be incorporated in all major development strategies, policies, regulations, and operational procedures. Relevant governmental organizations should regularly release to the public information on water quality and pollution sources. The information must be accessible for the public and concerned groups/

communities and be made available through multiple channels.

Build a sound legal base for information disclosure

The legal basis for information disclosure has to be strengthened. For this purpose, China should (1) add clauses in such laws as the Water Law, Environmental Protection Law, and Water Pollution Prevention and Control Law to emphasize the citizens' right of access to environmental information and make information disclosure a compulsory obligation of governmental organizations, water companies, enterprises discharging pollutants, and other major stakeholders; (2) define in more detail in laws/regulations the scope of information that is supposed to be disclosed to the public and the scope of information regarded as state secrets or business secrets subject to protection, and specify the forms, procedures, and time requirements for information disclosure; and (3) draft clauses on the liability of those who have not disclosed information as required, as well as measures against noncompliance.

Develop information systems to facilitate the citizen's access to water information

Two types of information systems should be developed. One is on water quantity and quality at both levels of river basins and administrative units, covering surface and groundwater. The other is information on major water users or groups of users and their pollution data, also at both the river-basin level and administrative-unit level. In particular, systems of information on toxic chemicals are urgently needed to prevent water pollution incidents. Organizations managing these information systems should share the information with other governmental organizations and disclose it to the public.

Improve public awareness of information disclosure

Due to weak participation in environmental management, the public's awareness of their right

of access to information is generally low. China should raise awareness through public education and campaigns so that the public can be more active in requesting water-related information from relevant government organizations or enterprises. This is essential to effective enforcement of laws/regulations on information disclosure.

PUBLIC PARTICIPATION IN WATER MANAGEMENT

As water management is related to the interests of a wide range of stakeholders at different levels, including the general public, public participation is also crucial to good water governance. Public participation is helpful to tailor policy to local situations, to maximize the social welfare and utility of resources use, and to protect vulnerable groups. It is an inherent part of the integrated model of water management, both as a driving force for other stakeholders to fulfill their duties and as a policy instrument of water management.

Current Status of Public Participation

Traditionally, China had a highly centralized bureaucratic system with a top-down governance approach and weak public participation. Over the past three decades, with economic and administrative reform deepened, public participation has been increasing in public affairs. In water management, China has taken a number of initiatives to encourage and facilitate public participation in recent years.

In the Environment Impact Assessment Law passed in 2003, specific articles are provided on public participation in the formulation of governmental plans and the design of construction projects. The Administrative License Law passed in June 2004 acknowledges the right of the public to express their opinions in public hearings. In February 2006, a specialized law on public participation—the Preliminary Regulation on Public Participation in Environment Impact Assessment—was promulgated by SEPA. It makes

organizational provisions for public participation, and clarifies the forms and procedures for public participation in environmental impact assessment. In May 2006, the MWR issued the Regulation on Public Hearings for Administrative Permits in Water Sector, defining the scope of administrative permits for which public hearings are necessary and making detailed stipulations on organizing public hearings. The Regulations on Water Withdrawal and Collection of Water Resource Fees (2006) makes it clear that the public should be informed and public hearings should be held when an application for water withdrawal is related to public benefits. It is believed that the overall legal framework has been much improved for promoting and protecting the legal rights of the public as well as protecting state and business secrets as defined by laws.

In recent years, the water users association (WUA), as an organization of water users, has become a very popular form of public participation in water management in rural China. In October 2005, MWR, NDRC, and the Ministry of Civil Affairs jointly promulgated the Guidance for Facilitating Establishment of Farmer Water Users Association, specifying principles and procedures for establishing such associations and their role and responsibilities in relation to governmental organizations and water supply enterprises. According to MWR, water users' participation in irrigation water management had taken place in 30 provinces/municipalities across China by mid-2007. More than 20,000 organizations of farmer water users, mostly in the form of farmer WUAs, have been established, involving more than 60 million farmers participating in water management on behalf of end-users of water.²

Ever since the Friends of Nature, the first environmental NGO in China, was established in 1994, the number of environmental NGOs has increased rapidly. A survey by the China Union of Environmental Protection in 2005 found a total of 2,768 environmental NGOs in China. Of these, 1,382 were initiated by the government, 202 by

the public spontaneously, 1,116 by students, and 68 were branches of overseas/international NGOs. The total staff of these NGOs amounted to 224,000, with 69,000 working full-time (SEPA 2006a). These environmental NGOs are playing an increasingly important role in environmental protection in China. Some of them participate in water management actively and make their contributions to water resource conservation and water quality protection. One good example is the China Water Pollution Map, which is managed by the Institute of Public and Environmental Affairs and used to disclose water polluters. Another is the active participation of Green Earth Volunteers and other NGOs in the water resource development planning of the Nu (Nujiang) River.

Major forms of public participation in water management in China are (1) public opinion solicitation, where public opinions are solicited on a certain issue in water management; (2) public hearings, where formal public hearings are organized by government agencies in which representatives of various stakeholders can express their viewpoints and raise questions over certain water-related issues; (3) experts' assessment/reviews of development plans and programs, where professionals with expertise are involved in water management; and (4) stakeholder coordination, where representatives of various stakeholders communicate and negotiate over water-related issues relevant to their interests. To date, experts' assessment/reviews and public hearings have been the most common in practice.

Areas for Improvement

Public participation in water management in China is still quite low. That can be attributed to several weaknesses; the major ones are summarized below.

Low awareness and capacity of public participation

Given the long tradition of government dominance in water management, neither govern-

ment agencies nor the public in general have strong awareness of the potential for public participation in water management. Because of lack of experience and the low level of organization, the public in general has limited capacity for participation in water management. Consequently, most citizens do not participate at the early stages until their quality of life has been seriously affected. Once they feel compelled to participate, their actions tend to be more aggressive, sometimes irrationally so. On the other hand, many government agencies have no intention to involve the public unless they are compelled by the law or agencies at higher levels.

Incomplete legal system

The legal provisions on public participation in water management are incomplete. First of all, in such essential laws as the Water Law and Law on Environmental Protection, the citizens' rights to access to information, to participate in decision making, and to question and supervise governmental agencies, are not clearly stated. Second, there are few legal provisions for the public to challenge government decision making through litigation or judicial review. Third, the provisions/regulations on the procedure and mechanisms of public participation are not detailed or clear enough, leading to distorted implementation. For example, although it is required that government agencies should respond to questions or appeals of the public, it is not clear how they should respond and what the result would be if they did not respond.

Distorted operations

Due to lax legal requirement and weak supervision, the activities of public participation are often distorted in practice, deliberately or unconsciously. In such forms of public participation as public hearings and expert assessments, the procedures for selecting representatives of stakeholders and experts are not followed strictly in practice. Some organizers tend to select those in favor of the views or interests of the organizers.

Barriers for NGOs

The existing procedural and financial requirements for registration of NGOs set by existing regulations pose significant barriers to development and participation of NGOs. For example, according to the Regulation on Registration and Management of Civil Organizations promulgated in October 1998, any civil organization needs to get the approval of a governmental organization or a quasi-governmental organization authorized by the government above county level before it can be registered as a legal organization. For a nationwide civil organization, the amount of operational funds should be no less than 100,000 yuan, and for a local one, no less than 30,000 yuan. If there is already a civil organization with the same or similar business in the same administrative units, the new one would be regarded as superfluous and refused registration. Because of such requirements, some NGOs have to be registered as for-profit companies that have to pay taxes. Since participation of the NGOs spontaneously initiated by citizens is sometimes not welcome by government agencies, NGOs initiated by governmental organizations play a more important role in water management. However, their representation of the public interest is not always ensured.

International Experience in Enhancing Public Participation

Involving the public in water management is a global trend. Many countries, developed and developing, centralized or decentralized, have taken actions to enhance public participation in water management.

As mentioned earlier, the EU signed the Århus Convention enhancing public participation in environmental management. It identifies three pillars of public participation: (1) the public's right to receive environmental information held by public authorities; (2) the right to participate from an early stage in environmental decision making; and (3) the right to challenge, in a court of law,

public decisions that have been made without respecting the two aforementioned rights or environmental law in general. Following the convention, the EU formulated the Water Framework Directive, requiring that all member states should encourage the active involvement of all interested parties in the implementation of the directive, and in particular in the production, review, and updating of river basin management plans.

In France there are institutional arrangements for public participation. At the river basin level, the river basin committees consist of representatives of different stakeholders, including water users, experts, and professional associations (accounting for 40 to 45 percent of the total), different administrative districts (36 to 38 percent), and the central government (19 to 23 percent). The board of directors of the water agency for each river basin also consists of representatives of local government officials, water users and experts, and central government officials, each accounting for one-third. At the regional level, local water committees are set up for tributary subbasins. Of all members of each committee, 25 percent are representatives of water users, owners of land along the tributary, and professional associations. At the local level, water federations are set up in two-thirds of cities/towns. These federations consist of representatives of government, water users, and water companies.

In the United States, the EPA issued the Public Involvement Policy in 2003 to provide for meaningful public involvement in all its programs and consistently look for new ways to enhance public participation. It requires that EPA staff and managers should (1) seek inputs reflecting all points of view and carefully consider the input when making decisions; (2) work to ensure that decision-making processes are open and accessible to all interested groups; and (3) not accept any recommendation or proposal without careful, critical examination. It also outlines seven basic steps for effective public involvement: (1) planning and budgeting for public involvement activities; (2) determining who needs to or should be informed of, is interested in, or is

affected by a forthcoming action and performing associated actions; (3) providing (if needed) technical or financial assistance to the public to facilitate involvement; (4) providing information and outreach; (5) conducting public consultation; (6) reviewing and using input and providing feedback; and (7) evaluating public involvement activities.

Public participation in such forms as a water users association is also very popular and plays an important role in water resource management in many developing countries, including India, Mexico, and Brazil.

Recommendations for Actions to Promote Public Participation

As a public good with strong externalities and a strategic resource crucial to the economy, environment, and public life, water is closely related to the interests of various stakeholders, including the general public. To balance the interests of various groups, and especially to protect the benefits of vulnerable groups whose voices often cannot be heard, China should make a greater effort and take stronger actions to promote public participation in water resources management. Aiming at the existing weaknesses in terms of public participation, and based upon experiences of other countries, major recommendations for actions promoting public participation in water management are summarized below.

Governments should be fully committed to and take gradual actions for promoting public participation

Public participation should be widely adopted as a complement to government actions in water resource management, ranging from planning and policy making to law and policy enforcement and education. It should be emphasized that encouraging public participation in public affairs is in line with China's long-term development goal to develop a more democratic and harmonious society. Given the low awareness and capacity of

public participation, China should work out a plan of action for promoting public participation gradually. At the current stage, China should improve implementation of existing policies on promoting public participation in water management, focus on increasing the involvement of experts, and enhance the participation of the public in water issues that are directly related to their lives.

Building a strong legal foundation for public participation

The rights of public participation should be emphasized in relevant laws to empower the public. In such laws as the Water Law and Law on Environment Protection, articles should be added to explicitly grant rights of participation in water management to the public. Three rights should be clearly defined: (1) the right of access to information, (2) right of participation in decision making, and (3) right to challenge water-related decisions by the government. Specific and detailed provisions should be made on forms, steps, and procedures of public participation to avoid distortion in practice, either deliberately or unconsciously. Provisions should be made for administrative re-examination, litigation, or administrative punishment against behaviors infringing the aforementioned “three rights” granted by law in practice.

Involving the public in water management organizations

As recommended above, a representative water management organization or commission should be established at the river-basin level for each river basin. For the long run, membership in the organization should be further extended to not only central and local government agencies but also representatives of various stakeholders, including water suppliers, water users, and the general public. At the current stage, to facilitate participation of water users, China should encourage and support the establishment of such organizations as water users associations and involve them in water management.

Providing support for development and participation of NGOs

China should adjust the existing legal policy on NGO management, simplifying the formalities of establishment, lowering the requirements, and, especially, granting them independent status. Policies should be made to encourage their involvement in water management in various forms.

In addition, to enhance the awareness and capacity of citizens in public participation, apart from information dissemination activities targeted to adults, China should start by enhancing the education of schoolchildren on environmental and natural resource management issues.

SUMMARY

Good water governance is composed of a series of elements. To address the serious challenges it is facing in terms of water management, it is vitally important for China to improve its water governance. Given the nation’s current situation, China needs to treat water as a strategic resource and attach the same importance to it as to food security and energy security. To achieve good water governance, China should make sustained efforts and initiate a wide range of actions. The most fundamental one is that China should shift to a new paradigm of water management, moving from traditional fragmented management to integrated water management. This requires a change in the mindset of both government officials as well as the general public so that a consensus can be reached that water is a scarce resource that should be effectively allocated through market mechanisms. At the same time, access to clean water and a clean environment are basic rights of the people, and these rights should be protected through legal provisions, regulatory measures, and enforcement.

To adapt to this new paradigm, China should improve its legal system, organizational arrangements, and policy instruments.

In terms of the legal system, China should (1) continue to strengthen the legal framework

for water resource management and pollution control; (2) focus on improving compliance and enforcement, especially by strengthening public participation; (3) incorporate in water-related laws the integrated approach to water management; and (4) grant legal status to river basin management commissions.

In terms of organizational arrangements, China should (1) set up a more effective mechanism in the central government—possibly a Water Resource Management Commission, the highest level of coordinating and policy-making body consisting of leaders of various water-related ministries/agencies and chaired by a vice premier, and/or a consolidated super ministry combining the water-related functions of MWR, SEPA, MLR, and other ministries—with proper authority and capacity for coordinating different sectors and provinces/municipalities to implement integrated water management; (2) establish a more effective mechanism for coordinating different governmental organizations at central and local levels; and (3) reform river basin management commissions (RBMCs). The river basin management commission should consist of representatives of central government agencies, local

governments, water users/the public, and experts to balance the interests of various stakeholders.

In terms of policy instruments, China should combine various instruments, including command-and-control measures, market-based instruments, information disclosure, and public participation. In designing policies, market mechanisms should be used more to improve the efficiency of water use, while direct government intervention (such as subsidies or investments) can be used in some areas for the sake of equity and social benefits. Information disclosure and public participation in various forms should be promoted to impose pressure on polluters and administrations to avoid temporally and spatially biased behaviors, and to protect the public from water-related environmental incidents.

Endnotes

1. For the details of water-related laws and regulations in China, please see the background report prepared by the China Institute of Water Resources and Hydropower Research, 2007.
2. Source: <http://www.chinacitywater.org/bbs/viewthread.php?tid=42076>

Deepening Water Rights Administration and Developing Water Markets

The allocation of water rights and the establishment of water markets can improve the economic efficiency of water use in China and help resolve water shortages. China is encountering growing difficulties in meeting its rapidly growing demand for water. At the same time, the environmental impacts of overexploitation of water resources are becoming increasingly apparent. It is therefore timely to consider options for improving initial water allocations, deepening the reform of water rights administration, and establishing water trading in China.

This chapter focuses on water rights administration, water allocation, and water markets. It discusses (a) the concepts behind and requirements for water rights administration and water allocation, with insights from international experience; (b) the water rights system in China, drawing on case studies and pilot projects to illustrate good practice and key challenges; (c) the rationale for water markets and trading; and (d) international experience in trades of various types, and recent Chinese experience with both local and regional/inter-sectoral trading. It concludes with recommendations.

THEORY OF WATER RIGHTS AND INTERNATIONAL PRACTICE

Water rights can be characterized in many different ways. Essentially, they are an entitlement (or a de facto “property right”) of an individual or entity to a share of a common water resource. Beyond this, however, are the legal and institutional arrangements surrounding the right. These arrangements define and give meaning to a water right—both for the right holder, for other water users, for the government (as resource regulator), and for all those with an interest in water resources (WET 2006). In this chapter, water rights are not used to refer to legal ownership rights (which are typically held by the state, as is the case in China). Water rights refer to rights to allocate, take, or use water.

Establishing a water right usually starts with a definition of the right of a user to abstract and/or use a certain amount of water from a water source,

such as a river, stream, pond, or aquifer. To effectively manage water resources, a complete water rights system needs to explicitly specify the amount of water resources that may be extracted and consumed per unit of time, with a responsibility to return a certain amount of water—with satisfactory water quality—back to the local water system. In other words, a water right includes three components: (1) the amount of water that may be extracted, (2) the amount of water that may be consumed (or lost to the system), and (3) the amount of water that must be returned with defined quality to the local water system. These three components define the parameters of a given water right.

The amount of water consumed can be more accurately measured by evapotranspiration (ET). ET refers to the transpiration and evaporation of water. Based on the water balance theory for a basin or an area, when rainfall and inflow and outflow water remain unchanged, the control of evapotranspiration is the key to keeping the groundwater table from dropping and keeping surface water flow steady. Hence, the ET quota (for the basin) should become the core control indicator and mechanism for the water rights system in the basin. Whether it is water rights allocation or control, water rights management should eventually be based on the allocation and control of ET quotas. Putting it another way, the ET approach focuses on measuring and managing the scarce resource (water that is actually “consumed” or lost to the system and local users) rather than on water that is extracted but then returned to the system. Hence the ET approach is more focused on managing actual water consumption, and can help improve overall water management and system efficiency. The ET approach is being tried in many countries: an example from New Mexico in the United States is presented in Box 5.1.

An allocation process defines initial rights to water. Subsequently, these rights may change in accordance with the rules that govern the water

rights system. Those rules may allow for government to amend the rights under certain circumstances, or for individuals to trade their rights in accordance with specified rules.

Finally, we note that formalized, statutory rights are not the only source of authority that helps regulate water use, particularly in rural areas where formal systems can become difficult to implement for single enterprises/users. Box 5.2 discusses other ways in which rights are defined and claimed.

Rationale for Rights-Based Management

A water rights system fundamentally involves identifying the total available resource and then assigning the rights to that resource among different groups (Hodgson 2006; WET 2006). Management of water resources via a rights-based system has several drivers:

- *Security.* Lack of security can act as a barrier to investment in water-dependent activities. A water rights system can provide legal protection for rights’ holders and certainty regarding the water that will be available to them and the process through which allocations are made.
- *Ecological sustainability.* By defining the water available to different parties, a water rights system sets a limit—a cap—on the total water available for use. This cap can be set at a level to ensure water abstraction is at an ecologically sustainable level.
- *Transparency.* A transparent approach to the allocation of water provides confidence to all parties that water resources are being managed in a way that will deliver certainty, security, and ecological sustainability.
- *Efficient water use.* Clearly identifying the shares available to different entities provides an incentive for investment in water conservation.

In addition, an effective water rights system provides the basis for a number of different policy

BOX 5.1 Water Rights in New Mexico

In 2005, the southwestern U.S. state of New Mexico adopted new rules and regulations (R&Rs) with the objective of establishing standards and procedures to administer the appropriation, allocation, and use of the state's surface and supplemental groundwater.

The R&Rs define the five basic components of a water right: (1) point of diversion, (2) place of use, (3) purpose of use, (4) owner, and (5) quantity. However, "beneficial use" is now the basis, measure, and limit of a water right. Beneficial use is further defined as the direct use of water by man for beneficial purposes, including irrigation, municipal, commercial, industrial, domestic, livestock, fish and wild life, and recreational uses. For beneficial irrigation water use, a consumptive irrigation requirement is defined as the quantity of irrigation water, expressed as a depth or volume, exclusive of effective rainfall that is consumptively used by plants or is evaporated from the soil surface. Consumptive use is then defined as the quantity of water consumed during the application of water to beneficial use. The quantity of water beneficially consumed depends on the requirements of a particular enterprise and how it applies and consumes the water. The authorized diversion of water that is not beneficially consumed in the course of water use is not part of the allowable consumptive use allocation of the water right. The consumptive use by a crop (beneficial evapotranspiration) does not include depletions such as evaporation from canals, ditches, or irrigation fields during surface application, transpiration by vegetation along ditches, evaporation or leakage from irrigation water pipes, evaporation of sprinkler spray and drift losses, and evaporation of runoff and seepage from irrigated fields (non-beneficial ET). The volume of water right for irrigation use is set based on the calculation of beneficial ET and other factors. The ET calculations are redone periodically to confirm that water is being used beneficially. The state is developing long-term data sets that will improve the process over time.

Return Flow Credit. An innovative and integral part of the water right includes a provision whereby water users can receive a credit on surface water return flows, expressed as a percentage of the total diversion of surface water that has been applied to beneficial use and returned to the same surface water stream from which it was appropriated. A return flow credit does not entitle the user to increase the authorized consumptive use amount. The return flow credit process is administered separately to ensure that return flows meet certain water quality standards (state and national).

Note: Further information is available on the website <http://www.ose.state.nm.us/>.

BOX 5.2 From Formal Rights to Contracts and Claims

Much of the literature on water rights focuses narrowly on formal rights and ownership regimes. Hence, rights are often discussed only as legal instruments issued by state agencies, or in terms of private/public and ownership/use distinctions. In practice, law is not the only source of authority that assigns effective rights, particularly where logistical and administrative hurdles make it difficult for the state to assign, monitor, and enforce individual entitlements.

Internationally, contractual agreements and rights asserted through user groups are widespread, particularly in irrigation schemes. Such arrangements can also be found in China. In some irrigation districts, for example, an agency will supply water to water user associations (WUAs) on a contractual basis: contracts have no legal authorization, but do specify the rights and obligations of both the agency and WUAs. At the farmer level, membership in a WUA then confers an entitlement to receive a bundled water service, subject to payment for that service.

Such arrangements can work well, even though they lack legal force. In particular, allowing farmers a say in decision making through a WUA can strengthen their ability to assert a claim to water proportionate to land area in systems where farm-level, volumetric monitoring is not possible. A key lesson is the need to improve participation and accountability, and thus strengthen rights.

Sources: Meinzen-Dick and Bruns 2000; WET 2007.

options for managing water demand (Perry et al. 1997; Hodgson 2006; WET 2006). For example:

- *Government-facilitated reallocations.* A water rights system provides greater transparency when the government chooses to reallocate water among water users. This in turn can provide confidence as to the consequences of the reallocation.
- *Reducing total water allocation and use.* Regulations can be used to reduce the water available under water rights, providing a fair and transparent mechanism for reducing total water use.¹
- *Pricing mechanisms.* Clearly defined water rights can provide an equitable basis for levying water charges, including both service charges and resource management fees.
- *Water markets and trading of water rights.* Well-defined water rights are an essential prerequisite for the establishment of a water market.

Requirements for a Water Rights System

A water rights system depends on clear, certain entitlements to water. For a system to deliver this requires that all relevant water and water use be managed within the regulatory system. Allocations need to be based on a planned approach, recognizing the entirety of the resource being allocated, as well as both current and future water use requirements. The allocations then need to be regulated at the water user level. To do this, a water rights system typically relies on (a) a planning mechanism to identify the available water resource and demands and define the total volume available for allocation—usually this is via some form of water allocation plan; and (b) a regulatory mechanism to enforce the allocations made under the water allocation plan, usually in the form of a licensing system.

This, in turn, requires that:

- Water allocation plans should be based on hydraulic boundaries—natural water basins or

aquifers—rather than political or administrative boundaries.

- All water sources should be managed in an integrated way, including both surface and groundwater.
- Total control over water use is maintained, including regulating water abstraction, consumption, and discharge volumes where necessary.

Due to the inherent variability in water resources, water rights will often assign a share of the available resource as opposed to a fixed volume.² The actual volume available to the right holder will vary depending on climatic conditions and the volume available at a particular time (in the reservoir, aquifer, or river). Consequently, water rights need to be allocated both in terms of the long-term right to water (via the water resources allocation plans, abstraction permits, and water certificates described above), and on an annual or seasonal basis, depending on actual availability in a given year. Annual entitlements to water would normally be a function of the long-term rights to water and the actual water available.

The process of determining annual water shares is critical to providing certainty to water users. Where this process is based on a pre-set formula, water users can be confident their share of the water resource is allocated in a consistent and transparent manner. Box 5.3 describes the annual and longer-term basis for determining allocations in Israel, where volumetric quotas are the principal instrument for ensuring a balance between demand and supply.

Water rights systems also depend on robust registration systems for recording water rights, sound monitoring systems to ensure water users take water only in accordance with their entitlements, and water accounting and reporting systems to provide transparency and confidence that the agreed management regime is being implemented. Systematic registration and monitoring of rights is a major challenge in many countries, and particularly so in China because of the numbers of water rights involved. Box 5.4 compares

BOX 5.3 Water Allocation Priorities in the Middle East: the Case of Israel

The Middle East is one of the most water-scarce regions of the world, with an average per capita water availability of less than 1,000 m³. Within the region, each country has to struggle with a fundamental challenge: how to safeguard the interests of agricultural users whilst meeting the needs of domestic and industrial consumers. Israel, with a per capita water availability of less than 300 m³, has arguably gone furthest in promoting water conservation and reallocation, based on the rigorous assignment and monitoring of quota-based rights.

As in China, Israel's 1959 Water Law defines water resources as public property subject to control by the state, with centralized powers for allocating water between competing uses. Specifically, the amount of water allocated between broad sectors in each calendar year is fixed by a water commissioner with wide-ranging powers, while water use within sectors is controlled through permits and pricing. All users in Israel require a license, which is issued annually.

Over the last two decades, Israel has gradually reduced annual allocations of freshwater to agriculture from over 70 percent of total allocations in 1985 to 55 percent in 2005. The change in water allocation has been possible for two main reasons. First, the country's economy is industrializing and there is waning dependence on agriculture. Second, there is rigorous enforcement of sectoral quotas and technical standards, with incentives to avoid waste within quotas through pricing.

Sources: Allan (2001); Cornish (2004); Zhou (2006).

BOX 5.4 Registering and Monitoring Users: International Comparisons with Groundwater Management

The Asian debate on how to create an effective groundwater management regime has been swayed by success stories from Australia, the United States, and Europe. Recommendations have therefore focused on the assignment and monitoring of clear water rights through well licensing. A major problem in transferring such lessons to China, however, is the number of people involved.

In a typical groundwater district in the U.S. or Australia, the total number of farmers is probably less than a thousand. In a comparable area in China, there may be 100,000 farmers, each withdrawing small volumes of water. Such users might be exempt from licensing in many countries. In the Murray-Darling basin in Australia, for example, permits are mandatory for all groundwater users, except those withdrawing water for domestic or livestock needs, or for irrigating small plots of 2 ha or less. A similar exemption applied on the North China Plains would exclude over 95 percent of groundwater irrigators.

What are the implications? In groundwater-dependent northern China, "thick and deep" approaches to rights-based regulation may only be practical in some well-defined, strategically important areas. In other areas, alternatives may have to be considered. One approach, currently being piloted, is to issue volumetric licenses to groups of groundwater users organized as WUAs. Water bureaus would be responsible for setting volumetric caps, but users themselves would monitor and enforce compliance, with penalties for above-quota abstraction and incentives for below-quota abstraction.

Sources: Shah et al. 2003; Calow et al. 2006.

rural groundwater management approaches in Australia, the U.S., and Europe.

Water Allocation and Environmental Flows

The granting of water rights is inherently linked to the process of providing for in-stream environ-

mental water requirements (commonly referred to as environmental or ecological flows). By determining how much water can be abstracted by water users, a water rights system—whether deliberately or by default—will determine the volume of water left for in-stream environmental purposes (WET 2007). The water resources allocation plan then is the key regulatory instrument for

determining the volume of water available for consumption, as well as for prescribing the environmental flows that will be maintained in a watercourse or aquifer.

The first step in the water allocation process should involve the division of water between environmental and human (consumptive) needs. The water set aside for human needs can then be subdivided amongst different regions, sectors, or individuals as required. The water set aside for the environment may be specified as a clearly defined “water right,” held by some entity on behalf of the environment (as is now the case in some jurisdictions in Australia), or may simply be the difference between the total resource less that allocated for consumptive purposes. In South Africa, a spe-

cific water reserve is set aside for environmental purposes. In Mexico, a statutory definition of minimum flows for rivers is defined (Hodgson 2006). Box 5.5 provides a summary of how environmental flows could be defined and allocated in China based on international experience.

The Need for Public Participation

Most modern water codes also emphasize the need for user participation in developing and approving plans and monitoring compliance. This is because the public is the primary stakeholder and main beneficiary of an effective water management system. The core of public participation is access to information, which is discussed in chapter 4. The

BOX 5.5 Determining and Defining Environmental Flows

Flow regimes are important to riverine health and freshwater biodiversity for several reasons. For example, (a) flow is a major determinant of the physical habitat in streams and rivers; (b) river species have evolved life cycles in response to natural flow patterns; and (c) flows maintain natural patterns of longitudinal and lateral connection. To protect freshwater biodiversity and maintain environmental services, it is therefore important to mimic components of natural flow variability. How can this be achieved?

A methodology for defining and providing environmental flow

The following steps should form part of the water resources allocation process. They are designed to identify the key assets, the flows they depend on, and management options to deliver those flows:

- *Step 1.* Identify the key river assets: these may be ecological, social, or economic, and can include specific species (e.g., a key commercial fishery) or habitats (e.g., an important wetland).
- *Step 2.* Identify the constraints on the asset: determine whether it is changes to the flow regime or other factors (e.g., pollution) that are affecting the asset.
- *Step 3.* Determine the key parts of the flow regime (e.g., low flows, summer flows, floods, etc) that are important to the asset. Determine how these flows have been, or will be, affected by water resources development. Assess the extent to which this change is likely to impact on the asset, based on analysis of historic flow patterns in the subject river or similar rivers.
- *Step 4.* Assess the capacity to alter water resources management rules to provide for the flows identified as important to the key river assets. Set environmental flow objectives, and develop management options to meet these objectives.
- *Step 5.* Establish monitoring requirements to assess whether the environmental flow objectives are being achieved.

Management options for delivering environmental flows

Management options can include a combination of: capping total water abstractions (i.e., total number and volume of permits); setting water sharing rules to decide the water available for each user (including the environment) in each year; setting specific operational rules that require reservoir operators to release water at certain times; and providing a specific allocation of water for the environment.

Source: WET 2007.

success of public participation in water resource management in the form of water user associations (WUAs) has been demonstrated in a number of pilot projects in China, including the World Bank's Water Conservation Project.

DEVELOPMENT OF WATER RIGHTS IN CHINA

Legal and Institutional Arrangements

Ownership of water resources is addressed in China's Constitution and the Water Law 2002. These state that water resources are owned by the state on behalf of the whole people, with ownership exercised by the State Council on behalf of the people.

The Water Law 2002 is the key law dealing with water rights. It provides a comprehensive framework for water planning and for the allocation of water rights. The law includes provisions on water resource ownership, rights of collectives to use water, water abstraction rights, water resource planning, water resource development and utilization, water resource conservation, water resource allocation, water use and savings, dispute settlement, and administrative responsibilities.

The Regulation on Water Abstraction Permits and Water Resource Fee Collection (the Water Permit Regulation) then provides a framework for granting and managing water abstraction permits. Water permits are subject to the provisions of the Law on Administrative Licenses.

The Ministry of Water Resources, on behalf of the State Council, has the primary responsibility for water resources management. Under the Water Law, MWR is responsible for managing water resources development, utilization, saving, conservation, and flood prevention. It is responsible for the preparation of water plans (regional and basin, flood management, water allocation, water protection, etc.) and for the management of water abstraction permits.

The River Basin Management Commissions (RBMCs) are authorized by MWR to manage water resources in their respective river basins. Water resources bureaus of local governments above the county level are responsible for water resources administration within their political boundaries.

Water Resources Allocation, Abstraction Permits, and Certificates

The Water Law 2002 describes the requirements for water resources allocation plans. Allocation of water is via both basin and regional water resources allocation plans, through which water is allocated among administrative regions. Thus, water in a transprovincial river is allocated among provinces. Provincial-level plans allocate water among prefectures, and prefecture-level plans allocate water among counties. Departmental guidelines on water resource allocation plans are currently being prepared.

The nature of the allocation to regions varies; in the northern part of China, it typically consists of an annual average water consumption volume; in the southern part of the nation, it is typically an annual water abstraction volume. In some cases in the north, plans specify required end-of-system flow requirements. In some cases in the south, allocation is done by flow rate in the dry season. In addition to regional allocations, plans may also allocate water to particular sectors (agricultural, industrial, etc). The allocated volume may be for both groundwater and surface water.

Access to water resources by an individual or unit is regulated by a water abstraction permitting system. By law, all water abstractions require a water abstraction permit. There are certain exemptions, such as for livestock and domestic purposes in rural areas and rural collectives taking water from their own ponds and reservoirs.

The permitting system is governed by a regulation issued by the State Council in April 2006. The water abstraction permit regulation provides a framework to be applied by all provinces in man-

aging water abstraction permits. The regulation provides details on the process for granting and managing permits. In general, a water withdrawal permit is valid for 5–10 years. The regulation requires that issuing water withdrawal permits should be based on approved water resources allocation plans and allocated water quotas.

Within irrigation districts, an abstraction permit for the whole district is usually held by the government agency responsible for administering the district. Farmers are then supplied their share of the water available to the irrigation district under the permit. In some areas in northern China, a district plan is developed that identifies each farmer or village's share of the available water. In most instances farmers do not hold any form of individual entitlement and allocations are made based on land area. In a few pilot areas trials have been conducted on granting water certificates to farmers that identify each farmer's share of the resource. This is coupled with a water ticket system, under which farmers pre-pay for the water they want in a particular year, season, or watering. A farmer is allowed to purchase water tickets up to a limit, based on their certificate volume and seasonal availability (see Boxes 5.6 and 5.11).

Annual Allocation of Water Supplies

In addition to the process for allocating long-term rights to water, a separate but connected process exists for determining the actual volume available for abstraction (or consumption) during any given year.

At the basin and region level, the annual allocation of water rights occurs via the annual water regulation plan. This plan is usually prepared based on the available and/or predicted water supply for the year. Some water regulation plans, such as that for the Yellow River, may be adjusted during the year to bring the plan into line with actual water conditions. In practice, annual regulation plans are not prepared for many rivers, particularly in southern China, where water resources are relatively abundant.

Holders of water abstraction permits are required to submit an annual water use plan to their administering authority. This is used as the basis for preparing an annual water abstraction plan, which dictates the actual volume available to the permit holder for the year. At the irrigation district level, annual or seasonal plans may then identify the actual water available that year and when it will be delivered. Some level of consultation is usually undertaken with farmers. Increasingly this consultation is via newly established water user associations. Again, this process is generally limited to the drier, northern parts of China.

Structure of Water Rights in China

Drawing on the above, water rights in China can be described in terms of three different levels of rights (WET 2006):

- *At a regional level.* Water resources allocation plans allocate available water within and between different provinces, prefectures, and counties, as well as between different sectors.
- *At the abstractor level.* Rights are assigned to individual abstractors.
- *At the village or farmer level.* Rights to a share of the water available within an irrigation district are shared among farmers, households, or villages.

Further, water rights at each of these levels exist in terms of both long-term and annual or seasonal rights to water.

Water Rights Management

The Water Law 2002 requires that water use be metered and subject to volumetric charges (water resources fees). Currently, domestic and industrial water users in most parts of China are subject to water resource charges based on quantities used. Measurement and monitoring facilities for regulation and enforcement are weak. There is

still a significant amount of water use that is not measured, and water for irrigation use is largely measured by the area of irrigation land, not the quantity of water withdrawn or consumptively used. The registration and measurement of groundwater abstraction is particularly limited due to the large number of dispersed wells (Lohmar et al. 2003; Shah et al. 2004; Wang et al. 2007b).

While the water rights and discharge control systems are well-advanced in terms of issuing rights, there are major deficiencies in regard to control and enforcement. In many cases water rights are paper documents not effectively used in water resources management because of inadequate control and enforcement of water use and discharges.

WATER RIGHTS REFORM IN CHINA: CASE STUDIES AND PROJECT INSIGHTS

Water rights systems typically evolve to meet the requirements of the local conditions. In particular, it is clear that the most detailed and robust systems inevitably develop in those regions where water is most scarce, and where there is greatest pressure on the resource. For these same reasons, the allocation of water rights in the Yellow River provides perhaps the most sophisticated example of the application of a water rights system in China (WET 2006). Box 5.6 summarizes how water is first shared among the 10 provinces and autonomous regions that take water from the Yellow River and, using Inner Mongolia as an example, describes how shares are assigned within the region, and to irrigators in Hangjin Irrigation District in particular.

In addition, a growing number of projects are contributing to water rights reform and lesson learning. Although each initiative has its unique characteristics, many share common points, including the assignment of water rights to specific institutions or groups; the transfer of funds between suppliers and users of water; the use of

innovative approaches (including water tickets and marketable quotas) to implement policies; the use of consultation (in some cases) between the various water users and institutional partners; monitoring and evaluation procedures to determine allowable withdrawals; the use of trades and markets to help promote more efficient use of scarce water supplies; and the constant need for institutional or legal changes to permit these systems to develop.

A recent development is a shift from focusing on water extraction to water consumption. Advances in remote sensing and geographic information system (GIS) techniques have made it feasible to manage irrigation water resources in terms of the amounts of water actually consumed by crops, trees, and weeds for evapotranspiration (ET) rather than manage total water withdrawals from surface and groundwater sources. The portion consumed through ET is the “real” consumption that is lost and not available for users downstream or from the aquifer. In contrast, the portion that returns to the surface or groundwater systems is still available for other users downstream or from the aquifer, unless its quality has deteriorated to the point that it is not suitable for economic use, in which case the losses are “real” losses.

The ET approach may be particularly useful in China. In its water-scarce areas, it is important to manage water resources in terms of net water consumption (i.e., ET). Past management in China based on water withdrawals has been shown to be unsuccessful because even with the same water withdrawal, the saved water from water conservation may be used to irrigate more land; that is, more water is consumed with less water returning to the local water system. In contrast, the ET approach focuses on actual water consumption, and encourages farmers to reduce water consumption. For example, farmers can reduce evaporation by reducing waterlogged areas, irrigating when evaporation is lowest (at night instead of during the day), using moisture-retaining mulches, and replacing open canals and ditches with pipes. Where excessive fertilizer

BOX 5.6 From River to Farm: Water Rights and Allocation in Inner Mongolia Water Resources Allocation Plan for the Yellow River

In 1987, the State Council approved a water resources allocation plan—the Plan of the Available Supply for Water Distribution—for the Yellow River to coordinate the water demands of the multiple users and regions within the basin. The Yellow River Basin Management Commission is charged with setting minimum flow requirements for the river at provincial boundaries and allocating relative shares of available water to 10 provinces and regions.

In a normal year, Inner Mongolia receives 5.86 billion m³ out of a total flow of 37 billion m³. In a drought year, however, shares across provinces are reduced. Ongoing shares within any given year are detailed in an Annual Regulation Plan based on the Annual Allocation Plan for the basin (published by the commission), which incorporates an annual water forecast and annual reservoir storage and reservoir “balancing.” In addition, the Regulation Plan provides for short-term adjustments.

Water rights of abstractors in Inner Mongolia

Water abstractors within Inner Mongolia require water abstraction permits, administered in accordance with the Regulation on Water Abstraction Permits. The largest of these are for Hetao and Hangjin irrigation districts, held by the Inner Mongolia Yellow River Irrigation Management Bureau (within the Water Resources Department of Inner Mongolia). Permit No. 1 for Hangjin Irrigation District (HID) allocates 410 million m³ to HID, including a mandatory return flow of 35 million m³ per year, though actual diversions vary according to available shares.

Water sharing within Hangjin Irrigation District

Currently there are no formal long-term rights granted to water users within the district. Rather, annual and seasonal plans are implemented through an iterative process of scrutiny and adjustment, with demands articulated through WUAs adjusted, as necessary, to account for supply restrictions imposed by the YRCC. The allocation process combines bulk volumetric charging to WUAs with area-based charging for farmers. Water User Associations purchase water tickets on behalf of farm members in advance of each irrigation, as part of what is both a preordering and prepayment system.

A pilot project within HID has defined water entitlements to the WUA level—the lowest volumetrically monitored points on the system. Allocations to WUAs can now be formalized by granting water certificates to each WUA. The annual-seasonal allocation process, and the sale of water tickets to farmers, would be undertaken within this framework. Once all stakeholders have gained experience in operating the rights-based system, water trading between WUAs can be contemplated.

Lessons

From a water rights perspective, the process of allocating water within the Yellow River demonstrates clearly how inter-connected the different management arrangements are. The water entitlement of a farmer within HID is a function of the rights held by the district as a whole, and of Inner Mongolia’s share of the available water from the Yellow River. A robust water rights system depends on an integrated and consistent approach to managing these water rights, at all levels.

Source: WET (2007).

and pesticides runoff is a problem, the ET approach will encourage farmers to reduce their chemical use and runoff, since return flows that are unusable downstream will be deducted from individual ET quotas.

One such ET-based initiative is the Hai Basin Integrated Water and Environment Management Project, which is discussed in Box 5.7.

A key element of this project is the distinction made between consumptive and nonconsumptive water use, and the practical implications this has for the definition, allocation, and monitoring of rights. As noted in Chapter 3 (Box 3.4), the distinction is a vital one in any demand management strategy, since only those savings in consumptive water use—specifically, nonbeneficial

BOX 5.7 Defining and Allocating Consumptive Water Rights in the Hai Basin

The Hai Basin Integrated Water and Environment Management Project has been under implementation since 2002. It is managed by the Chinese government with the assistance of the World Bank through a Global Environment Fund (GEF) grant. The project is piloting water resources planning and management through the allocation of ET quotas. The objective is to increase the volume and value of agricultural production in the demonstration areas, while not exceeding the ecologically sustainable withdrawal limits. Because of current excessive withdrawals of water resources in the basin, this amount will be less than the current ET and will be gradually lowered until enough water is released to maintain environmental functions and avoid groundwater depletion. This goal can only be achieved by reducing nonbeneficial and low-beneficial ET, and raising crop water productivity (yield and value of production per unit of ET).

The project uses satellite remote sensing techniques to measure, target, and monitor ET at the basin level and at lower levels all the way down to individual farm plots. Once the complete monitoring system is in place and functioning, it will be possible to implement a water trading system to improve the economic efficiency of water use, while at the same time ensuring that water usage is sustainable and not overexploiting the water resources. The Hai basin project also establishes that a cooperative coordination mechanism among governments and departments at different levels is crucial for implementing ET-based water rights administration.

Source: Development Research Center of the Ministry of Water Resources 2007.

ET and flows to nonrecoverable sinks—represent “real” water savings. A similar ET-based approach has also been adopted in the World Bank–funded MWR Water Conservation Project to reduce the current overexploitation of groundwater on the North China Plain (see Foster and Garduno 2004).

In the Song-Liao River basin, pilot projects aimed at reforming and modernizing the water rights regime have also been implemented at the watershed level. Here, the Song-Liao Basin Commission selected the Daling River basin and the Huoling River basin within the watershed as sites for pilot projects for allocating water rights. The initial allocation of water rights considers current water use and future water needs, and determines water quotas for each province based on individual water use quotas to promote an equitable allocation. Somewhat unique to this case in China was extensive consultation and coordination among the various authorities involved in water resources management and explicit consideration of maintaining sufficient stream flows to support aquatic ecosystems. Water allocation plans were developed at the basin level with active participation of the provincial governments.

Comprehensive reform of water rights has also occurred in the Heihe (Black River) basin in Gansu, with Zhangye City selected by MWR as the first pilot project in China to build a water-saving society and establish new systems of water rights administration. This initiative is discussed further in Box 5.12.

BASICS OF WATER MARKET AND TRADING

The Advantages and Disadvantages of Market Allocation

Growing water scarcity and increasing differences in water values among users have prompted growing interest in water markets as a means of improving water allocation and reducing scarcity costs. The theoretical foundation underlying water trading is based on the difference in the economic value of water in different uses. When water availability is insufficient to cover all water needs, water markets with legally defined, market-tradable rights allow for the purchase or lease of water-use rights among users. The result is to reallocate water from low-value

uses to higher-value uses, with both buyers and sellers better off than before. In this way, market transfers can raise the average productivity of water within a sector (typically agriculture), as well as provide a mechanism for reallocating water between sectors (from agriculture to urban-industrial users). Water markets should define the three central components of water rights: water extraction, actual water consumption (an ET measure), and return flows. Note that most sellers of water rights are not concerned with how water is actually used by the “buyer” of the water right (that is, consumed or just passed through the system), since the negative impacts will occur further downstream and will not, in most cases, affect the initial seller of the water right.

When properly measured and defined, market transfers of water have a number of potential benefits over alternative allocation mechanisms. In contrast to allocation through administrative order, for example, market allocation guarantees compensation to users, with decisions based on individual (or group) assessment of the value of water in alternative uses. In contrast to water pricing, a system of tradable rights is also voluntary: only those entering the market will pay (or receive) additional charges associated with the purchase (or sale) of entitlements. The reallocation of water then becomes a matter of voluntary and mutually beneficial agreements between willing buyers and willing sellers (Dinar et al. 1997; Chong and Sunding 2006). The voluntary nature of water trades serves to safeguard sellers (for example, farmers) who always choose to stay out of the market to ensure they will not be worse off as a result of the trade.

Market transfers also have some disadvantages, however, related to the specific characteristics of water and the potential for market failure. These include defining water rights, especially when flows are variable; measuring water flows, especially in systems where monitoring is weak or absent; enforcing withdrawal rules; properly accounting for actual water consumption (a mea-

sure of ET—a physical “loss” from the water system); investing in the necessary conveyance systems; and the need to account for external or “third party” impacts, such as those that might occur if return flows from irrigation are sold without reference to downstream groundwater users (Dinar et al. 1997; Cornish et al. 2004; Perry 2007).

Water Rights and Market Types

Internationally, the most common types of market transaction occur through informal “spot” markets in the absence of formally defined rights. These usually involve trading water among similar uses: the sale or exchange of irrigation “turns” in a rotational system, for example, or the sale of water by the owner of a groundwater borehole to nearby farmers (Perry et al. 1997).

Tradable water rights, on the other hand, are based on an initial specification of rights determined by available supply, and specification of the conditions under which rights may be traded. Volumetric rights can then be assigned to individual beneficiaries within sustainable limits, with rights holders allowed to buy or sell either the right itself (a market in tradable rights), or buy and sell the water only (a lease market) subject to certain rules. In both cases, the initial specification of rights—and their subsequent monitoring and enforcement—should ensure a balance between demand and supply, with specified assignments for social and environmental uses.

It follows that tradable water rights are more likely to support inter-sectoral and/or inter-regional transfers. However, such transfers may also have to meet stricter preconditions. For example, restrictions may apply to ensure that certain minimum flows in a stream or river are maintained for environmental or recreation reasons, or to protect the rights of other users who may be affected by a transfer. The volume of return flow (extractions for use minus the actual ET consumption) is a key variable. For this reason, most formal markets have been confined to individual basins or service areas.

INTERNATIONAL EXPERIENCE WITH WATER MARKETS

Internationally, tradable water rights are still a rarity. Most countries facing severe water scarcity (for example, the case of Israel in Box 5.2) have opted instead for administrative systems based on top-down allocation plans and licensing arrangements. Nonetheless, interest in water markets is growing, and experience in countries such as the U.S., Spain, Australia, Mexico, and Chile indicates that market transfers can generate significant economic benefits (Saleth and Dinar 2004; Chong and Sunding 2006).

The water-scarce western United States is home to some of the world's most active water markets (Landry and Anderson 1997). Water rights regimes vary between states but, in most cases, are tightly controlled and regulated. Colorado, for example, has a strict system of water rights based on the prior appropriation doctrine that is legally enforced, transparent, and provides all users—favored or otherwise—with information for planning their operations. Market transactions are embedded in a legal

and institutional framework that carefully regulates external effects, with the Office of the State Engineer investigating all aspects of proposed developments and transfers. Moreover, each of the seven water basins in Colorado has its own specialist Water Court, dealing exclusively with water issues and water disputes. Only consumptive rights can be sold, and only under the condition that no injury is done to downstream users (Perry et al. 1997; Marino and Kemper 1999).

While such arrangements provide safeguards for third parties, obtaining authorization to change water use is often a lengthy and costly process. An exception is the Colorado Big Thompson Project, where relatively unrestricted trading of water rights is permitted (Box 5.8). Because of significant variations in water demand between areas and users, the Northern Colorado Water Conservancy District established a water market allowing rights to be traded on a permanent basis, with a central registry for recording ownership and ownership transfers. In this case, rights are defined as diversions rather than as consumptive uses; downstream users who may

BOX 5.8 The Colorado–Big Thompson (C-BT) Project

The C-BT Project represents one of the most active and well-established water markets in the western U.S. The Northern Colorado Water Conservancy District (NCWCD) is granted by contract the perpetual right to use all water made available by the construction and operation of the C-BT Project. The NCWCD has the authority to allocate, reallocate, and set assessment rates on water allotment contracts. Permanent ownership and transfer of water allotments can only be approved for beneficial uses within the boundaries of the project area.

Each year, the NCWCD Board of Directors determines an “April Quota,” which sets the maximum amount of water available from project supplies for the current year based on hydrologic conditions and anticipated water demand. This may be adjusted according to hydrologic conditions during the course of the year. Individual water users obtain water rights through allotment contracts signed with the district. Annual fees are collected on each allotment to cover the fixed and operating costs of the project.

Since the early 1960s, water within the district has been actively traded among agriculture, municipal, and industrial uses. The success of the C-BT water market can be attributed to the establishment of clearly defined water rights, the high reliability of supply, its use as a supplemental “new” supply for the region, a well-developed distribution system, the large number and diversity of market participants, and, especially, to institutional rules and administrative procedures that minimize transfer restrictions and costs.

Source: Michelsen 1994; Marino and Kemper 1999.

benefit from return flows are not entitled to compensation if their water rights are affected by trade.³ This arrangement lowers the transactions costs of trade as third-party impacts are not considered, but raises the wider question as to when such impacts can and cannot be advantageously ignored.

The United States has also accumulated substantial experience in water banking, both temporary and permanent. Water banking is an organized water trade conducted through a clearinghouse to facilitate transfers within a given service area. Idaho's water supply bank was established in 1980 to facilitate short-term leasing or renting of water (Box 5.9).

Elsewhere, Chile has been a leading international example of the use of pro-market policies for water resources management (Bauer 1997). Chile's National Water Code of 1981 established a system of water rights that are transferable and independent of land use and ownership—essential preconditions for the development of formal water markets—with transfers subject to the general system of real estate title registration (Bauer 1997). Water rights are defined as permanent (from unexhausted sources) or contingent (temporary, from surplus water), and as consumptive and nonconsumptive.

The Murray Darling basin in southeastern Australia began allowing the market transfer of water entitlements in the 1980s in response to growing scarcity and variable water distribution.

The process began with the formalization of historic rights based on patterns of land use, with each riparian assigned an entitlement, or entitlements, specified in terms of both volume and security. Variations in the security of entitlement help ensure consistency with the erratic nature of water availability. The system is complex, allowing for the possibility to buy and sell high-, medium-, and low-security entitlements, and provisions for both seasonal and permanent transfers (Box 5.10).

EMERGING EXPERIENCE OF WATER TRADING IN CHINA: CASE STUDIES

The trading of water rights is just beginning in China. Current water laws have few provisions on water rights transfer, and provisions on aspects such as transfer conditions, procedures, and beneficiaries of transfer are incomplete. For example, MWR's *Opinions on Water Rights Transfer*, issued in 2005, sets out some fundamental principles to guide market arrangements, but provides little detail on how tradable rights should be defined and managed in terms of consumptive and nonconsumptive uses, return flows, and protection for third parties.

Although not strictly a market in tradable rights, pressure to release water for growing urban demands is driving ad hoc experimentation in inter-sectoral and/or regional transfers. For example, the cities of Dongyang and Yiwu in

BOX 5.9 Idaho Water Supply Bank

The Water Supply Bank manages natural stream flows and groundwater and is administered through the Idaho Department of Water Resources (IDWR). It substitutes for a water rights transfer process by removing some of the assessment requirements of transfers. Consequently, access to water sought through the Water Bank is generally provided within a couple of weeks, as opposed to several months through a water transfer. The IDWR keeps a list of water rights available for lease on the Internet; interested parties can call the IDWR to see if water may be available to them.

Water users who in any given year have rights to more water than they need can put the excess stored water or natural flow rights they will not use in the bank. From there, the water can be sold or leased to people who do not have enough to meet their needs. This system helps make excess water available to other users for irrigation or other authorized uses. Water from the Water Supply Bank has also proven valuable in providing stored water for downstream salmon recovery efforts.

BOX 5.10 Water Markets in the Murray Darling Basin, Australia

The Murray Darling basin is home to probably the most advanced system of tradable water rights in the world. In a process that began more than 20 years ago, water rights in the basin have been formalized, separated from land ownership, and specified in terms of both volume and supply security. Water users in all states now hold a legal entitlement to a water share specifying the source of water, its reliability and/or security, and conditions on how that water may be used. In addition, salinity entitlements—the rights of an area to export (i.e., flush away) salt—have also been defined, with each area obliged to stay within its entitlement or face stiff penalties.

Water trading can be either temporary or permanent. In temporary trading, a right to take water—but not the right itself—is sold for a particular season once the water has been confirmed as available. Such transfers are widely used to reallocate water locally between individual users, generally within irrigation schemes. In permanent trading, ownership of the water allocation itself changes and the seller relinquishes all rights to the entitlement. These trades generally reflect some form of structural adjustment within an enterprise or the introduction of water efficiency measures.

To date, the market for temporary transfers has been much larger than that for permanent trade. For example, of the 990 million m³ traded across the Murray-Darling basin in 2001–02, only 8 percent was traded permanently. This reflects the fact that temporary trades are more localized, easier to organize, and not subject to the same kinds of restrictions that apply to permanent transfers. In both cases, transfers are voluntary, with prices agreed between buyer and seller, and with price and sale information made publicly available, often online.

Water trading within states has been possible since the late 1980s. Procedures for interstate trading have only recently been developed and piloted. These include the specification of “equivalent ratios” defining, at a basin scale, what a unit of water in one place equates to in another; approval processes in both buying and selling states’ water licensing authorities (both states must approve the trade); and annual adjustments to state allocations made by the commission to reflect any transfers that have taken place.

Source: Murray Darling Commission website, www.mdbc.gov.au; Turrall et al. 2005; WET 2006.

Zhejiang Province signed China’s first intercity trading agreement under which Dongyang agrees to transfer a total of 50 million m³ of water each year to fast-growing Yiwu at a price of RMB 200 million yuan. Dongyang will bear the cost of water reservoir maintenance, and Yiwu will pay a management fee based on actual water supply at a rate of RMB 0.1/m³ in addition to constructing the water conveyance infrastructure. However, such arrangements do not constitute an exchange of clearly defined tradable rights. Rather, transferred water is assumed to be owned exclusively as a private good by the donor city, or water resources administration, with trade occurring via closed contractual agreement rather than a market with many potential buyers and sellers. In this instance, specification of the transfer as a fixed volume rather than a share of available supply has led to

problems. Dongyang was obliged to transfer 50 million m³ of water to Yiwu even during drought, adversely affecting agricultural production and generating strong opposition from local people.

Similar types of transfer have also been brokered between irrigation districts and downstream urban-industrial users. For example, the Inner Mongolia Water Resources Department has initiated pilot projects in which industries are encouraged to invest in water-saving facilities in agriculture and, in return, receive the water from leakage and waste reduction in irrigation. Under the guidance of the Yellow River Conservancy Commission and MWR, Inner Mongolia has assigned water withdrawal quotas among six riverside cities, drafted a plan for water transfers, and established an Office for Water Transfer Affairs to manage transfer funds and oversee

implementation. One such agreement is discussed in Box 5.11.

The channel lining and water transfer model is, in many respects, an attractive one: downstream industries can weigh up the costs and benefits of water-saving investment in irrigation districts and reach market decisions; the water permits of IDs can be adjusted and enforced by government agencies to reflect transfers; new investment in supply augmentation can be deferred or canceled, and farmers see their irrigation charges fall as they no longer pay for leakage. Nonetheless, the Hangjin experience also highlights some potentially negative impacts, particularly in terms of agency financing and third-party effects.⁴ Moreover, rights to the traded water remain ambiguous. In particular, it is unclear whether the permits assigned to irrigation districts are owned by the irrigation agency, or just held by such organizations on behalf of farmers in a form of “trusteeship.” Other programs in China have focused more on establishing the basic under-

pinnings of rights-based management, with water trading viewed as one of a number of beneficial outcomes. One initiative combining many different elements has been implemented in the water-scarce Heihe (Black River) basin in Gansu Province. The city of Zhangye accounts for 92 percent of the population and 83 percent of the total water withdrawal in the river basin, and has a critical role in the sustainable use of the basin’s water resources. To optimally utilize the water resources of the Black River and mitigate conflicts between water withdrawals and environmental flows, a range of measures has been implemented (see Box 5.12).

Since implementing the pilot project, Zhangye has made good progress in water resources management. Water withdrawals from the Black River have been reduced by more than 300 million m³ each year; downstream aquatic ecosystems and the environment are gradually recovering; and Lake Juyanhai has restored streamflow after many dry years.

BOX 5.11 Channel Lining and Water Transfer: Experience from Hangjin Irrigation District, Inner Mongolia

In order to address water shortages experienced by downstream industrial users on the Yellow River, the Office for Water Transfers Affairs under the Water Resources Department of Erdos City has initiated a novel water transfer project. Beginning in 2004, the office has overseen a program in which irrigation returns saved through channel lining in Hangjin Irrigation District are transferred to downstream industries, with the costs of lining met directly by industrial beneficiaries. The outcome is a transfer of 78 million m³ of water to downstream users.

Although the transfer program is a new one, its effects on different stakeholders are already becoming apparent. In particular:

- *Impact on industry.* The willingness of industrial enterprises to invest in channel lining indicates that this is a least-cost supply option for them, at least in the short to medium term.
- *Impact on farmers.* Farmers have benefited from reduced irrigation fees as they no longer have to pay for unlined delivery (and therefore leakage) to WUA purchase points. Farmers are also likely to benefit from reduced soil salinity as waterlogging in some areas is a serious problem.
- *Impact on the irrigation agency.* Hangjin Irrigation Management Bureau has seen its financial position undermined by the channel lining program, with losses of around 1 million CNY/year anticipated by project completion. This is because farmers are no longer paying for leakage.
- *Impact on other uses/users.* Some wetlands toward the tail of the irrigation district have dried up, and impacts on groundwater levels within and outside the district are uncertain. Questions remain over whether leakage reduction programs in water-stressed basins generate “real” savings (see Box 3.4).

Source: WET 2007.

BOX 5.12 Defining, Allocating, and Trading Rights in the Heihe Basin

Zhangye City in the water-stressed Heihe (Black River) basin of Gansu Province was chosen by the MWR as the first pilot project to build a water-saving society and establish a system of water rights administration. A sequenced approach to improving water resources management has been implemented, focusing initially on data collection and analysis and the definition and allocation of water rights. Following this, various demand management measures were implemented, including water use controls, quota management, water pricing, and the introduction of water markets.

- *Water allocation and quota management.* Water rights were defined and clarified with quantitative targets for water consumption determined in the Water Allocation Plan for the Black River. Local governments at district or county levels and their water bureaus allocate water among reservoirs, irrigation, urban water supply, and other water uses.
- *Water ticket and trading system for irrigation.* A water ticket system was established for the irrigation area of the Liyuan River, with WUAs purchasing group tickets from the water administration on behalf of farmers based on their water use permits.
- *Farmers' water user associations (WUAs).* WUAs were established at the village level to promote voluntary participation in water management. Water user groups were then formed within the WUAs. Authorized by the government, all or part of the rights in maintaining, managing, and using engineering facilities were granted to water users for self-management.
- *Institutional arrangements.* Various institutional systems and administrative rules were established to support water rights management, such as Measures on Water Resources Administration, Rules on Water Rights Transaction Administration, Conventions on Water Affairs Consultation, and Measures on Management of Pumping Wells.

There are more examples of rights reform and water trading in China not included here. A general observation is that few represent purely market-based transactions. In most instances, there has been major government involvement in identifying the parties involved and brokering the deal. This is not a criticism, simply a recognition that there are multiple options for reassigning water, and in many instances efficiencies can be gained from some form of central control over the process.

CHALLENGES AND LESSONS FOR CHINA

There are a number of aspects of the current water management system in China that pose a problem to the introduction of a comprehensive water rights system of the kind outlined above. These are summarized below.

- *Rights to water are not clearly defined.* The rights afforded the holder of the entitlement are not

well specified. It is not always clear who holds the right and to what the right entitles them. Water resources allocation plans have only been completed in some basins, and seldom at all regional levels. Similarly, there are many water abstractors—particularly farmers in surface water irrigation districts and rural groundwater users—that do not hold abstraction permits.

- *Consistency and integration need improvement.* There is little or no coordination between water resources allocation plans at different levels. This leaves open the likelihood that plans that apply to the same area may be inconsistent. Similarly, there is little or no connection between water resources allocation plans and abstraction permits. Permits should be granted based on the volume of water available under an allocation plan; however, this is not currently the case with permits, which are generally decided on a case-by-case basis.
- *No total control over water use.* Different regulatory instruments (for example, different allocation plans or abstraction permits) can

take different approaches to the way water rights are defined. In some cases, rights are defined as an abstraction volume, in others as a consumption volume. These different approaches are not of themselves a problem. However, rights may be granted for abstraction, with an assumption that certain water will be returned to the system; that is, there is an assumption about the volume actually consumed. Where there is no requirement for this water to be returned, there is a risk that the assumption will prove false, resulting in overconsumption.

- *Environmental sustainability.* There is a general lack of consideration, and provision for, environmental water requirements. In some instances water has been set aside for the environment, but these volumes are generally not allocated on a sound scientific basis. This poses a threat both to the long-term health of the water resources in question, and hence also to the ability of the source to supply water suitable for human consumption.
- *Limited security.* There are few rules in place that protect against changes to water rights and no clear provisions dealing with what happens where an entitlement is adversely affected. Also, there is limited certainty for water users. There is broad discretion in terms of decisions affecting what water will be available under an entitlement in any given year—whether at the regional, abstractor, or farmer level.
- *Limited information and transparency of process.* There is limited information publicly available regarding how water is allocated from year to year, the details of permits, the monitoring of water abstractions, etc. This information is often stored in paper records by different agencies, and is difficult for other agencies or the public to access.
- *Limited public participation.* Procedures for public participation during the initial allocation of rights, trading, and management are not clearly defined, and there is little scope for

the public to be involved in, and to develop an understanding of, water rights and the allocation process.

- *Implementation, monitoring, and enforcement are generally poor.* In many cases, the overarching policies may be strong, but the capacity and resources do not exist to implement them fully. This is particularly so for rural groundwater use in northern China.

Specific lessons on water rights and trading can be drawn from market experience in other countries and China's emerging experience. These lessons include the following:

Lesson 1

The entitlements of users under different levels of water availability should be clearly defined, with assignments for environmental uses as appropriate. In particular, allocated water rights should not exceed water availability, determined through sound water balance analyses and ongoing monitoring.

The initial specification of rights should ensure an overall balance between demand and supply. In China, the step-wise approach to rights specification, allocation, and enforcement adopted in the Heihe basin and the Hangjin Irrigation District suggests a sensible way forward. The trading difficulties that emerged between the cities of Dongyang and Yiwu, on the other hand, indicate how problems can occur when rights are not clearly defined at the outset.

Major differences between the Chinese and international contexts should be noted, however. In China, most irrigation schemes were not designed or engineered to deliver controllable, monitored flows to individual farmers. This means that individual rights, of the kind taken for granted in the U.S. or Australia, have to be asserted indirectly through a water user group. In these circumstances, defining and allocating group entitlements is a practical alternative, but raises questions about the democratic nature of group decision making in water trading

decisions. Finally, there is the issue of environmental flows to be considered in water rights.

Lesson 2

Infrastructure needs to be in place that is capable of delivering changing allocations.

In China, most of the trades described in this chapter use existing infrastructure to reallocate water. For example, the water liberated from channel lining in Hangjin Irrigation District flows downstream to industrial buyers, with the permits of both buyer and seller adjusted accordingly. Local trade within IDs is also an option, though infrastructure has to be capable of redistributing water—at least to WUA purchase points—in accordance with market signals. One advantage of channel lining programs is that they enhance water control, making it easier to allocate water between areas and sluices and thus, potentially, between WUAs trading group entitlements.

Lesson 3

The ET approach targeting reduction in consumptive water use can be a powerful instrument for water management in conditions of extreme water stress.

The goal of improved water resources management and water rights allocation is the more rational use of scarce water resources. The ET-based water resource management being piloted in the Hai basin and elsewhere in China is an innovative approach. The ET approach helps promote the sustainability of the water resource system by focusing on the better management of actual consumption of water (actual ET) rather than just the extraction and use of water. This may be particularly important in the agricultural sector where different production techniques can result in very different ET outcomes, even with the same nominal water extraction quotas. In urban areas, an ET strategy will be designed to reduce water consumption (and increase return flows) rather than just focusing on reducing the gross use (extraction) of water.

However, from an overall perspective, ET-based water rights administration has not been accompanied by a replicable, developed, and sound administrative framework and institutional system, and still requires in-depth studies and explorations.

Lesson 4

Monitoring and measurement procedures and standards that are acceptable to both buyers and sellers should be in place.

Volumetric allocations require volumetric measurement, ideally direct measurement via water meters and sluices. In addition, measurement standards and procedures need to be accepted as legitimate by both buyers and sellers. Monitoring is more than a hardware issue. There are some sharp distinctions between international and Chinese contexts. Irrigation districts in China may include many thousands of small landholders, each using small volumes of (un-metered) water. Most systems combine bulk volumetric delivery to intermediate purchase points with area-based charging within each irrigation area. Transfers within irrigation systems (other than those arranged informally between neighbors, for example) will require the definition and reallocation of group rights.

Monitoring clearly becomes more complex when a distinction is made between consumptive and nonconsumptive uses of water withdrawn (as is explicit in the ET-based approach). Restricting trade to consumptive use has a fundamental advantage: third-party objections to transfers are potentially reduced since the amount of return flow can be specified.

Lesson 5

Effective regulation is needed, with procedures in place to identify and address third-party effects and resolve disputes, particularly for large-scale transfers.

Trading is embedded in a legal and administrative framework that carefully regulates transactions. Specifically, where water trading has

worked beyond the purely local level, there are in place laws assigning rights, laws describing how rights may be traded, legal systems that enforce such rights and punish infringements, and (in most cases) systems in place for protecting the interests of third parties. A key challenge is to encourage as much trading as possible while still addressing externalities.

RECOMMENDATIONS

Drawing on both international and Chinese experience, this chapter has examined the requirements for and functioning of a modern water rights system, and has analyzed opportunities and constraints for the further development of water trading in China. We offer the following recommendations.

- *Use water resources allocation plans as the basis for water rights.* Water resources allocation plans should be developed—first at the basin level, then at the regional level—as the basis for allocating water within a basin. Plans should clearly identify three components: (1) the water available for abstraction, (2) the amounts of water consumed, and (3) the amounts that must be returned to the local water system. Water rights should then be defined accordingly with plans setting a cap for total water abstraction permits in the plan area. Where possible, a practical distinction should be made between consumptive and nonconsumptive use so that water conservation efforts are effectively targeted, and water trading does not affect the interests of other users.
- *Recognize ecological limits of water resources.* Water resource allocation plans (and associated water rights) should recognize the requirements of the in-stream environment for water. Water should be set aside for this purpose, recognizing the importance of different parts of the flow regime for different parts of the ecosystem.
- *Water withdrawal permits need to be clearly specified and implemented.* Permits must be specified in volumetric terms and need to be linked to the initial allocation of water established in the water resource plan. The total amount of water withdrawal permits should be limited to the maximum allowable amount based on sustainable water use with sufficient consideration of environmental uses and new water uses.
- *Where feasible, an ET-based water resource management should be promoted.* The ET approach focuses on actual water consumption and hence encourages more efficient use of water, increased return flows, and the adoption of more water-saving technologies. The ET approach can thus help improve the sustainability of the water resource system in both agricultural and urban areas. Based on the experience of the pilot projects in Hai basin, the governments should promote the ET-based water resource management, especially in water-stressed areas.
- *Explore opportunities for trading but recognize its limitations.* The sale or lease of water rights can be an effective approach to raising the productivity of and returns to water within and between sectors. International experience—though limited—indicates that active markets of varying hues can generate significant economic benefits once certain preconditions are in place. However, establishing clear, enforceable rights—and then developing effective markets that work in the public interest—are often a complex and time-consuming process. A step-wise approach to water trading needs to be adopted.
- *Build capacity in water rights administration and trading and clarify responsibilities.* Water rights administration needs to be strengthened, with the conditions, procedures, rights, and obligations for water withdrawal, consumption, and return flows clearly specified. Adequate monitoring, reporting, and enforcing are part of effective water rights administration. Farmer claims to water shares within a group entitlement can be strengthened through investment in WUAs to raise participation and account-

ability. Allocating group rights to rural groundwater associations or user groups can also help address the problem of excessive groundwater withdrawals. Water trading further requires laws assigning rights, laws describing how rights may be traded, legal systems that enforce such rights and punish infringements, data on resource conditions and trends, and (in most cases) procedures in place for protecting the interests of third parties.

Endnotes

1. To maintain confidence in the water rights system, any reductions should be made in accordance with predetermined principles, particularly with respect to any compensation payable as a result of the reduction.
2. Even where rights are specified in absolute terms (e.g., Chile, Mexico), allocations may—for practical purposes—be translated into proportional shares (Hodgson 2006).
3. Neglecting third-party impacts represents an exception to the law in the western U.S., where return flows are treated as part of the system and subject to appropriation. The exception is possible here because of the transfer of supplemental water from another basin. The federal government retains ownership of all return flows (Frederick 1993; Marino and Kemper 1999).
4. This is also a subject of vigorous debate in the United States. For example, the saving “gains” from channel lining in a major, gravity-fed irrigation scheme were initially defined in terms of leakage reduction. Detailed analysis of the situation to determine water available for transfer, however, revealed that 80 to 90 percent of the leaked water was already consumed elsewhere, and thus potential “savings” were minimal (Perry 2007).



Improving Efficiency and Equity in Water Pricing

The pricing of water is a key determinant of the demand for water and the efficiency of water use. In recognition of this, central and local governments in China since the early 1990s have been increasingly using water tariffs to manage resources and improve water services, cost recovery, and demand management. Nevertheless, repeated studies have shown that water supply and sewerage prices are generally still too low in relation to the scarcity value of water, and are not yet adequate to balance supply and demand at a level that is sustainable for the long term. A key concern is the potential impact of further tariff increases on the poor.

To address such concerns, this chapter focuses on pricing issues regarding the supply of water—and the disposal of wastewater—for residential, industrial, and commercial use. It first presents an overview of water pricing policy and actual practice in China. Next, it looks beyond financial objectives, emphasizing that in principle prices should reflect the full delivery, environmental, and depletion costs. The chapter then reviews issues of social impact and affordability, and discusses pricing and income support methods to protect the poor. It refers to a number of implementation issues, as well as financial issues and metering. It concludes with recommendations on how to address potential impacts on the poor through careful design of water tariffs, as well as combining their implementation with expansion and improvement of water services for the poor.

WATER PRICING IN CHINA: POLICY AND PRACTICE

China has made a commitment to reform water pricing. Since the early 1990s, China has increasingly charged for water and gradually increased the level of water tariffs in both urban and rural areas. There are now regulations and policies laying the basis for governments to charge for water use based on local circumstances. Revenue from water tariffs already covers at least the operations and maintenance costs of most water supply utilities, even in many

rural communities. The general public is willing to support charges as long as the quality of the service is good and the tariff level is acceptable.

The Administrative Regulation on Urban Water Supply Pricing, introduced in 1998, provides a legal basis for water supply pricing in China. The regulation states that (a) the general principles for setting water tariffs are “cost recovery, reasonable profit, water conservation and social equity;” (b) municipalities are responsible for approving water tariffs; (c) tariffs should cover operation and maintenance, depreciation, and interest costs; (d) tariffs should allow for an 8 to 10 percent return on the net value of fixed assets, depending on the sources of funds; (e) tariffs should be appropriate to local characteristics and social affordability; (f) municipalities should gradually adopt a two-part tariff consisting of a fixed demand charge and a volumetric charge or increasing block tariffs (IBT), where the first block should meet the basic living needs of residents; and (g) public hearings and notice should be conducted in the process of setting water tariffs.

In terms of charges for wastewater, the Water Pollution Prevention and Control Law of 1996 provides a legal basis for charging wastewater fees to all users connected to an urban sewerage network. It stipulates, among other things, that urban sewage should be treated in a centralized wastewater treatment plant, and that its costs should be recovered through a wastewater treatment fee to ensure effective operation.

In addition to tariffs for water supply and sewerage, water bills typically include a water resource fee and a water development fee. The water development fee is based upon the cost of the raw water supply infrastructure. The water resource fee, in principle, reflects the opportunity cost and scarcity of the actual raw water source, and is charged to all water users. Guided by the Ordinance of Water Permits and Water Resource Fee Management of 2006, water resource fees are determined by the local government(s). The fee goes to local and central governments as part of general revenue. In practice, the majority of the fee income is retained

by local governments. Zhejiang Province, for instance, specifically states that local governments keep 80 percent of the fee and submit 20 percent to the provincial government. The fee is to be used for water resources development, saving, protection, and management. The actual use of the fee varies, depending on local needs. For instance, a portion of the fee in Beijing is transferred to the South-North Water Transfer Project. Some counties send part of the fee revenue to local forestry bureaus for ecological compensation in river basins.

To meet the objective of cost recovery, water tariffs in China have been increasing since the early 1990s. For example, during the period from 1991 to 2004 water tariffs in Beijing increased from 0.12 to 3.70 yuan/m³ (Table 6.1). In Chongqing during the period from 1999 to 2006, they rose from 0.85 to 2.8 yuan/m³.

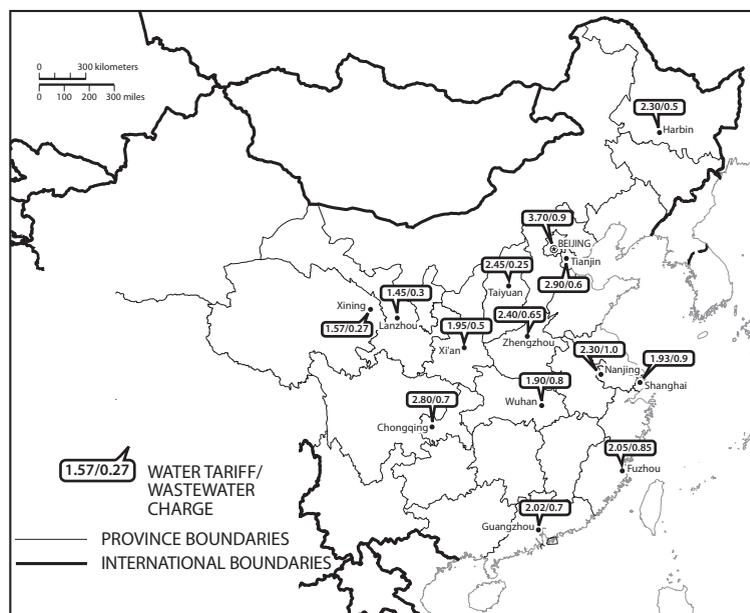
Tariffs are expected to continue to rise. Among China’s large cities and megacities, charges typically range from 1 to over 3 yuan/m³ of water for residential use (Figure 6.1). Compared to charges that were generally below 1 yuan in the 1990s, this is a significant increase. The wastewater treatment fee ranges from 0.25 to 1.00 yuan/m³, compared to the typical 0.08 to 0.10 yuan/m³ prior to 1996.

Despite this progress, water pricing in China is still inadequate to finance efficient utility management, and, more fundamentally, to support sustainable long-term development of water resources. Subsidies from general government revenues are still the norm. Only a few cities charge residential consumers more than a purely nominal amount for wastewater management. According to the data from NDRC, the average wastewater charge in 36 large- and medium-sized Chinese cities is 0.67 yuan/m³, equivalent to two-thirds of the treatment cost.¹ By the end of 2005, over 150 cities charged nothing for wastewater,² and 278 of 661 cities had no wastewater treatment facilities at all.³ This shortfall in wastewater treatment capacity is a major reason for China’s continuing water pollution problem.

TABLE 6.1 Water Tariffs in Beijing, 1981–2007 (yuan/m³)

	1981.1 ~ 1991.12	1992.1 ~ 1996.3	1996.4 ~ 1997.11	1997.12 ~ 1998.8	1998.9 ~ 1999.10	1999.11 ~ 2000.10	2000.11 ~ 2002.1	2002.2 ~ 2003.1	2003.2 ~ 2004.7	2004.8 ~ present
Water supply fee	0.12	0.30	0.50	0.70	1.00	1.30	1.60	1.70	1.70	1.70
Wastewater treatment fee	0	0	0	0.10	0.10	0.30	0.40	0.50	0.60	0.90
Water resources fee	0	0	0	0	0	0	0	0.30	0.60	1.10
Residential water tariff	0.12	0.30	0.50	0.80	1.10	1.60	2.00	2.50	2.90	3.70

Source: Beijing Water Company information at http://www.bjwatergroup.com/htm/law/18_2.htm.

FIGURE 6.1 Municipal Water Tariffs and Wastewater Charges by City (yuan/m³)


Source: The numbers in figure 6.1 are 2006 data reported at <http://www.xspi.com/gongq/ShowArticle.asp?ArticleID=4300>. The water tariff of each city includes the sewerage charge.

Another aspect of water pricing that deserves scrutiny concerns the variation in municipal water tariffs and sewage treatment fees. As illustrated in Figure 6.1, developed coastal cities (especially those in North China and in the lower reaches of river basins) usually charge water tariffs and wastewater treatment fees much higher than less-developed upstream cities. For instance, in 2006 the three cities with the highest sewerage fees were Nanjing (1.0 yuan/m³), Shanghai (0.9 yuan), and Beijing (0.9 yuan); the lowest were Xi'an (0.36 yuan per cubic meter), Lanzhou (0.3 yuan), and Xining (0.27 yuan). The cities with the highest prices are in downstream coastal areas, while those with the lowest prices are in upstream inland areas. Partly as a result, the downstream cities have much higher wastewater treatment capacity and treat a larger share of their wastewater than the upstream cities, leading to greater environmental damage along the rivers, and a lower effectiveness of water pollution investment nationwide. While the variation may be justified by different levels of development and differences in affordability among different cities, establishing a more reasonable mechanism for setting the price right—taking into account both affordability and environmental objectives—is a challenge for China.

A particularly egregious example of poorly coordinated water pricing is found in Xi'an City and its surrounding area in Shaanxi Province, where water shortages are severe and worsened by water pollution. Drinking water and sewage tariffs in Xi'an City were 1.95 and 0.36 yuan/m³ respectively in 2005.⁴ In the same period, the drinking water price in Jiaokou, which is downstream from Xi'an, was reported to be as high as 15 yuan/m³ because the Wei River was heavily polluted and local residents had to transport drinking water from the city. Yet for a nearby papermaking mill just across the Wei River, which relied on groundwater, its cost was only 0.08 yuan/m³ (ADB 2005). Such a pricing situation is obviously not conducive to efficient water resource use and management.

The Chinese government has been trying to address the low-tariff problem. In 2006, NDRC asked local governments to raise sewage treatment fees to 0.8 yuan/m³ by the end of that year. Although a price increase aiming to raise revenues to expand sewage treatment facilities is generally in the right direction, the request was made regardless of its affordability for local residents in less-developed regions. Meanwhile, some sewage treatment plants actually earned profits exceeding their financial requirements. This suggests that pricing policy needs to be carefully designed in order to help solve a problem rather than cause more problems.

The low-tariff problem in China has been discussed in detail in a number of studies. For instance, a 2007 analysis by the World Bank—*Stepping Up: Improving the Performance of China's Urban Water Utilities*—addressed general management aspects of the urban water sector (World Bank 2007b). These studies have typically proposed price reform to encourage more efficient and less wasteful water use, but their main focus has been on the recovery of water production and delivery costs to permit the efficient operation of the concerned enterprises and the ability to finance needed system expansion. Additional attention is needed to also reflect environmental and depletion costs in water pricing.

PRICING FOR ENVIRONMENT AND DEPLETION

To help address China's water shortage, water prices need to be set at a level that balances supply and demand and is sustainable. For the long term, this means that prices need to recover the marginal opportunity cost (MOC) of supply; that is, the full economic cost of providing an additional unit of water. For the accounting of economic costs to be complete, the MOC needs to include: (a) the marginal delivery cost (MDC), which is the cost incurred in producing and delivering an incremental unit of water to the user, such as extraction, transmission, purifi-

cation, and distribution; (b) the marginal environmental cost (MEC), which reflects the cost of environmental externalities associated with the use of water, such as wastewater removal and treatment costs; and (c) the marginal user cost (MUC), which reflects the value of water in alternative uses or the depletion cost (which is the cost of depriving water from alternative users). This can be formally expressed as $MOC = MDC + MEC + MUC$ (Pearce and Markandya 1989). The adoption of MOC as the pricing objective is essential to signal the scarcity of water to all users, and to provide them with the right incentive to use water efficiently and to adopt appropriate measures to save and protect the water resource.

The MOC pricing approach has been illustrated by a series of studies conducted under the auspices of the China Council for International Cooperation on Environment and Development (CCICED), in which the rapidly escalating costs of water and its disposal are typically shown to imply the need for prices well in excess of those required to cover the purely financial costs incurred by the utilities concerned (Warford and Li 2002). However, this will not be equally true in all cases; adoption of the principle would tend to highlight differences between cities and regions in terms of the real costs of water consumption and disposal, thus providing important information for regional economic planning and decision making.

One of the CCICED studies was conducted in the late 1990s (Spofford and Wu 1998) found there were large regional variations in the availability and cost of water within China. It compared pricing policies for Beijing and Shanghai. In the case of Beijing, where water was in short supply and where massive investments in cross-country transmission of water were projected for the future, prices for nonagricultural use were probably from one-sixth to one-tenth what they should have been (with agricultural use being almost free of charge), so there were potentially huge savings to be achieved from price reform.

In Shanghai, on the other hand, where supply costs were not rising rapidly, prices roughly approximated the economic cost of supply.

These studies also emphasized that—quite apart from avoiding wasteful use at the municipal level—MOC pricing has a major strategic role. Allowing regional variations in the real cost of water to be reflected in price policy would tend to encourage large water-using industries to shift to the cheapest sources of water and to invest in water treatment, recycling, and reuse. Improved pricing would also encourage careful consideration of the regional water demands of agriculture, and the scope for meeting future food requirements by means of less water-intensive land use in water-scarce regions.

Our AAA case study on the water tariff reform and income impact in Beijing also proposes that pricing policy should be developed around the concept of MOC. It estimated that current residential tariffs are about one-half of the long-run marginal cost (equivalent to the MDC) of water (about 7 yuan/m³), not including the marginal user and depletion costs MUC.

Few studies have addressed the marginal user cost or depletion cost of water, which should in principle be reflected in the water resources fee component of the overall price. In general, it is clear that in water-scarce regions, current water resource charges do not come close to reflecting the marginal user or depletion costs. This has been documented in our analysis in the Hai River basin. It estimated the economic value of water, which is equivalent to the marginal user cost (Box 6.1).

With regard to wastewater, the Beijing study described in Table 6.1 shows that wastewater charges, which are based on the volume of wastewater discharged and in turn on the quantity of water consumed, are about 0.9 yuan/m³, which just covers treatment costs. The Beijing study estimates that wastewater treatment will cost around 1.25 yuan/m³ by 2010, and proposes that wastewater charges should be equal to or higher than that level.

BOX 6.1 The Marginal User Cost of Water in the Hai River Basin

An ongoing study of the Hai River basin provides some estimates of the economic value of water (EVW), which is a good estimate of the marginal user cost (MUC, or the cost of depletion). This region has the most severe water-related problem among all major water resource regions in China. However, while water delivery costs (MDC), at 5.08 yuan/m³, are relatively high, they are minimal in comparison with the potential costs of a water shortage in the region. The study estimated the EVW—or MUC—in terms of value added in alternative industrial or agricultural uses. It found that the average EVW for economic sectors based on integrated water withdrawal in eight study areas was 41.8 yuan/m³. It was highest in the services sector, at 208 yuan/m³, followed by construction at 180 yuan/m³, and mining and quarrying at 114 yuan/m³. The lowest was for various agricultural uses, ranging from 3 to 16 yuan/m³. There is considerable variation in EVW between different areas. The highest average EVW is in Beijing, while it is much lower in predominantly agricultural counties.

Furthermore, the implementation of MOC pricing requires that for industry and certain types of commercial activity, it is important to distinguish between wastewater dischargers based on the quality of effluents. A variable tariff should be used based on volume and type of pollutant. In line with the polluters-pay principle, effluent charges should be based (to the extent possible) on the cost of environmental damage caused by the specific pollutants being discharged into the wastewater stream.

Marginal Costs and Planning

Even if it is not feasible or desirable to immediately raise prices to the level implied by marginal opportunity costs, the estimation of MOC should be an essential element of water resource management and planning. The MOC provides a benchmark by which implicit subsidies can be estimated, and should be used to assist in regional planning and locational decisions, thereby encouraging potential consumers to reveal their genuine willingness to pay, and discouraging water-intensive development in inherently high-cost water areas. In view of the rapidly increasing costs and scarcity of water in China, the importance of pricing in assisting such strategic economic decisions can hardly be overstated. However, to be effective, price reform cannot be restricted to municipal water supply and sanitation; the approach pro-

posed in this paper must also be applied to agricultural irrigation and industrial water users that directly withdraw their own water supplies from surface and underground resources.

SOCIAL IMPACT AND AFFORDABILITY

Price reform in the water sector worldwide has often encountered strong social and political opposition, and China is no exception. Local governments are often reluctant to raise water tariffs to a sustainable level. This is mainly because of concern over the potentially negative social impact of water tariff increases, especially on low-income households. Better assessment of the social impact of water tariffs, and measures to protect the poor, are critical issues to be addressed in water tariff reform.

Social Impact

Although often stemming from concern for the well-being of poorer households, low water tariffs result in inadequate financial performance by a water utility and may have perverse consequences for income distribution. This is illustrated by evidence from Chongqing City.

In 1999, the residential water tariff in Chongqing was around 0.85 yuan/m³. The municipal government provided free capital investment to

water utilities, which was equivalent to a subsidy of 1.34 yuan/m³. The municipal water company needed 500 million yuan each year for new construction, extension, and improvement of water supply service. This amount was greater than the total annual budget for all municipal construction activities. The result was that neither the expansion nor the quality of water and sewerage services could keep up with the rapid growth of the city. At that time, inadequate funding meant that only 20 percent of municipal distribution pipelines met national technical specifications, and the water available for residential consumers barely met minimum drinking water standards. Meanwhile, only 6 percent of municipal wastewater was treated, and untreated domestic and industrial wastewater contaminated public water bodies and threatened human health.

The social impact of low water pricing on the poor was negative and obvious. First, higher income consumers enjoyed better quality service and were the main beneficiaries of the prevailing policy of subsidizing water supply, since they consumed the most water. The 2006 willingness to pay (WTP) survey shows that the poorest households with monthly incomes below 200 yuan consumed only 0.4 to 8 m³ of water per month (2.4 m³ on average), while those with monthly incomes exceeding 1,500 yuan used from 1.5 to 30 m³ (9.6 m³ on average). On this basis, given a subsidy of 1.34 yuan/m³ regardless of consumption level, the poorest households received only 3.23 yuan per month on average from water subsidies, while the average higher income households enjoyed a subsidy of over 12 yuan per month.

Second, low water quality and inadequate service have a disproportionate impact on the poor. It is well documented that inadequate funding precludes extension of networks into underprivileged areas. In Chongqing, the analysis shows that the public spent more on bottled water and other water-related expenses than on metered water, due partially to their concerns over the poor quality of tap water. Failure to expand and improve

service to low-income areas gives poor people no alternative but to consume water of inferior quality, often obtained from private sources at extremely high cost. These findings prompted a major evaluation of the relationship between financing public services and poverty issues in the city of Chongqing, referred to subsequently in this paper.

Affordability

Even though poor families may not benefit much from water subsidies, they will be hurt the most if prices increase. Affordability for the poor is a concern in any pricing reform effort. The issue of affordability of water supply by the poor is analyzed and addressed in the studies of Chongqing and five small cities or counties in Shandong, Henan, and Chongqing. They provide a good illustration of the situation confronting municipal authorities in China.

There were 168,000 unemployed people in Chongqing's urban districts in 2004, which was about 4–5 percent of the total labor force. Local governments provide the unemployed as well as the retired with small pensions (ranging from 155 to 210 yuan per month, depending on the district in which they live), but these are sufficient only for basic living requirements. A survey conducted in the summer of 2006 in one urban district and five towns in Chongqing Municipality shows that the low-income (less than 400 yuan per month per household) population comprised 5 to 28 percent of the total sample, indicating that the percentage of the poor is significant and cannot be ignored. As estimated by the survey, the WTP for water by the poor was generally low and barely exceeded the existing water tariff. Even then it amounted to about 3 percent of household incomes. It is clear that the poor would be reluctant to accept a new price increase without additional financial support. The general public in the city (90 percent of those interviewed) agreed that the government needed to provide minimum living support to

this group to compensate for further increases in water tariffs.

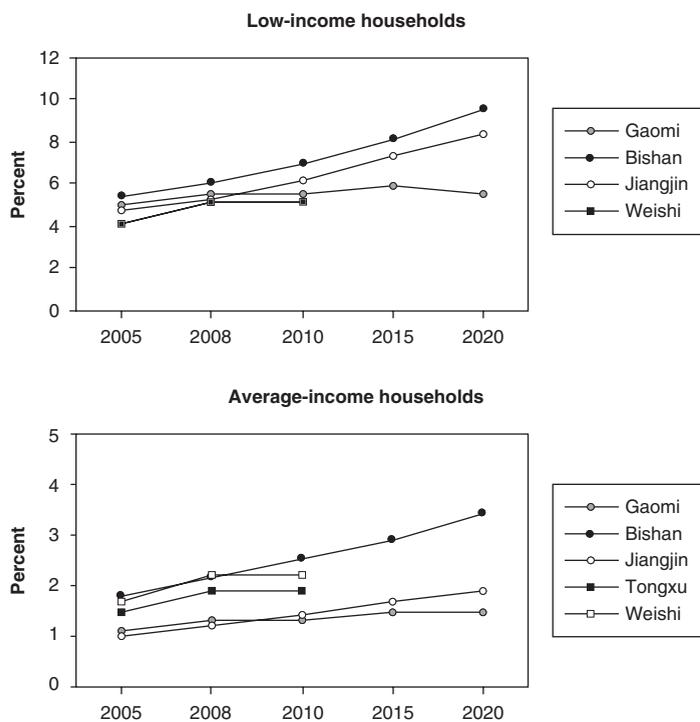
The Beijing study referred to above shows how this issue is affected by income and price elasticities of demand, presenting estimates according to income group. The combination of two features, namely (a) generally low-income elasticity and (b) higher-price elasticities for lower-income groups, confirms that the poorer, typically less well-educated consumers are more price sensitive.

Figure 6.2 further summarizes the situation for the five small towns—Gaomi in Shandong, Bishan and Jiangjin in Chongqing, and Tongxu and Weishi in Henan. In light of the widely accepted view that the maximum proportion of household income to be spent on water and

sanitation should be between 3–5 percent, affordability is clearly an issue for low-income households in each city/county, even before projected increases take place. Among the cities or counties studied, Bishan and Jiangjin face the greatest challenge; taking into account projected increases in incomes, the proportion spent on water and sanitation will reach 8–10 percent by the year 2020. This is required just to satisfy the relatively narrow objective of financial self-sufficiency for the concerned water authorities; basing prices on MOC would clearly be much more problematic.

Another important aspect of affordability is that poor communities, often villages or rural towns as a whole, may be unable to afford the investment and operating costs required for an

FIGURE 6.2 Share of Water and Wastewater Services Expenses for Average and Low-Income Households



adequate service level to be supplied. This often requires special governmental support.

PROTECTING THE POOR

A major challenge in raising water tariffs to reflect MOC is how to reconcile the objective of economically efficient water use while ensuring that poor people obtain adequate service for their essential needs. Provided safeguards for the poor are built in, price reforms aimed at improving the quality (safety, regularity, accessibility, etc.) of water services may be a win-win solution.

Globally, a variety of pricing measures have been employed. An OECD report (2003) grouped them into two categories: income support measures and tariff-related measures. Income support measures include water bill reductions or waivers, water service vouchers from the government, capped tariff rebates and discounts, and payment assistance. Tariff-related measures include increasing block rates, capping metered tariffs, special tariffs for low-income consumers, subsidized connections to the network, and so on. In China, three general approaches are used: increasing block tariffs, income support, and price waivers for the poorest households.

Increasing Block Tariffs

Raising the price of water may have significant regressive impacts. A uniform pricing scheme may attain efficiency conditions at the margin, but it also gives rise to affordability problems for poorer sections of the population, with potential threats to their health and general well-being.

A common way to address this dilemma is to change the prevailing flat-rate tariff to one that charges more for higher rates of consumption. Chinese national legislation specifically refers to the role of the two-part tariff in ensuring that the poor are able to obtain sufficient water for their basic requirements. Generally, increasing

block tariff (IBT) structures can be used to reflect the true cost of water to customers using large volumes of water, while allowing subsidized prices for essential use. The first block provides an element of subsidy and hence protection for low-income households, while rates applied to the last block of consumption should reflect the marginal opportunity cost of water.

IBT raises several issues. First are the implications for revenue sufficiency. Significant price elasticities mean that the vast majority of consumers end up in the first block and only pay a subsidized tariff. The tariff will therefore fail to achieve cost recovery and the quality of the water supply will be hard to sustain or improve. This problem can be resolved by reducing the size of the first block. Experience—from Beijing and other cities in China—suggests there is no need to subsidize water in excess of that required for basic household requirements. Over and above this level, water should be treated as any other consumer good and priced at MOC. A two-step tariff is thus sufficient. Determination of the volume of water that is required for basic needs is therefore crucial, and may vary according to local economic and climatic conditions. In general, however, the level recommended by the World Health Organization (WHO) of 40 liters per capita per day (equivalent to about 5 m³ for a household of 4 persons) should be considered.

Some Chinese cities have set the first block at much more than the basic need for living in China, and therefore reduced the effectiveness of water tariffs as an incentive for water saving. In Lijiang City, for instance, the first block is up to 25 m³ per household per month, which is charged at 1.40 yuan/m³ (plus 0.40 yuan/m³ for wastewater treatment). The second block, from 25 to 35 m³, is priced at 2.10 yuan, and the third block, above 35 m³, at the price of 2.80 yuan/m³. Since for a typical household of four persons, the first block is far more than that required to meet basic needs, very little water is sold in the second and third blocks,

with the attendant inadequate cost recovery for the water company.

The second issue concerns incentives for the water supply enterprise itself, whose objective is full cost recovery or an adequate return on capital. When IBT is introduced, the poor, being subsidized, may become a lower priority for the water utility. Thus, a utility that aims to recover costs will have a greater incentive to improve service for the more affluent neighborhoods and households than for the poorer ones. In the longer term, the tariff structure may thus perversely induce a lower quality of service for the poor. The potential for such unintended effects, and the regulations required to remove them, needs to be weighed against the potential welfare enhancing effects described above.

A third issue concerns subsidies for the rich. The IBT system subsidizes all water consumers, rich and poor, for the first block of water consumption. Furthermore, the subsidy is maximized when households consume the full first block. Moreover, poor households are frequently larger than richer ones. Although family size appears to be relatively uniform in Beijing, it is likely that low-income households will lose out in a system based on a four-member family; that is, where several of the poorer households share one metered connection.

Other Options

Other measures, such as the provision of minimum income support and water service vouchers, are employed in China to allow the poorest households to obtain adequate water supply services. While designed to be temporary, and to phase out as incomes increase, the rapidly escalating costs of water supply may mean these income support measures remain relevant for the near future, and thus are worthy of serious consideration. Actually, it is by no means certain that, even with continued rapid economic growth, incomes will increase at a faster rate than the cost of water.

These approaches involve a number of practical difficulties. Administrative problems associated with the issuance of vouchers for low-income households to exchange for water and sanitation services could include the printing of fake vouchers, while trading of vouchers has also occurred. Another practical problem is that while a subsidy earmarked for water may help to overcome objections to price reform in the short run, this may be of no help for future price increases. In general, in a time of rapid change in China, with large “floating” and migrant worker populations, the most vulnerable members of society often do not qualify for support from the local authority in which they currently happen to reside.

In practice, a combination of methods may be required. This is implicit in the recommendations made in a recent (2007) proposal to the Chongqing Municipal Development Reform Commission, which refers to a “Five Orientations” package. The package includes cross-subsidies among water consumers; rational establishment of the basic water requirement per family; use of vouchers that can only be used to pay for water, based upon volume of use; and a management system that ensures consistency and efficiency in collecting and allocating the subsidies to those who need them most.

Rural and Low-Income Communities

The general recommendation that prices should cover both water supply and disposal costs may not be feasible in the short term for poorer communities, or for those whose supply costs are particularly high. This may apply in particular to low-income rural communities. In such cases, a subsidy from general revenues transferred from the provincial- or county-level authorities may be unavoidable for initial investment in infrastructure; thereafter, revenues should at least cover operation and maintenance costs. This will pave the way for increasing financial self-sufficiency on the part of water and sewerage

authorities as ability to pay increases. Establishing a link between local taxation and water use, combined with educational campaigns, is a necessary component of any strategy to avoid wasteful use.

For deprived areas within an otherwise fiscally sound water supply jurisdiction, assistance may be provided by cross-subsidies from higher volume water consumers to facilitate extension of distribution networks and thereby reduce or eliminate connection fees.

Overcoming Public Resistance to Price Reform

While increasing prices to cover water production and delivery costs is difficult enough, covering environmental and depletion—or user—costs is clearly even more challenging, not only because the levels required will typically be much higher, but also because political and social acceptance of such changes usually requires evidence of actual expenditures. To some degree, this can be overcome by taxation collected by a public agency per

unit of consumption, rather than an increase in the revenue accruing to the water company for expenses not yet incurred. It is clear that such problems are compounded when existing services are inadequate. A chicken-and-egg situation may thus exist, since improvement in service may typically require additional revenues, but prices cannot be increased when service is poor.

Overcoming public resistance to the increase in water price or tax is a problem encountered by water authorities worldwide. The study therefore proposes that greater efforts should be made to involve stakeholders in water pricing policy making, including public hearings to provide an opportunity for all stakeholders to state their interests. The public hearing process must be transparent, together with enough information disclosure to make the process effective. Above all, price reform should be gradual, and in parallel with improvements in both the quality and extension of access to water supply and sanitation services. Such an approach can be successful, as demonstrated in the case of Chongqing (Box 6.2).

BOX 6.2 Making Price Increases Acceptable: the Case of Chongqing

An attempt to obtain public support for price increases that were required to provide funding for improvement and expansion of facilities in Chongqing received a hostile reception at public hearings. Consequently, the Chongqing municipal government conducted a research effort to facilitate a public awareness campaign. This was aimed at educating the population about the costs of supplying water and managing wastewater generated in the city, and the impact on service quality if the municipal water supply system was unable to increase revenues. It showed that the primary losers when prices are too low were the poor, whose service standards remained inadequate; indeed, the richer consumers, who consumed the most water, were the biggest beneficiaries from the subsidies involved.

In addition to the educational process, and in recognition of the problems the poor had in paying higher water prices, the Chongqing municipality decided to implement a number of parallel subsidies for disadvantaged groups—such as the unemployed—sufficient to maintain basic living standards, which included paying the increased water bills. The study also recognized that a step-by-step approach must be used, and a schedule for gradual increases in prices over a number of years was introduced. Because the public was made aware of the findings of the study and in particular the rationale for the price increase, subsequent public hearings attended by representatives of disadvantaged groups were very constructive. The whole process was instrumental in making the required price increases socially acceptable, and the reforms have apparently been effective in reducing average water consumption in the city.

OTHER IMPLEMENTATION ISSUES

In addition to the need to protect the poor in water tariff reforms, there are other issues concerned in implementation. Some of these are discussed below.

Performance Incentive Systems

Prevailing incentive systems clearly work against serious price reform in the water sector. In common with experience in the rest of the world, immense difficulties arise in increasing prices of water; political unrest has often been the result. In the past, the combination of relatively high turnover rates of public officials and the long-term nature of the water scarcity issue has been sufficient to preclude effective action. However, the increasing immediacy of the water shortage issue will presumably be matched by an increasing willingness of local and national officials to take the measures urgently required—if the performance evaluation system is enhanced to reward local officials who take the risks inherent in pricing reform.

Gradualism

Water tariff reform is usually hampered by the prevalence of market imperfections elsewhere in the economy, which would mean that price reform in the water sector alone may at once be inefficient and inequitable (Warford and Li 2002). In particular, parallel pricing (as well as other market-related and management) reforms are still required for major competing uses, primarily agricultural water use and direct industrial abstraction of water, both of which should also be priced based on MOC. In effect, management and pricing failures in these areas increase the scarcity and therefore the opportunity cost of water for municipal purposes. Until parallel reforms are undertaken for the irrigation and industrial sectors, the true opportunity cost of water used for municipal purposes remains un-

clear, and the ability of municipal authorities to contribute to overall efficiency in water use will remain severely constrained. Hence, price reform in the water sector should be gradual and in parallel with overall trends in market liberalization in China.

Metering

Volumetric pricing is necessary to achieve the economic and other objectives of water supply management, but this requires meters to measure the amount of water consumed. While installation of meters in new buildings is increasingly the policy in Chinese cities, much effort is clearly required if universal metering is to be achieved. It will usually be the case that investment in metering, and the associated meter reading and billing costs, are justified for industrial and commercial users. Nevertheless, these costs may not be warranted for some small consumers, depending in large part upon their levels of consumption and the cost of water. Therefore, metering should be addressed on a case-by-case basis.

Excessive Tariff Revenue

If an MOC approach is used, and where marginal costs are rising significantly, revenues will be generated in excess of financial requirements. In most cities, the bulk of consumption is by a very small proportion of industrial, commercial, and high-income residential consumers. MOC pricing for the top block of a two-part tariff will therefore typically provide ample scope for subsidizing low-volume use, extension of distribution systems to low-income areas, and adequate quality of supply. The question may then arise as to the disposal of any excessive profits that the utility might make when marginal costs are rising. Precise mechanisms for dealing with this will depend upon the form of ownership of the utility concerned. But the general principle should be that profits in excess of the level mandated in national legislation should be recovered by the government and used

to augment general revenues, or to substitute for other forms of taxation.

Use of the Water Resource Fee

The water resources fee (covering environmental and depletion costs) should ideally be estimated by appropriate local government organizations based upon water scarcity in a river basin. Such a device would create more incentive for utilities and local governments to protect scarce resources rather than raise funds, while at the same time facilitating an IRBM approach to water management. However, since the revenues from the water resource fee are largely retained by local governments (although usually earmarked for their own spending on water-related activities), they provide an incentive for overexploitation of water resources at the local level (i.e., the achievement of local benefits), rather than for the pursuit of basin-wide objectives, which are chronically underfunded. In addition, due to the existence of the revenue from the water resource fee earmarked for local water bureaus, the funding source of local water bureaus is limited to such revenue and excluded from government budgets in many cases. It would be desirable to convert the water resources fee into a tax.⁵ The tax revenues would be transferred to the central government and be appropriated to support water resource development and protection on the local, basin-wide, and national basis. The funds of local water resource management programs should be de-linked to the revenue of local water resource fees and directly provided by governments through their annual budgets.

RECOMMENDATIONS

Despite recent efforts by the government, water pricing reform in China is facing challenges ahead. Water tariffs, including wastewater treatment fees and water resource fees, are generally too low and have to continue increasing in the years to come. To effectively address its water

problems, China needs to set the price to cover full delivery and environmental costs and, more ambitiously, also depletion costs. Although concerns over the pressure of tariff increases on inflation and the income impact on the poor are legitimate and should be taken into account in water pricing reforms, they should not be used to hold back pricing reforms. Generally speaking, price controls work against market mechanisms and tend to be an ineffective instrument for preventing inflation. In addition, there are adequate measures to protect the poor that can be jointly applied to pricing reforms. Our recommendations are as follows:

- Given the magnitude of the water scarcity problem, China should aggressively use pricing policy to internalize the externalities of water use. In accordance with its commitments to building a public service-oriented government and to avoid sharp increases in water tariffs, price reform should follow the MOC approach. The government can cover the capital investment cost of water facilities (including drainage networks), whereas the users should cover operation and maintenance costs and the increasing external costs of water and its disposal, specifically the costs of environmental damage in production and consumption, and the opportunity costs of depletion.
- China should make a greater effort to enhance water metering. Accurate water metering is a precondition for the price mechanism to play its role in stimulating water-related activities. The difficulty in water metering, especially for groundwater use by households, has been one of the major barriers to the effective adoption of price instruments. China should enhance expanded installation of water meters and ensure their actual operation with a sound supervision system.
- Governments should develop the capacity to estimate water depletion costs in a river basin or on a regional level. Estimated depletion costs should be charged to the concerned utility by

the local authority. A system should be devised in which MOC estimates can be integrated into regional and national water management and economic planning systems.

- The public should be fully informed of the problems of low service quality, indirect costs, and inefficiency caused by underpricing or subsidization of water and the importance of water tariff increases. To make a water tariff increase acceptable, its social impact, especially the income impact on the poor, has to be addressed. A number of income or price support measures can be used to protect the poor and ensure a win-win result in water tariff reforms.
- Already adopted in Chinese regulations, the increasing block tariff approach, especially a two-tier tariff structure, is recommended for residential consumers. The first block should follow the WHO-recommended 40 liters per capita per day (i.e., about 5 m³ per month for a household of four persons), with the second block gradually increasing to full MOC. Other price or income support methods for the poor are encouraged to be adopted based on local political and economic circumstances. Water tariffs for commerce and industry should cover full MOC.
- For several reasons—economic efficiency, social equity, and acceptability—a gradual approach to price reform is recommended. Public hearings, consumer education, and transparency are necessary to overcome resistance to price reform, especially when existing service quality is poor. Parallel pricing reforms should be carried out for other water uses, in particular for agricultural use and large-scale industrial abstraction. In general, water pricing reform should parallel the overall market reform trends in China.
- The water resource fee, which is currently retained by local governments, provides little incentive for the local governments' support of basin-wide or national level sustainable water

resource development. In the long run, the fee should be converted into a tax, the proceeds of which will be transferred to and appropriated by the central government. Such a conversion would provide a financial basis for the central government to facilitate more efficient water resource planning based on national priorities for water resource development and management. The funds of local water resource management programs should be de-linked to the revenue of water resource fees and directly provided by central and local governments through their annual budgets.

Finally, as evidenced by a series of OECD reports, international experience offers limited guidance in this area. With a few notable exceptions, water pricing policies throughout the world fail to address the subject of water scarcity head-on, in large part due to the political sensitivity of the subject. Given the urgency of the problem facing the country, China should look beyond international experience and exercise leadership in this area before the water crisis becomes unmanageable.

Endnotes

1. "China to Charge on Wastewater and Solid Wastes across the Country." See Xinhuanet.com at http://news.xinhuanet.com/politics/2007-04/02/content_5926101.htm.
2. Ibid.
3. Qiu Baoxing, Vice Minister of Construction, Speech at the Press Conference organized by the State Council, August 22, 2006. See <http://gov.people.com.cn/GB/46738/4734083.html>.
4. The water tariff and wastewater charge in Xi'an City were the numbers prior to the pricing reform on October 1, 2005. They have since gradually increased to 2.90 yuan/m³ and 0.65 yuan/m³ (as of April 2007), respectively, for residential use. See "Water Tariff Raise in Xi'an" at http://www.xawb.com/gb/news/2007-03/02/content_1126532.htm.
5. In Chinese terminology, a fee is usually collected and retained by local governments and is classified as extra-budgetary revenue for some specific use. A tax, however, is collected by the central government and its revenues are allocated through the government budget.

Protecting Ecosystems in River Basins through Market-Oriented Eco-Compensation Instruments

Addressing water scarcity involves protecting water sources. The Chinese government has attached importance to protecting ecosystems in the upper reaches of river basins. It is implementing or experimenting with a large number of ecological conservation programs at the national level. Both central and local governments are increasingly interested in the use of economic instruments, mainly government transfers from public funds under the name of ecological compensation mechanisms (ECMs), to protect ecosystems. For example, the “Grain for Green” program, which distributes some \$8 billion per year, was launched right after the major Yangtze River flood of 1998.

Although these programs have had some positive impacts on ecosystem restoration and generated much interest in expanding the use of ECMs, there are still some issues. In particular, their heavy reliance on public financial transfers (mainly from the central government), and the lack of a direct causal link between ecosystem service providers and ecosystem service beneficiaries, raises some doubts about the long-term sustainability of ECMs. An urgent question is how to sustain these programs financially and improve their efficiency.

In addition to the ECM approach, there are other possible transfer mechanisms, including payments for ecosystem services (PES).¹ PES is both more market-oriented and self-financing than the ECMs currently used in China. PES directly links ecosystem service providers and beneficiaries.

This chapter focuses on exploring and promoting PES in China. It begins with an overview of the policy and practice of ECMs in China, followed by a discussion of the concept and methodology of the PES approach. The succeeding sections consider the international experience with PES and examine the potential of applying the PES approach in China, using as a case study the example of a small nature reserve in the upper reaches of the Yangtze River. The chapter concludes with recommendations.

ECOLOGICAL COMPENSATION MECHANISMS IN CHINA

As a large and densely populated country, China faces major challenges to properly conserve and manage its river basins. As identified in earlier chapters, China's rapid urbanization and economic growth have placed severe demands on available water supplies—both surface water and groundwater. Agriculture, industry, and municipal users all compete for increasingly scarce, and often polluted, water supplies. As the availability of water is becoming a major constraint to economic growth, China is looking for ways to better protect and manage existing water supplies and the watersheds that produce them.

Ecosystems in upper reaches, especially forests and wetlands, are an important source of clean water that flows down rivers and provides a source of water for households, communities, and other users, including natural ecosystems, in the lower reaches. In China the upper reaches of major rivers are mostly in the western parts of the country. Due to a semi-arid climate, extreme weather, and generally low soil productivity, the upper reach regions are ecologically fragile and vulnerable to degradation. These same regions, however, have a long history of settlement. Most of the communities are poor, with an economy dependent on agriculture or animal husbandry. Unsustainable land use practices—including steep slope cultivation, overgrazing, and poor conservation techniques—and the thirst for economic development have put significant pressure on ecological conservation.

Nationwide, it is estimated that 40 percent of the country's land area is affected by some form of degradation (wind and water erosion, overgrazing, deforestation, and/or salinization), mostly in the upper reaches of river basins. Degradation is estimated to have accelerated from 1,500 km²/year in 1970 to 3,500 km²/year by the late 1990s. The causes include abnormally heavy rainfall, deforestation, and soil erosion in upper reaches. Another significant factor is human encroachment on flood plains and the conversion of flood-prone

lands; a major flood took place in the Yangtze River in 1998. The floods caused major loss of life and extensive property damage; economic losses were estimated at over RMB 200 billion. In the aftermath of this disaster, the Chinese government was determined to take action to protect the ecosystems in upper reaches of major river basins and prevent similar disasters in the future.

Current Practices

The Chinese government, which is the main steward of natural resources in the country, is exploring various tools for ecological conservation and natural resource management. The concept of integrated river basin management (IRBM) has attracted attention in China and elsewhere in the world. IRBM has proved administratively challenging to implement. While it recognizes the multiple links within watersheds, and the need to coordinate actions for improved management, water planners also realize that targeted interventions are often necessary.

Ecological compensation mechanisms (ECMs) were first introduced in the 1990s, and, along with other tools, have become very popular. ECMs in China are a modern variant of traditional government payments to providers of ecological services. The government transfers money from many different sources (e.g., resource taxes, excise taxes, industrial taxes, and pollution fines) and compensates land owners (or land users) for specific actions that produce environmental benefits. Using government transfers for environmental protection is a well-established tradition around the world, whether payments are for soil conservation measures, improvements in watershed management, or coastal zone protection measures. Some authors call this approach “supply-side,” since the government decides what environmental services to support and uses general tax revenues to do so.

Recent national strategies and policies adopted in China reflect the growing attention to ECMs as instruments for ecological conservation. So

far, no single specific law on ECMs has been promulgated, but there are several natural resources and environmental protection acts with specific clauses on PES, including the Grassland Law, Environmental Protection Law, and Sand Control Law, among others. As early as 1991, market mechanisms for watershed management were introduced in laws such as the Water and Soil Conservation Act.²

Various applications of the eco-compensation approach, many of which are experimental, are under way in China at the national and local levels. These include compensation for migration of residents living near water sources or reservoirs; subsidies to sewage treatment plants; compensation to foster the forestry sector in upstream areas; and payments to farmers to compensate for lost production from reducing fertilizers and pesticides inputs. At the central government level, the Chinese government has developed and implemented a number of the largest public payment schemes for ecosystem conservation in the world, including the Sloping Land Conversion Program (SLCP), the Natural Forest Protection Project (NFPP), and the Forest Ecosystem Compensation Fund (FECF).

The SLCP (also called the “Grain for Green” program) was initiated in 1999. It was designed to restore natural ecosystems and mitigate the adverse impacts of agricultural practices carried out in previously forested areas or marginal land, which resulted in flooding, sedimentation of reservoirs, and dust storms. Farmers who enroll in the scheme receive payments for grain seeds, seedlings, and management expenses. The SLCP is one of the largest public transfer schemes in the world. It reaches some 30 million farm households, includes over 7 million hectares (ha) of cropland, and distributes some \$8 billion per year (Uchida, Rozelle, and Xu 2007).

In the forestry sector, the NFPP now covers 17 Chinese provinces. It calls for a moratorium on forest felling along the Yangtze River and the mid- and upper reaches of the Yellow River, as well as for a decrease in timber production in Eastern

Mongolia. Local governments are expected to protect the remaining 94.2 million ha of natural forest. In order to increase the pace of forest restoration, 8.66 million ha of forest and 6 million ha of grassland will be established along the Yangtze and Yellow rivers, and forest coverage in these areas is expected to reach 3.72 percent. The payment made for protection and reforestation averages RMB 71 per ha per year (\$9/ha), 90 percent of which is paid by the central government.

The FECF program targets the management of privately owned standing forests, and compensates land owners for the ecosystem services provided by their land and for the land and resource use restrictions involved with participation in the program. The scheme currently covers 26 million ha in 11 provinces, and costs the government about RMB 2 billion (\$253 million) annually, of which about 70 percent goes to farmers for an average payment of RMB 71 (\$9/ha). Local governments are encouraged to provide additional funds. In December 2004, FECF was extended to cover the entire country. It covers key state-owned non-commercial forests, as well as woodlands in areas at risk of desertification and soil erosion.

There are many smaller-scale examples of ECMs implemented by local governments or entities, such as the water rights trading scheme between Yiwu and Dongyang cities in Zhejiang Province; the eco-compensation payments being developed between Beijing, Tianjin, and local governments in the upper watershed of the Miyun reservoir; and the water use payment scheme between the water company in Lijiang and Baisha town and the nearby sources of their water.

The Problem and a New Direction

Although China has made major investments in ECM programs, and has some of the largest such programs in the world, the effectiveness and efficiency of many ECM practices in China are now in question, as shown in a number of recent analyses of national ECM programs (see Xu et al.

2006; Scherr et al. 2006; and Uchida, Rozelle, and Xu 2007). Because of problems such as low or incomplete payments, lack of transparency in the operations of the managing authorities, and high transaction costs, there is growing concern over the financial sustainability of these programs over the longer run.

The causes of the problems are based not only on the weak legal and institutional basis of clear ownership and property rights over natural resources in China, but also the lack of effective market mechanisms to send the right signals. ECM applications in China have been mostly driven by government intervention, with little attention paid to the forces of supply and demand for environmental services, or to inter-sectoral coordination and collaboration.

It is becoming clear that the country should try to move away from schemes where the government is the sole buyer of the service to one where it will play a supporting role in creating and maintaining an enabling environment and market for transactions by private actors. A more thorough involvement of local actors—especially the ecosystem service providers and beneficiaries—in the design, implementation, and monitoring phases is therefore needed. The examples of local interests and initiatives in eco-compensation schemes suggest that there is significant interest and potential for PES systems in China.

CONCEPT AND METHODOLOGY OF PAYMENT FOR ECOSYSTEM SERVICES

In the past those who benefited from environmental services (the beneficiaries) often had no connection with those who provided the services and made no direct payments for their provision (other than through general taxation, which governments then redistributed to many uses). At the same time, those who provided the services (the service providers) received no direct financial payments for providing this service. Although both the ECM and PES concepts share similar

objectives (improved provision of environmental services), the PES concept recognizes the direct link between service provider and service user and is designed to mimic a market transaction where previously a market did not exist.

Determining the appropriate payment for an environmental service obviously depends on many factors, including how much the service beneficiaries value the service (and their ability to pay) as well as the cost to service providers of maintaining the service. The actual level of PES payments has to be determined in each case, and must balance these two needs.

Types of Ecological Services and Beneficiaries Involved in PES Schemes

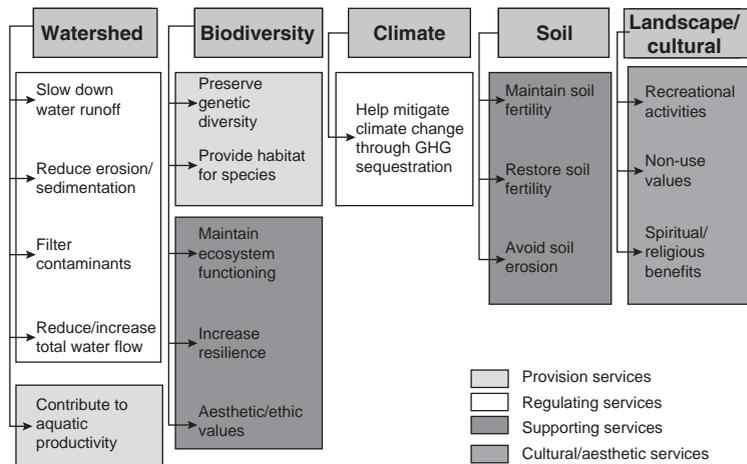
In practice many of the early PES systems have developed around ecosystem services where the cause and effect link between the provider of the service and the beneficiary is close: for example, watershed protection and consumers of the water produced by the watershed, or recreational users of coral reefs and the protection and/or conservation of the coral reefs. Figure 7.1 lists a wide variety of ecosystem services that are potentially amenable to PES schemes.

When the beneficiaries are direct (or even indirect) users of the resource, it is easier to identify and impose fees to support a PES system. If the beneficiaries are using broader ecosystem services, it is more difficult to identify them and impose the PES fees. In the latter case, one possibility is a general “environmental tax” on all citizens in the country (or a province or region) to collect funds to help provide broad ecosystem services. Such broad taxes are never popular and the taxpayers rightly feel that their money is not necessarily producing any real benefits for them.

Economics and Mechanics of a PES System

The economic logic behind establishing a PES system is seen in Figure 7.2. In this example the

FIGURE 7.1 Main Ecological and Environmental Services by Type of Service



Source: FEEM Servizi 2006.

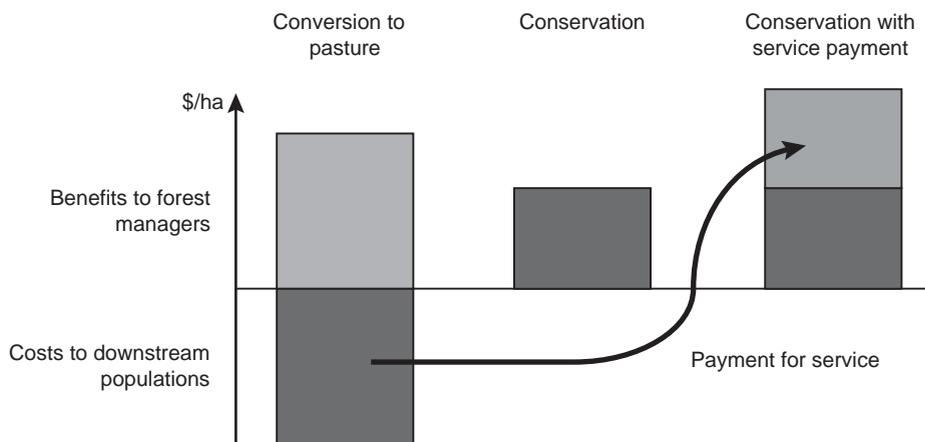
focus is on how a landowner manages a forested area in a watershed. The owner/manager can convert the forest to pasture and earn the expected return, as shown in the bar on the left side of Figure 7.2, or the owner can leave the forested area under conservation and earn the expected return, as shown in the middle bar. Since conversion to pasture earns more income for the landowner, the landowner will favor this option. Conversion, however, reduces the environmental services of the land in terms of providing water to downstream users. This is shown as the “cost to downstream users” area below the axis in the left hand bar in figure 7.2. Herein lies the quandary: from a social perspective the net benefit to society from conversion of forest to pasture is quite small or even negative, but the forest manager does not see it the same way. He or she compares the two areas above the axis in the first two bars and makes the reasonable decision to convert from forest to pasture, since the net benefit to the forest manager is larger.

With a PES system, however, a payment is made to the forest manager that produces the

result shown in the right hand bar in Figure 7.2—the forest manager has a larger net benefit (revenues from conservation plus the PES payment), and the downstream beneficiaries are also ahead since the cost of the PES payment is less than their loss would be if the forest land was converted to pasture. Both upstream service providers and downstream service users are better off than without the PES system.

The actual mechanics of a PES system are seen in Figure 7.3 (Pagiola and Platais 2002). The PES system has a governance structure (institutions) that allow payments to be collected from beneficiaries of the ecosystem service (on the left hand side of Figure 7.3). The payments then go into some sort of financing mechanism (often a special fund) and are distributed via a payment mechanism to the various service providers (or land users in the example in Figure 7.3). Almost all PES systems follow a similar pattern. The main differences lie in the details of how service beneficiaries make payments (the taxes) and the form of the financing and payment mechanisms. Pagiola and Platais explore these issues at length in their 2007 report.

FIGURE 7.2 The Simple Economics of Payments for Environmental Services



Source: Pagiola and Platais 2002.

Factors Determining the Ease or Difficulty in Establishing a PES System

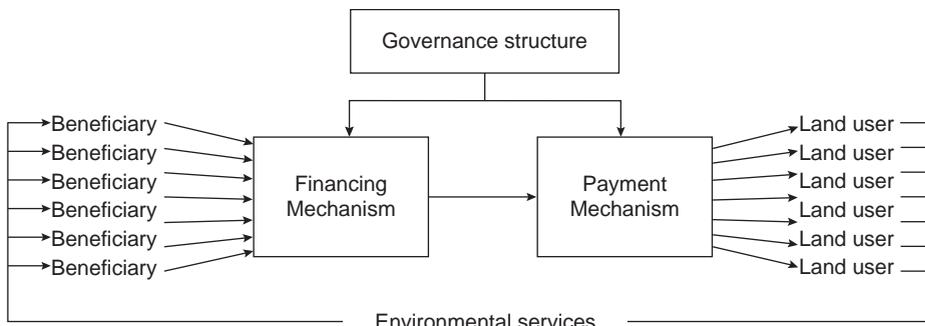
Whereas ECM programs are fairly straightforward—government funds are transferred to providers of environmental services—the defining characteristic of a PES system is the establishment of a financial link between those who benefit from the use of an environmental service and those who provide it. Since a PES system is basically creating

a new market where one did not exist before, a number of factors will influence the ease with which a PES mechanism can be implemented.³ The main factors to consider are the following:

The “distance” between cause and effect

The link between ecosystem service providers and service users or beneficiaries varies from very direct and immediate (for example, local watersheds and drinking or irrigation water supply) to very distant

FIGURE 7.3 The Flow of Compensation from Beneficiaries to Land Users in a PES System



Source: Pagiola and Platais 2002.

(for example, carbon sequestration and impacts on global warming). It is normally easier to set up a PES system when the “distance” is small, and harder to do so when the “distance” is large.

The numbers of service providers and service beneficiaries

Since payments need to be made to the providers of the ecological service, service providers should be relatively few in number and an institutional mechanism must exist (or be created) to reach them and make the payments. The number of service beneficiaries also matters, but may not be as much of a problem. In many watershed-based PES schemes, the beneficiaries (individual users) are already paying for the water or electricity provided, and therefore the additional PES payment can be added to existing billing and collection systems. The water utility in effect is the user group and one utility may represent hundreds, thousands, or even millions of people.

Collecting beneficiary payments and making transfers payments to service providers

It costs money to collect money and it costs money to distribute money. Therefore, to implement a PES system it is important to take into account the management costs involved. Sustainability of a PES system requires that the costs of administering the system be kept low. A number of successful PES systems have overall “costs” of 20 percent or less—meaning that 80 percent or more of the collected money is actually used to make payments to the service providers.

The legal and institutional framework

Without doubt the biggest potential handicap to establishing a PES system is the creation and/or functioning of an appropriate legal and institutional framework. This is very important, since financing is often being newly collected and payments are being made to those who were not previously receiving payments. It should be emphasized that the PES approach is not an

example of “business as usual” and that PES systems are usually implemented, at least initially, at the local level. Whether new laws or institutions are required depends on the situation in each country, and tends to be very location-specific.⁴

THE GROWING INTERNATIONAL EXPERIENCE WITH PES SYSTEMS

The earliest examples of PES systems were often associated with watershed management and potable water supply. Service users (water customers) demand and are willing to pay for potable water, and a mechanism usually exists (the water bill) that can be used to collect the PES payments. Still, the institutional mechanism for making the payments to environmental service providers usually has to be developed.

Box 7.1 lists a number of international examples of PES schemes. Two of the best-known examples are the cases of New York City in the United States and Heredia in Costa Rica; these are discussed here in more detail. Although these two cities are polar opposites with respect to size, the PES approach used in each is actually quite similar.

New York City

New York, one of the largest and richest cities in the world, obtains its water supply from watersheds in the Catskill Mountains north of the city. Water quality was naturally good and little or no treatment or filtration was required to make the water potable. New York City consumed between 4 to 5 billion liters of water per day. However, by the end of the 1980s changing agricultural practices and other developments in the Catskills—such as nonpoint source pollution, sewage contamination, and soil erosion—threatened water quality (Pagiola and Platais 2007).

New York water planners considered two options: constructing a water treatment system at a capital cost of \$4 to \$6 billion with an additional annual operating cost of about \$250 million (for a total present value cost of some \$8 to 10 billion),

BOX 7.1 Additional Examples of Payments for Ecological and Environmental Services

- *Brazil*: A water utility in Sao Paulo pays 1 percent of total revenues for the restoration and conservation of the Corumbatai watershed. The funds collected are used to establish tree nurseries and to support reforestation along riverbanks.
- *Costa Rica*: A hydropower company pays \$10/ha/year to a local conservation NGO for hydrological service in the Penas Blancas watershed. In the town of Heredia, the drinking water company earmarks a portion of water sales revenue for reforestation and forest conservation.
- *Ecuador*: Municipal water companies in Quito, Cuenca, and Pimampiro impose levies on water sales, which are invested in the conservation of upstream areas and payments to forest owners.
- *Lao PDR*: The Phou Khao Houay Protected Area currently receives 1 percent of the gross revenues from a downstream hydropower dam, and the proposed Nam Theun 2 hydropower project is expected to provide over \$1 million/year for the management of the Nakai-Nam Theun Protected Area.
- *Japan*: The Kanagawa Prefectural Assembly adopted an ordinance in October 2005 that will impose an additional residence tax to be used exclusively for protecting water sources, with the funds going to projects aimed at conserving and restoring forests and rivers.
- *Colombia*: In the Cauca valley, water user associations have assessed themselves additional charges and used the revenue to finance conservation activities in their watershed areas. Watershed management in the country is partly funded through a 6 percent tax on the revenue of large hydroelectric plants.
- *United States*: New York City's Watershed Agriculture Program, launched in 1994, involves paying dairy and livestock farmers to tackle nonpoint source pollution and to retire environmentally sensitive lands from production.

Sources: McNeely 2006; USEPA 2006.

or implementing a plan to work with the upstream land owners/managers in the Catskill watershed to eliminate potential problems and maintain a high quality water source. The second option was chosen. It is a classic PES approach that included a number of different measures and actions (including payments for both on-farm capital costs and pollution-reducing agricultural measures). The plan was implemented for a cost to New York City of about \$1.5 billion, or less than 20 percent of the cost of constructing and operating a water treatment system. Note that the “market” in this example exists between the water utility in New York City and the watershed managers, and not between the millions of individual water consumers in New York City and the watershed managers.

Heredia, Costa Rica

Heredia is a small university town in Costa Rica, not far from the capital of San Jose. Faced with

similar issues as New York City—changes in the watershed were having an impact on the potable water supply—Heredia decided to set up a PES system that would tax the water users (about 50,000 connections) in order to pay farmers in the watershed to undertake improved conservation measures. Heredia consumes about 3 million liters per day, one-tenth of 1 percent of New York City's consumption (Castro 2000; Barrantes and Gamez 2007).

In the late 1990s researchers (see Castro 2000) considered a variety of environmental services produced by a forested watershed—water supplies, biodiversity, carbon sequestration, recreation, and flood mitigation. If land was converted, extensive dairy operations were the most attractive alternative use with an estimated gross income of about 53,000 colones per hectare per year—a bit over \$175 per ha per year. Further analysis showed that farmers were willing to “sell” their conversion rights and maintain the forest under conservation

for a payment of roughly 23,000 colones per ha per year (about \$75). This money will compensate farmers for forgone income and allow them to undertake additional conservation measures.

Further analysis estimated that a PES payment of 2.70 colones per m³ of water (less than US \$ 0.01) would be sufficient to collect enough funds from water consumers to pay the PES payment of 23,000 colones per hectare per year. The PES charge is equivalent to an increase in the water tariff of between 1 and 3 percent (water rates vary by type of water use). This system is now being implemented, and the PES charge is less than 2.5 percent of the total water bill.

It is sometimes surprising to note that even with so much interest in PES systems (often seen as a potentially self-financing answer to improved environmental conservation), the actual examples of successfully implemented systems are still quite small. PES systems usually focus on indirect uses of environmental resources (e.g., watersheds and water supplies; reef conservation and fisheries). There are many examples of direct payments for environmental service use (as in the case of reef conservation and divers, for example). Raising admission fees for recreational uses is a fairly common example since the distance between the service provider and the user is effectively “zero.” When the distance is greater and the services are provided indirectly, the number of examples of effective PES systems decreases rapidly. When environmental services are provided at the national or global level, successful examples of PES systems are even fewer in number. This example points out that PES systems are not a universal panacea, and that many countries are struggling to implement the PES approach. China is no exception in this regard.

POTENTIAL USE OF PES IN CHINA

Although PES is considered relatively “new” in China, as discussed earlier there is historic precedent for the government to make payments to

individuals to encourage them to take ecologically friendly land use decisions or other investments—examples include many ECM projects, including the “Grain for Green” program. Whether these include funds for improved terracing of erosion-prone uplands and loess areas, or grants to discourage deforestation in wooded areas, these are basically supply-side PES systems, but ones that are funded by revenues (taxes) collected by the government. What was missing in the past was the explicit link between payments from the beneficiaries of improved ecosystem services, and transfers/payments to those who provide these services. This is what makes the PES approach different.

As previously mentioned, a critical first step is the identification of the cause and effect link between ecosystem conservation and management and the provision of ecosystem services to beneficiaries. Once this is established, the payment system can either reflect a payment for some desirable ecosystem good or service, or a payment to prevent something bad from happening.⁵

Economists like the idea of “low hanging fruit”—easy victories that can be obtained with minimum effort. In the development of PES systems we also look for low hanging fruit—examples where a system can be easily and quickly implemented. Such a situation would exist when the following conditions are met:

- The cause and effect link between providers of ecosystem services and the beneficiaries is clear and relatively close.
- The beneficiaries realize the importance and value of the ecosystem services.
- Mechanisms exist (both institutional and legal) to efficiently collect payments for the ecosystem service from the beneficiaries and make transfer (payments) to the service providers.
- The institutional structure to collect payments and make transfers is in place.
- The number of service providers is manageable and the number of beneficiaries is clearly defined and not too large (or at least clearly defined as in the case of municipal water consumers).

- There is public and private support (on the part of both the government and individuals) for establishing a PES system.

Even when a PES scheme makes perfect sense, there is the very real question of the political economy of introducing something new, especially when it involves collecting funds and then making transfers to another group. For instance, if one group of service providers starts to receive payments when none was given in the past, other service providers in other areas may well demand payments also. One answer is that in theory those who provide valuable ecosystem services should receive payments. Rather than seeing this change in mind-set as an obstacle and using it as a reason for not attempting to implement a PES system, resource managers should recognize that new demands for PES systems may arise. This is actually a good development in the long run as ecosystem service providers and ecosystem service beneficiaries develop a deeper understanding of and appreciation for the value of environmental resources.

Illustration of a Potential PES Application: The Case of Lashihai Nature Reserve and Lijiang Old Town in Yunnan Province

The Lashihai Nature Reserve was established in 1998 in Lijiang City, Yunnan Province, China.

The reserve’s main purpose is the protection of the Lashihai wetland (including its important freshwater lake), a Ramsar-listed wetland important to migratory birds. Major protection measures focus on fishing, poaching, and hunting within the wetland and threats from increased tourism to the wetlands and agricultural activities in the surrounding areas.

In a recent study carried out by FEEM and Conservation International in conjunction with Chinese researchers and the Nature Conservancy (2007), a number of major environmental issues were identified, including the following:

- The Lashihai watershed provides important ecological services, including biodiversity protection (especially birdlife) and landscape/water supply benefits in terms of improved water quality in the nearby tourist town of Lijiang.
- Crops are eaten by protected bird species, resulting in economic damages to local farmers.
- There are economic costs associated with changes in agricultural practices to reduce fertilizer input into the water system that serves both the wetlands and Lijiang town.

There are a number of ecological/economic interactions in this case, only some of which are suitable candidates for a PES system. Table 7.1 summarizes the main ecological/environmental services, service providers, and service beneficiaries. The most obvious candidate for a PES system is that between the wetlands, agriculture, and the tourist town

TABLE 7.1 Summary of EES, Service Providers, and Service Beneficiaries in the Lashihai Case Study, China

EES Service	Service Providers	Service Beneficiaries
Improved water quality for landscape services	Farmers around the Lashihai Lake	Citizens of Lijiang tourism industry—Lijiang old town/visitors to the old town
Maintenance of birds’ biodiversity	Farmers around the Lashihai Lake	Tourism industry—Lashihai Nature Reserve Visitors to the nature reserve Global benefits—biodiversity preservation ^a

Source: FEEM Servizi 2007.

a. Global benefits are traditionally not included in local PES schemes.

of Lijiang. The Lashihai wetland is an important source of supplemental water flow to Lijiang (and its system of canals). Lijiang is a major tourism destination (estimated at some 2,300,000 domestic visitors and 110,000 international visitors per year) and both tourists and merchants in the town value the amenity benefit of good quality water for consumption and for landscape uses as it flows through the town. Parts of the case study focused on estimating willingness to pay by tourists for water quality and water quantity services, and the costs of improving agricultural practices to help maintain or improve water quality.

The link between the wetlands and surrounding agricultural areas is two-fold: first, agricultural activities affect the quality of water entering the wetland, and second, the protected birds in the wetland forage outside of the wetland for food, and eat part of the crops in nearby fields. In addition, there is a growing tourism industry in the wetlands, largely focused on bird watching. The problem with the wetland-farmer link is that there are benefits and costs on both sides, and the number of yearly visitors to the wetlands is still fairly small.

The Wetlands-Agriculture-Lijiang link

Lijiang is a major tourist destination and water quantity and quality are important to the visitor experience. The case study focused on the links between Lijiang and agricultural practices of surrounding farmers. In this case the farmers are the potential providers of the improved EES—better quality water—and the visitors are the beneficiaries. The study carried out a contingent valuation method (CVM) survey of the willingness-to-pay (WTP) of visitors to Lijiang for improved water quality. A CVM survey is an analytical technique that relies on people’s responses to a hypothetical question to estimate economic values. In the Lijiang study the CVM survey determined there was a median WTP of 8 yuan for “landscape” water quality, with an average or mean WTP of 10.3 yuan.⁶

In contrast, a separate survey of the WTP of visitors to the wetlands for maintenance of bird

biodiversity in the nature reserve found the same median WTP—8 yuan—but a much higher average or mean value of 33.4 yuan (due in part to the very high maximum WTP results for biodiversity viewing as reported in Table 7.2). This means that on average wetland visitors were often willing to pay more per person for bird biodiversity conservation than visitors to Lijiang town were willing to pay for better “landscape” water quality. Of course, the number of visitors to Lijiang town far outnumbered the number of visitors to the nature reserve.

Looking at the situation of both the service providers (largely farmers around the Lashi Lake) and the service beneficiaries, it is evident that the two main ecological services—water quantity/quality and biodiversity (largely birds) conservation—have quite different stories. It appears much easier to use a PES scheme to fund the provision of water for landscape services and good water quality in Lijiang old town than it would be to fund biodiversity conservation and farmer compensation for bird damage. The study estimated, based on the WTP results and the number of annual visitors, that environmental service beneficiaries would be willing to pay from 32 to 42 million RMB per year for landscape and water quality services, but only between 500,000 and 2.1 million RMB per year for biodiversity protection (largely bird life).

TABLE 7.2 Suggested Increase in Lijiang Old Town Visitors’ Fee to Fund PES Scheme

	Domestic	International	Total
Increase	1%	5%	
RMB per person	0.4	2	
Number of paying visitors	2,315,700	109,680	
Funds generated (RMB/year)	926,280	219,360	1,145,640
Funds generated (US\$/year)	117,174	27,749	144,923

Source: FEEM Servizi 2007.

Funding a PES scheme

Based on these results, the study concluded that a small increase in the fee presently charged visitors to Lijiang would be sufficient to raise enough money to pay for needed agricultural extension services and other measures (including promoting organic agriculture) to help the agricultural sector provide the desired ecological services (improved water quality and quantity). Thus a PES system seems quite feasible, given the direct link between agricultural practices and the ecological service of improved water quality, and the very large number of visitors (service beneficiaries) to Lijiang. It is important to note, of course, that water quality in Lijiang old town is also affected by the town itself. To address water quality more broadly in Lijiang will require measures to both improve the quality of water coming from agricultural areas, as well as to manage municipal sources of pollution such as sewage and wastewater.

Since the visitors already pay a fee, it would be fairly easy (and low cost) to impose the extra ecological service charge. In fact, the study calculated that if the average visitor fee of 40 yuan was increased by 1 percent for Chinese visitors (to 40.4 yuan) and 5 percent for foreign visitors (to 42 yuan), this would produce enough revenue to implement the PES scheme and pay the required transfers to service providers (Table 7.2). Experience in other parts of the world suggests that the proposed increase is very modest and should have no impact on the number of visitors. In fact, a substantially larger environmental surcharge could probably be added to the visitor fee and still have no negative impact on demand.

The agriculture-wetlands link

The focus of the economic analysis of the agriculture-wetlands link was on the damage created by birds eating grain from farmers' fields. These costs were estimated to be as high as 1.8 million yuan per year (about \$233,000). Since the average number of visitors to the reserve is still fairly

small (estimated at 50,000 Chinese and 15,000 international visitors per year), a substantial fee would have to be collected per person in order to implement a PES system. This fee, which would have to average about 28 yuan per visitor, considerably exceeds the average stated WTP as determined by the CVM survey mentioned earlier (a median value of 8 yuan).

The authors of the study concluded that even with a two-tiered pricing system for wetland visitors (a higher charge for international visitors than for national visitors), a PES system for the agricultural-wetlands link would only be partially sustainable, and that additional funds would be required from other sources. If domestic visitors were charged 8 yuan and international visitors were charged 40 yuan, this would raise about 1 million yuan per year, about half of what is needed to compensate farmers for bird damage to their crops (Table 7.3). The full report of the case study (FEEM Servizi 2007) has much more detail on the study and the estimated values.

The Lashihai case study pointed out a number of useful lessons. Establishing a PES system is easier when the cause-effect link is clear, the number of service providers is manageable, and existing institutional structures can implement a new payment system (such as the already existing visitor fee at Lijiang old town). In contrast, it will be much more difficult to introduce a PES

TABLE 7.3 Suggested Entrance Fees to Lashihai Nature Reserve to Fund PES Scheme

	Entrance Fee (RMB yuan)	Entrance Fee (US\$)
Number of domestic tourists: 50,000.00	8	1
Number of international tourists: 15,000.00	40	5
Total revenue	1,000,000	126,500

Source: FEEM Servizi 2007.

scheme in the Laishihai Nature Reserve since the number of service beneficiaries is small and a payment system is not in place.

The case study further discusses the institutional arrangements in Lijiang old town and in the Lashihai Nature Reserve, and how existing institutional systems will affect the implementation of any PES system. As the study points out, there are other political economy concerns over the impact of introducing a new financing mechanism on the rest of the society beyond the direct service providers and beneficiaries in Lashihai watershed—for instance, the communities outside Lashihai area who provide drinking water or other environmental services to Lijiang old town. These concerns have to be addressed appropriately in order to build up enough political momentum for launching a PES system and facilitating its smooth implementation. For more details, see the full case study report and supporting institutional analysis and implementation guidelines (FEEM Servizi 2007; Conservation International, the Nature Conservancy, and FEEM Servizi 2007).

RECOMMENDATIONS

Although PES schemes are not a universal panacea or always easy to introduce, they offer potential opportunities to enhance and complement existing efforts (usually some form of ECMs) to implement improved ecosystem conservation in China's watersheds. The chapter offers the following recommendations to help improve existing practices of eco-compensation.

- Given the urgency of protecting water supply by improved management of ecosystems in the upper reaches of river basins, China should continue to expand its ecological conservation programs through expanded use of market mechanisms. The current practices of public transfers for ecological conservation (ECM projects) should be encouraged, especially when the

ecosystem service providers and beneficiaries are far apart and their links cannot be explicitly defined, or where there are obvious poverty alleviation benefits.

- The traditional supply-side ECM approach, relying heavily on transfers of general public funds, may be less efficient and effective than other approaches, and there are long-term concerns about their financial sustainability. This is especially true in those situations where the market can play a role in collecting payments from ecosystem service beneficiaries and allocating funds to the service providers. When these conditions hold, market-oriented approaches such as PES should be considered.
- PES has the potential to be more widely used in China, especially in small watersheds, and play an important role in conserving ecosystems and protecting water-source areas. If designed and managed well, PES can be self-financing, and efficient, and reduce demands on direct government involvement in financing day-to-day operations (both major requirements of ECM schemes). The government should promote efforts to create PES schemes.
- Political will is crucial in introducing a PES scheme or other innovative financing schemes. However, broader political economy concerns (particularly regarding introducing a new fee) can make introducing a new PES scheme difficult. These issues must be addressed upfront, and any new PES scheme should be monitored and analyzed. In addition, the government should recognize and reward those groups that are leaders in trying new approaches, including PES schemes.
- Governance mechanisms and institutional arrangements are also crucial in implementing PES schemes. Building on existing institutional and social systems is often the most cost-effective way to make a PES scheme work; establishing a new revenue collection and payment distribution system is costly and time consuming. A simple benefit-cost analysis can be done to show if the institutional costs of any new PES

scheme are justified by the expected increase in net revenues available for transfer (revenues less collection/administrative costs).

Endnotes

1. Note that one sees three different terms used for the “E” in PES—environmental, ecological, or ecosystem—but the idea is the same. In the current literature the term environmental is most commonly used. In this work we often use the three terms interchangeably.
2. There are specific ordinances or rules issued by relevant central government agencies or local governments to promote the use of ECM; examples include the Ordinance of Converting Farmlands to Forests issued by the State Council in 2002, the Management of National Forestry Ecological Compensation Funds issued jointly by the Ministry of Finance and the State Forestry Administration in 2004, and the Guidance of Ecological Compensation Pilot Projects issued by SEPA in 2007.
3. A useful discussion of these factors is also found in the FEEM case study paper (2007) and Pagiola and Platais (2007).
4. Useful guidance and examples are provided in Pagiola and Platais (2007).
5. Note that the traditional polluter-pays approach championed by the OECD in the early 1960s and now commonly used in China today is a variant of the PES approach, but one where the creator of pollution is charged an amount that is in theory linked to the magnitude of damage done to others. It is not intrinsically a PES system, since the polluter is charged for damage created, and the beneficiaries of the unpolluted service are not asked to help pay for the service.
6. A median value is the point where half of the respondents were willing to pay at least this amount, while the mean or average amount is the total WTP of all visitors divided by the number of visitors.

Controlling Water Pollution

Water pollution in China is a pervasive problem that threatens the health of ecosystems, increases the cost of treating water for drinking, industrial, and commercial uses, and exacerbates water scarcity problems, especially in the North. Yet water pollution control has not received as much attention as other water-related issues such as flood control, drought remediation, water diversion, and soil erosion. Given the serious impacts of water pollution, the government needs to take stronger action to address it.

Effective water pollution control yields multiple benefits in protecting both the natural environment and human health, improving water quality for various uses, and alleviating water shortages. This chapter examines the complexity and difficulty of water pollution control; describes other national attempts to control pollution; identifies and discusses a number of institutional and policy issues that need special attention; and presents recommendations.

SERIOUSNESS OF WATER POLLUTION

In recent years, water pollution has emerged as one of the most serious environmental issues in China. In its strategy and other official documents, the central government has placed it at the top of the list of seven major environmental problems facing the country (SCCG 2006). Since the mid-1990s, COD (chemical oxygen demand) reduction has been one of two major total emission control targets at the national level (the other is SO_2). Even so, total COD emissions have increased since the early 1990s, largely due to an increase in emissions of untreated municipal wastewater. In spite of over a decade of effort, it was not until 2007—when total 2007 COD discharges were reported to be 3.14 percent less than in 2006¹—that this trend began to be reversed.

Nevertheless, overall water quality in China remains poor. In 2006, only one-fifth of China's monitored river sections achieved Grade I or II water quality standards—the highest quality—while more than one-third were Grade V or V+—the most polluted categories and unsafe for any use. In

recent years, there have been increases in the share of river sections at both ends of the distribution. During the 1991–2006 period, the percentage of sections rated Grade I or II increased from 4 to 24 percent, while the portion rated as Grade V and V+ also increased slightly, from 31 to 33 percent (Figure 8.1).

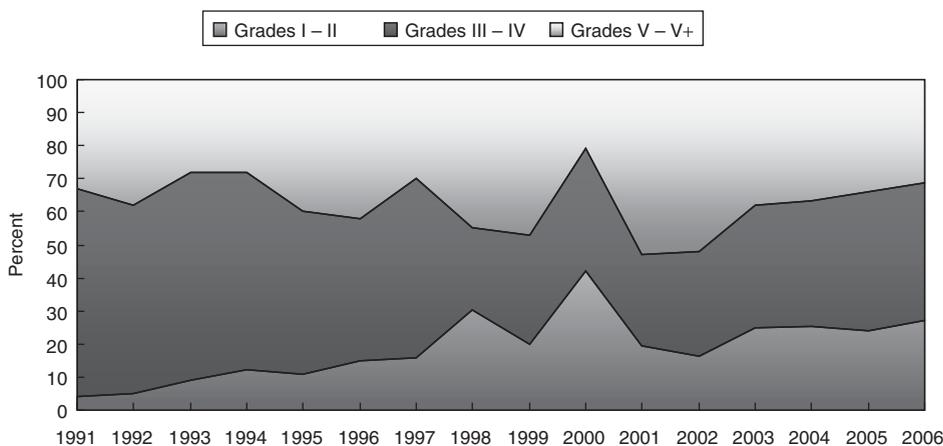
Although statistical data show some general improvement in water quality in monitored sections, there has actually been deterioration in several major rivers in the last five years. In northern China in 2001 and 2005, the percentage of monitored sections with water quality worse than Grade III was consistently above 60 percent, especially in the Songhua and Huai rivers, where the percentage in these categories actually increased (Figure 8.2). In the Pearl and Yangtze rivers, two major southern rivers that are relatively clean, the worst water quality categories rose by a large margin (Figure 8.2). In 2006, more than 60 percent of large lakes and all urban water bodies were in some stage of eutrophication. Conditions were particularly serious in several large lakes, including the Taihu, Dianchi, Chaohu, and Baiyangdian.

Drinking water sources were threatened by increasing pollution of rivers flowing through cities and towns, particularly where industries are relatively well developed. According to monitoring results in 2006, among 382 major drinking water sources in 107 key cities, only 72.3 percent met drinking standards, decreasing from 80 percent the year before. Water pollution accidents—such as in Lake Tai in the early summer of 2007—occurred frequently and caused water shortages with severe impacts on social and economic development. The environmental cost of water pollution was estimated at 286 billion yuan in 2004, equivalent to 1.7 percent of GDP in that year (SEPA and NBS 2006).

CAUSES OF POLLUTION AND KEY CHALLENGES FOR POLLUTION CONTROL

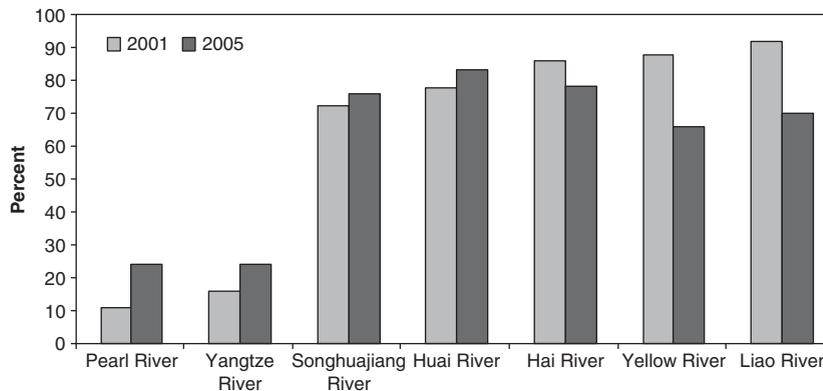
The effectiveness of water pollution management is highly correlated with a country’s stage of economic development. In general, poorer

FIGURE 8.1 Water Quality in Chinese Rivers, 1991–2006



Sources: *China Statistical Yearbook* (various years); *China Environmental Status Bulletins* (various years); World Bank 2001.

Note: Grades I–III refer to water that is safe for human consumption after treatment; grades IV–V refer to water that is safe for industrial and irrigation use; and grade V+ refers to water that is unsafe for any use.

FIGURE 8.2 Percentage of Sections with Water Quality Grade IV to Grade V+, 2001 and 2005

Source: *China Environmental Status Bulletins* (2001–05).

Note: Grades I–III refer to water that is safe for human consumption after treatment; grades IV–V refer to water that is safe for industrial and irrigation use; and grade V+ refers to water that is unsafe for any use.

countries do less to control pollution, while wealthier countries do more. The same pattern has also been observed within large countries like China—poorer regions or areas often do less to control water pollution, while richer areas or regions do more (even if they face bigger challenges, in part due to the same factors that make them richer). Important factors determining the extent of water pollution and its control include the aggregate level and regional variations in economic activity, population growth, and urbanization; the region’s natural endowment of water resources; and the effectiveness of institutional and policy arrangements.

The serious water pollution problem in China is attributable to various institutional and policy failures. These include (a) poor law enforcement and compliance due to weak institutional capacity; (b) failure to implement water pollution prevention and control plans; (c) lack of incentives for wastewater treatment; (d) malfunctioning of the wastewater discharge control system, with problems associated not only with the issuance of permits, but also with monitoring and enforce-

ment; (e) the influence of local and sectoral interests in river basin management, as well as the lack of integrated planning and local commitments; (f) increasing but unchecked pollution from townships, villages, and nonpoint sources; and (g) insufficient and spatially imbalanced investment in wastewater treatment. Some of the above points—such as low incentives and weak institutional capacity for water management—were discussed in previous chapters. This section focuses on the remaining issues.

Poor Water Quality Despite Reported Higher Compliance

According to official statistics, mainly from the *China Statistical Yearbooks*, the three compliance indicators—EIA execution, emission standards for industrial sources, and urban sewage treatment—are all at a good level. In 2006, the first two indicators were reported to reach 90 percent and more, while the third was over 50 percent. However, water quality in the major water bodies remains low. The sharp contrast between

the poor water quality and high reported compliance reflects the problems of environmental management and reporting systems. An inspection of the implementation of environmental laws by the NPC revealed that the compliance rate for EIA is actually only about 50 percent, while compliance with emission standards is below 70 percent. Compliance and enforcement are no doubt the most important issues to be addressed if water pollution is to be controlled and solved.

Failure of Water Pollution Prevention and Control Plans

Many water pollution prevention and control plans have been prepared at the national, local, and river basin levels. For instance, the central government and most local governments have developed five-year plans for water management. All the major transprovincial river basins also have such plans developed by RBMCs. These plans usually have four major components: (1) water quality targets, (2) total emission control targets, (3) construction projects and financing, and (4) regulations to be enforced.

However, many plans have failed to achieve their water quality and pollution control targets. For example, the Huai River basin was the first river basin in China to involve a major planning effort for water pollution control. Its experience is summarized in Box 8.1.

An evaluation of the implementation of the Water Pollution Prevention and Control Plan (WPPCP) in the Huai River basin identified several reasons for the poor implementation of water pollution control plans. First, water quality targets were too ambitious and lacking in technical details necessary for implementation, indicating that planners tended to underestimate the difficulty of addressing water pollution problems. Second, the four components mentioned above (water quality targets, emission control targets, construction, and regulations) were not adequately coordinated. Third, although most plans included a financial budget for emissions control, they typically specified only the total investment required, without clear assignment of funding responsibility between governments and other entities at various levels. Fourth, the supervision and implementation of the financed projects, as well as their subsequent operation, were very

BOX 8.1 Implementation of Water Pollution Control Plans for the Huai River Basin

The Huai River is the only river basin for which three consecutive five-year river basin Water Pollution Prevention and Control Plans (WPPCPs) (1996–2010) have been prepared and implemented. The State Council has also issued the Provisional Decree of Water Pollution Prevention and Control for Huai River. However, an evaluation of the first two five-year plans (1996–2005) found that the water quality and total emission control targets were not achieved. For instance, the 9th FYP's (1996) water quality target for 2000 was to achieve Class III for the entire main stream. However, by 2005, the water quality at 80 percent of the national monitoring sites in the basin was still at Class IV or worse.

Moreover, the financing plans for wastewater treatment laid out in the 9th and 10th five-year WPPCPs also failed. Although these plans expected local governments to fund the program, there were no specific allocations from the central to the local governments for this purpose. As a result, while the central government assigned the funding responsibility, the local governments waited for the funds to be allocated from the central government. Because of weak supervision, poor coordination at different government levels, and lack of a monitoring mechanism for financial performance, the funding was totally inadequate.

In addition, all three plans specified goals for total emissions control. However, the goals applied only to industrial and municipal point sources. Nonpoint sources and management of water quantity were not considered, making it impossible for ambient quality goals to be achieved.

weak. And fifth, there was no assessment of the effectiveness and efficiency of the plans, and no penalties in case plan implementation failed. More broadly, pollution control plans were poorly integrated with plans for water resource management and land use, as well as more general social and economic development plans in the same river basin. The evaluation of the Huai River basin plans indicates that without good integration with other water-related plans, the effort to achieve pollution control cannot be successful.

Integrated Planning and Local Commitments Are Lacking

While there are some successful stories of integrated river basin management, they are few in number and generally only apply to small watersheds. One such good example is the West Lake of Hangzhou City, where the municipal government established a basin-wide management, planning, financing, and administrative system to successfully treat wastewater, control land use in the catchment of the lake, remove significant point sources of pollution (primarily factories), restore streams and wetlands, and control pollution from tourism. The success of the West Lake program, however, was primarily due to the fact that the municipality covers the lake's entire catchment area.

Most river basin management in China is driven by local and sectoral interests. Lack of integration and cooperation across jurisdictions is a common problem. Building popular and political support for integrated river basin management (IRBM) is still at an early stage in China (for a recent publication promoting IRBM in China, see Wang et al. 2007c).

According to China's Environmental Protection Law and the 2008 Water Pollution Prevention and Control Law (WPPCL), local governments are responsible for local environmental protection and for funding the main share of local water pollution control invest-

ments (in line with the polluter-pays principle). This is also specified in all river basin WPPCPs. However, since the damage caused by water pollution usually affects downstream users outside its jurisdiction (an example of an environmental externality), pollution control is invariably a low priority in local government budgets. In addition, the current mandate and responsibility of water resource management authorities at both the central and local levels puts a greater focus on water diversion and erosion control than on reducing water pollution, even though the latter, particularly where transboundary impacts are present, is typically the most important issue basin-wide.

The Wei River, a major tributary of the Yellow River in Shaanxi Province, illustrates the failure caused by the predominance of local and sectoral interests over basin-wide objectives. The river basin has been plagued with floods, soil erosion, water shortages, and pollution for a long time. Many of these problems are transboundary, affecting lower reaches of the Yellow River. Water pollution is the most serious. In 2006, water quality in nine out of thirteen monitoring stations was worse than Grade V, and 74.9 percent of the Wei River did not meet the assigned water function zoning standards.

Given the importance of the Wei River's water problems, an integrated river basin management plan was prepared in 2002 and approved by the State Council. As shown in Table 8.1, the plan included an investment of 22.6 billion yuan for flood control, water supply, erosion control, and pollution control, of which 62 percent was to be funded by the central government, primarily to address transboundary problems. However, the budget for water pollution prevention and control only accounted for 14 percent of the total water-related investment, and only 20 percent of the water pollution control budget was from central government funds. The rest was expected to come from local budgets, but these funds did not materialize. The failure of local governments to carry out their financial obligations

TABLE 8.1 Planned Water-Related Investment Shares between the Central Government and Local Sources in Wei River Basin

Spending Items	Ratio of Central Government to Local Investment
Water Saving	2:01
Water Pollution Control	1:04
Water Use	2:01
Flood Control	8:02
Water and Soil Conservation	7:03
Ecosystem and Dry Farming	1:01
Total investment (billion yuan)	22.6
Share of central/local government (%)	62.4%/37.6%

Source: The Integrated Control Plan of Wei River Basin in Shaanxi Province (Working Group of Weihe River Basin Comprehensive Control Plan 2002).

has so far meant that the pollution control components of the plan have not been implemented (Working Group of Wei River Basin Comprehensive Control Plan 2002).

Increasing Pollution from Small Towns and Nonpoint Sources in Rural Areas

As mentioned in Chapter 2, rural areas of China have been suffering from water pollution from TVIEs. With accelerated urbanization, wastewater from small towns is also an increasingly significant pollution source in rural areas. China has more than 19,000 established townships (*China Statistical Yearbook 2006*) with a population of about 200 million people.² In most of these small towns, wastewater is discharged without treatment in any form. Untreated water pollution from these small towns has particularly severe impacts because it more directly affects ecological systems and agricultural production. However, China still lacks a well-developed national program to deal with water pollution from small towns, including basic monitoring and reporting. While China has increased efforts

to control water pollution, they are concentrated in urban areas, especially the large and mid-sized cities. In the 11th FYP, sewage treatment targets are only set for large and mid-sized cities, and there is no plan for small towns. In addition, as also mentioned in Chapter 2, widespread non-point water pollution in rural areas is still out of control in general, which has imposed serious impacts on the rural environment.

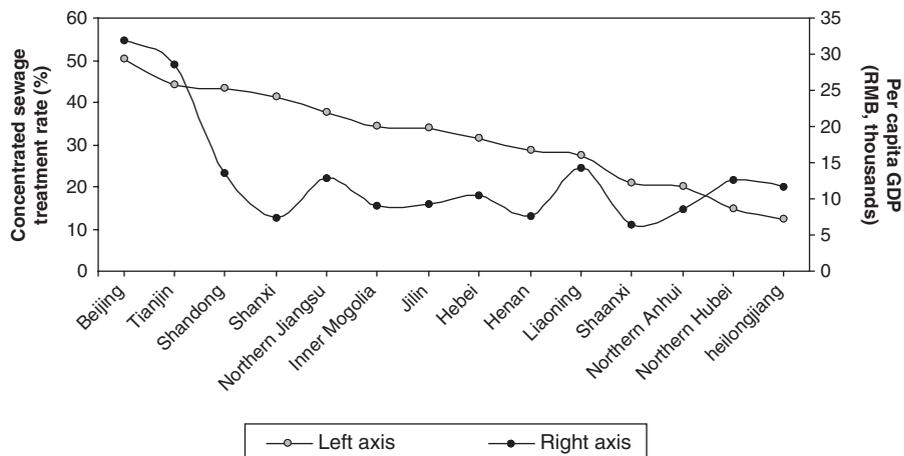
The case of the Qixinghe Natural Reserve illustrates the weakness of the water pollution control program in rural areas. The Qixinghe Natural Reserve in Heilongjiang is one of the best preserved and representative wetlands at the national level. Based on national regulations, the Qixinghe River, the reserve's main water source, should meet Grade I standards. Yet it has experienced severe water pollution in the past few years. Recent water quality monitoring demonstrated that water quality was as low as Grade IV and V (Table 8.2).

Field investigation revealed that the main pollution sources were industrial enterprises located upstream, whose untreated wastewater discharges far exceeded national emission standards. Besides, there were many nonpoint sources in surrounding areas. All the sources were located in the countryside, where neither MEP nor the local EPBs have taken serious action to control emissions.

Insufficient and Spatially Imbalanced Wastewater Treatment Investment

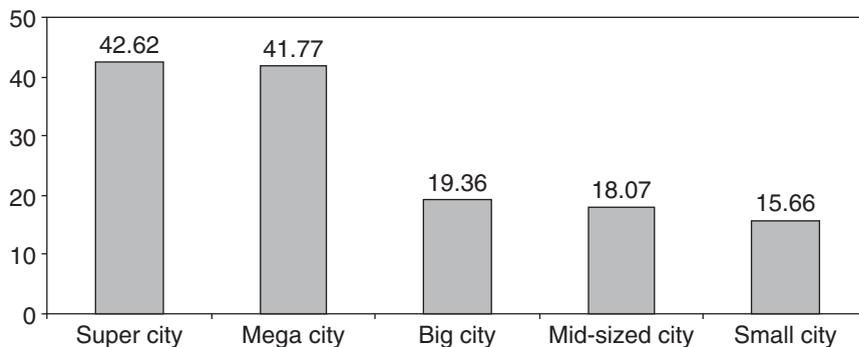
In addition to insufficient total investment in wastewater treatment (mentioned in Chapter 3), wastewater treatment capacity is unevenly distributed. Figure 8.3 shows wastewater treatment investment in the provinces along the Yellow River. One can see that investment is concentrated in downstream and coastal areas (economically rich areas), while funding for sewage treatment is insufficient in the upstream areas, which are less developed and where water quality is bad and downstream environmental impact is

FIGURE 8.4 Centralized Sewage Treatment Rates and per Capita GDP in 14 Provinces in Northern China, 2003



Sources: Per capita GDP is obtained from *China Urban Yearbook, 2004*. Centralized sewage treatment rates are from *China Urban Development Statistics Yearbook, 2004*.

FIGURE 8.5 Centralized Sewage Treatment Rates by City Size in 2003 (%)



Source: *China Urban Development Statistics Yearbook, 2004*.
 Note: Super city = more than 2 million population; mega city = 1 to 2 million population; big city = 0.5 to 1 million population; mid-sized city = 0.2 to 0.5 million population; small city = less than 0.2 million population.

badly lagging (by half or more) behind those of cities with populations exceeding 1 million (mega and super cities).

Such a spatial imbalance is the result of both market and policy failures. In order to effectively improve water quality in a river basin, water pollution control should be planned, financed, and managed for the river basin as whole. This will require more fiscal support through government transfers, in particular for the poorer upstream cities and towns. But the existing pricing and funding policies fail to promote adequate investment in upstream regions, which compounds the market failure.

INTERNATIONAL EXPERIENCE

There is extensive international experience with water pollution control. Although almost all governments tend to initially focus on the problems of water supply (demand for clean water is very evident and there is a willingness-to-pay for clean water for domestic, municipal, and industrial uses), water resource managers soon realize that there is a direct link between the sustainable availability of clean water and how water pollution is controlled.

International experience in water pollution control has evolved over the last several decades. Initially, it was characterized by a more traditional command-and-control approach of setting standards coupled with a “supply-side” approach of investment in water pollution control infrastructure (especially treatment of urban and industrial waste water). It has since moved toward a greater reliance on a mix of command and control with economic approaches such as polluter-pays type levies and other economic instruments to promote the desired investments and behaviors.

OECD Countries as Leaders in Water Pollution Control

The rich OECD countries have done the most to address water pollution issues. Not only does their wealth allow them to make the required

investments, but their citizens also demand a cleaner water environment and make their demands known through the political process. The actual approaches used have varied from country to country. The choice depends on various factors, including the size of the country, social/institutional setup, and the political system. A review of OECD countries (Gillespie 2007) shows that while water quality standards are usually set at the national level, the responsibility for ensuring compliance with those standards is normally delegated to subnational governments. This is seen in most countries with a federal structure such as Austria, Belgium, Germany, and the United States, but also in such countries as Denmark, Italy, and Poland.

In some cases, however, the national environmental agency has regional branches, with staff members responsible for enforcement, as in the case of France. Other countries, such as Ireland, have a relatively autonomous enforcement agency, with regional branches that are entirely part of its structure. And finally, there are some countries where all water pollution control activities are carried out by a central/national office and no subnational structures exist.

Role of the Public in Compliance with Pollution Control Measures

A key test of the effectiveness of different institutional approaches is the degree of compliance with environmental standards. While the experience of OECD countries has been mixed, one key contributing feature is the need to generate effective support from the general public. In some cases the presence of a technically aware, politically empowered public has been more important than formal legislative or regulatory standards imposed by environmental authorities. This is perhaps best illustrated in the case of Japan (see Box 8.2).

Control Mechanisms

Traditionally, efforts to control water pollution have primarily employed command-and-control

BOX 8.2 Public Participation and Compliance with Environmental Standards: The Case of Japan

Public awareness and empowerment are basic requirements for effective collaboration between government and industry, as illustrated by Japan's experience in the early post-World War II years with the major health impacts of water pollution (Minamata disease). Historically, the central government has typically lagged behind sectoral or local government initiatives, and only strengthened environmental standards when public pressure combined, in some instances, with industrial self-interest forced it to do so. Motivated by economic self-interest on the industrial side, with pressure from an increasingly concerned domestic population, standards are determined on the basis of informed technical opinion. Once established, there is almost complete compliance. Building up trust between government and industry has been shown in Japan to be an essential element of efficient environmental management, and public empowerment has been integral to this process.

methods. These may take the form of permits to establish an industrial facility with a given maximum discharge limit for defined pollutants, as well as the establishment of effluent standards to be monitored and subjected to periodic inspection. Failure to comply with standards may result in fines or other legal penalties.

In recent years, increasing attention has been given to the implementation of the polluter-pays principle, whereby the polluter is levied a charge based on levels of pollution discharged. The advantages of this approach are thought to include fairness, the prospect of raising revenue, and the potential for achieving a given reduction in pollution at the lowest possible cost.

However, there have been serious difficulties in implementing the polluter-pays approach. In particular—and in common with other regulatory methods based on monitoring of emissions—there have been major administrative difficulties in ensuring compliance, particularly for nonpoint source emissions. In response, while there has continued to be an increase in the use of pollution levies, the main growth has been through the imposition of taxes on inputs, or on materials that in the process of production (or use) tend to generate pollution (so-called product charges). Good examples are taxes on pesticides and fertilizers; such taxes have been used for several years in Scandinavian countries. By taxing pesticides and fertilizers, farmers have an incentive to use these expensive inputs more carefully and thereby reduce environmental pol-

lution. The funds collected from these input taxes can also be used to address environmental issues.

Although economists prefer the polluter-pays approach, since it offers the chance of achieving the goal of pollution reduction in a least-cost manner, environmental managers often distrust it. In contrast, water quality managers often prefer command-and-control approaches since they appear to offer greater certainty in reaching physical goals (ambient quality standards) even if the cost is higher. The choice of policy instrument involves a tradeoff between potential economic savings against the ease (and feasibility) of implementation. For example, the use of water effluent charges in Germany has been effective in reducing pollution. Germany has also promoted increased investment in pollution-reducing best available technology (BAT) by offering rebates. Effluent fee rebates are designed to encourage compliance with compulsory BAT standards, with part of the investment expenditure in BAT-conforming treatment plants being eligible for the rebate. A drawback of this system is that it reduces the incentive function of effluent fees, but it is probably a necessary price to pay to improve industrial compliance.

In some OECD countries, such as Belgium and France, the revenue from pollution and permit fees goes to the treasury (which is also in line with the principle of preventing conflicts of interest, an issue that has been associated with the Chinese pollution levy system). However, in

Australia, Finland, Ireland, and the U.K., a significant part of the environmental agencies' revenues (in some cases up to 65 percent of budgets) is raised directly from permit and inspection fees paid by the polluters (Gillespie 2007).

Clearly inconsistent with the PPP approach, a large proportion of economic instruments are in the form of subsidies instead of taxes; for example, low-interest loans and tax holidays to encourage investment in pollution control equipment. Although there is always the potential for subsidies to have a distorting effect on investment decisions, China has actively used subsidies to promote greater investments in pollution-control activities.

EMERGING INSTITUTIONAL AND POLICY ISSUES

A number of issues in water pollution control are underestimated or even overlooked. These issues include the following: carefully defining the objectives of the Water Pollution Prevention and Control Law; providing more reliable and complete information on pollution sources; emphasizing the linkage between water pollution and unsafe drinking water sources; strengthening the deterrent function of current legislation and enforcement systems for managing water pollution; promoting routine pollution prevention over after-incident treatment; and addressing the relationship between the polluter-pays principle and government responsibility at the regional and national level, especially in those areas where governments have some responsibility due to their past activities.

Alignment of the Law's Objectives with Its Reach

There is a mismatch between the objective of the newly amended Water Pollution Prevention and Control Law (WPPCL) and its legal reach. As stated in the WPPCL, its objective is to prevent and control water pollution, protect and improve

the environment, provide safe drinking water, and promote sustainable economic and social development. In practice, achieving such multiple objectives is almost impossible because the objectives—such as public health, resource utilization, and economic and social development—are too broad (and normally the targets of other relevant laws and programs). The WPPCL has neither the authority nor the capacity to address these targets, and indeed there is nothing in it to describe how to meet them. It would be more appropriate for the WPPCL to have more narrowly focused objectives, such as those found in the U.S. Clean Water Act, whose objective is the “restoration of physical, chemical, and biological integrity” of waters.

Pollution Source Information and Management

Water quality has been regarded as the primary goal of most WPPCPs. Official weekly and annual reports on the water environment emphasize data on water quality. Although water quality is clearly the ultimate goal of water pollution control, an improvement in water quality depends on effective control of pollution sources. However, there are only partial information datasets on sources of pollution. The problem is compounded because three major water authorities—MWR, MEP, and MHURC—are all involved in water quality management, and cross-sectoral coordination is often a challenge.

After many years of effort, information is now available on most of the main point sources of pollution. Four existing and ongoing environmental information systems are used by MEP and local EPBs: (1) the environmental statistical program, (2) the pollution levy program, (3) the emission reporting and permit program, and (4) the environmental impact assessment (EIA) program. Information from these sources is collected by local EPBs and transmitted to and managed by MEP. Although the information is imperfect, compiling and comparing emissions

information from various programs could form the starting point for establishing a unified information system of pollution sources, promoting inter-agency information sharing, identifying failures in pollution control programs, and developing a more comprehensive strategy for water pollution control.

Safe Drinking Water and Pollution Control

Frequent water pollution incidents have recently stimulated governmental actions to secure the safety of drinking water. In the Decision on Implementing the Scientific Development Strategy and Strengthening Environmental Protection released by the State Council in December 2005, drinking water safety was highlighted as a high-priority task. But the response of local governments is usually to search for alternative sources of supply—such as water transfer and underground water extraction—rather than controlling water pollution. In some cases, local governments have even diverted polluted water to less-developed downstream areas to avoid investing in wastewater treatment.

Alternative sources may be effective in providing safe drinking water in the short run, but are not, in many cases, the appropriate final and sustainable solution. Furthermore, this short-run approach may involve more risks, such as (1) disturbing water resource allocations and causing further water shortages, which may result in additional environmental impacts because of added engineering projects; (2) ignoring the urgency and damage caused by water pollution, which will delay and reduce efforts in pollution control, and (3) shifting the burden to other regions and future generations, thus causing transboundary or trans-generational externalities. From a long-term perspective, pollution control—instead of water transfer and underground water extraction—is the most important and effective way to address the problem of providing safe drinking water.

Routine Pollution Prevention Versus After-Incident Treatment

The well-known Songhua River toxic spill in 2005 and the algae outbreak in Tai Lake near Wuxi City highlighted the absence of an effective prevention and response system for pollution incidents. A series of actions were subsequently taken, including the 2006 National Plan for Environmental Emergency Response and the subsequent 2007 National Emergency Response Law. However, the pollution emergency plans and laws mainly focus on response rather than prevention. This approach is insufficient: the primary reason for the increase in water pollution accidents is not the lack of emergency response plans, but the government's ineffectiveness in the supervision and control of pollution sources. A comprehensive risk assessment and management program for pollution sources should therefore be introduced at all levels of government to assist in emergency prevention. Further discussion on water pollution emergency prevention is presented in the next chapter.

Effectiveness of Legal Instruments: Pollution Compensation Versus Fines

National environmental laws contain provisions regarding lawsuits, cleanup, economic compensation, and fines for pollution damage. But for a long time now, the systems have failed to perform a deterrent function for water pollution since the maximum fines have been set too low—it may be cheaper to pollute and pay the fine than to prevent pollution. According to the Implementation Regulation of WPPCL, the fine for pollution causing massive damage should be calculated as 30 percent of the direct costs, and the amount of the fine should be no more than 1 million yuan. For example, in 2004 the Tuojiang River was polluted by the Chuanjiang Corporation, which finally paid 1 million yuan (about \$122,000) in penalties and 11 million yuan (about \$1.34 million) in compensation (SEPA 2006b). In

contrast, in developed countries the compensation and penalty can be very high (see Box 4.1 in Chapter 4 for the experience and some cases in the United States). To some extent, the low and capped fines encourage polluters to ignore pollution control because the financial consequences are so limited. In the newly amended WPPCL (2008), the punishment against non-compliance is strengthened, but still limited.

Another problem under the existing system is that lawsuits against water polluters can only be aimed at compensation for private damages, whereas most water pollution damages the general public. Obviously, this type of legal compensation hardly provides the right level of incentive to control polluting activities, because the public goods part of environmental damage—such as to fragile ecosystems—is not subject to legal liability claims.

Polluter-Pays Principle Versus Regional and National Responsibility

Two basic principles enshrined in Chinese law regarding the responsibility of water pollution control are (1) polluters are responsible for pollution control, and (2) local governments are responsible for environmental quality. These principles should be applied flexibly, in recognition of the large differences in the nature and severity of water pollution, as well as in the level of economic development in different areas of the country. In particular, poverty in upstream areas may result in polluting activities damaging richer downstream areas, but neither polluters nor local governments may have the ability to take remedial measures. In addition, some pollution problems are caused by past development policies that are beyond the control of the local community. In such situations, complete reliance on local governments and the market cannot result in satisfactory pollution control, for reasons of both economic efficiency and fairness. Therefore, the central government should focus on transboundary water issues and play an impor-

tant financial role in water pollution control by taking responsibility for some of the problems for which it has been historically responsible and providing financial support to poorer areas for this purpose.

RECOMMENDATIONS

Water pollution control is critical to the quality and effectiveness of other water-related efforts and investments, such as water transfers, water saving and water extraction, and the maintenance of a safe supply of drinking water and protection of human health and ecosystems. However, because of its relatively short history, the intersectoral nature of the issue, and the fragmentation of responsibilities for addressing it, the control of pollution has the weakest institutional system among those in the water sector.

Strengthening compliance and law enforcement must be the overarching priority of the government's water pollution control efforts. The key to controlling and solving serious water pollution in China is the strengthening of law enforcement to improve compliance by industries and other polluters. The government has to use all available means—legal, institutional, and policy—and, through them, mobilize the public and motivate the private sector to ensure full compliance with all pollution control requirements. A few specific recommendations are provided below:

- *Improve the effectiveness of water pollution control legislation.* The WPPCL should specify implementable objectives focusing on control of pollution emissions and ambient water quality rather than broad economic and social development goals and should clearly define the responsibility of the central government. While the WPPCL should definitively require local governments to be responsible for protection of the water environment at the local level, the involvement and supervision of the central government and superior governments

should also be clearly stated in the law. Generally, the central government possesses water management rights and financing responsibility. Clearer financial arrangements should be made to match duties of pollution control with authority over financial resources, especially between the central and local governments. In addition to supervision of provincial governments, the central government needs to assume more financing and supervisory responsibility for transboundary water pollution issues.

- *Improve pollution control planning.* Water pollution control planning in river basins should be improved, with the introduction of more realistic and tangible targets. Pollution control should not be regarded as the final target, but the way to achieve a clean and healthy water environment. This requires a long-term, integrated, but progressively targeted strategy for the protection of water quality. The immediate target should be to aim at all point pollution sources to comply with existing emission standards. For mid-term targets, a system of emission standards based on ambient water quality objectives should be established. In addition to human health, ecological conservation must be seriously considered and integrated into the standards. Water pollution control plans and water resource management plans should be coordinated with economic and social development plans and supported by budgetary planning.
- *Control rural pollution.* Attention should be given to addressing rising water pollution in small towns and rural areas. The regulation of industrial and municipal sources in small towns and rural areas should be carried out by local EPBs and supervised by MEP. With regard to wastewater, sewage treatment in small towns should be promoted through the introduction of cost recovery policies, selection of efficient technologies, and the promotion of treated water reuse for agriculture. This should be done in collaboration with the ongoing national New Countryside Development program.
- *Unify and strengthen the pollution monitoring system.* Better monitoring capability is required for the whole range of measures required for effective pollution control. The current segmented water monitoring system—involving MEP, MWR, and MHURC—has to be reformed. In the short term the systems should be better coordinated, with a unified set of monitoring criteria and procedures for releasing water quality information through one channel such as MEP. In the medium term, the different monitoring systems can be consolidated and managed by a third entity independent of any single ministry.
- *Strengthen the wastewater discharge permit system.* To be effective, the wastewater discharge permit system should be built on a more solid legal basis, with a special administrative regulation issued by the State Council. The issuing of permits has to be technically sound and based on environmental quality, with daily maximum levels of discharge specified in order to achieve ambient targets. It should target key pollutants first and aim to control the total pollution load within the allowed pollution carrying capacity of the environment.
- *Increase the use of market-based instruments.* Pollution control efforts should take full advantage of market mechanisms to overcome market failures in pollution reduction. Economic incentives (such as the pollution levy and fines) have to be tightened up and fully used in order to provide a strong incentive for polluters to comply with emissions standards and other environmental requirements. The upper limits of maximum fines specified in current laws should be increased. Furthermore, the system of trading of water discharge permits should be gradually introduced in watersheds to improve the economic efficiency of wastewater treatment.
- *Enable litigation for public goods.* The litigation system should be used to give more protection

to the public interest. The law should encourage or require local governments on behalf of the public to initiate lawsuits against polluters and demand full compensation for damage to public goods—for example, to ecosystems—where damage to individuals is hard to identify. For significant cases, MEP itself might be the plaintiff. For any court judgment on private compensation for water pollution where the damage to public goods is ignored, environmental authorities should state their disagreement and request a review of the judgment.

- *Increase financing for market gap areas.* There are several areas where market-based approaches cannot be expected to effectively address pollution control problems. In these areas, the

central government needs to establish special budget accounts with which to finance water pollution prevention and control. These areas include: (1) transprovincial pollution control and management, (2) important ecological regions and water sources, (3) dealing with accidents affecting international water bodies, and (4) other issues with a national dimension that cannot be properly managed at the local level.

Endnotes

1. See the Government Work Report 2008 delivered by Chinese Premier Wen Jiabao to the National People's Congress in March 2008.
2. Source: http://news.xinhuanet.com/fortune/2006-10/16/content_5210351.htm.

Preventing Water Pollution Disasters

Frequent and major water pollution emergencies have become one of the notable environmental problems in China in recent years. If not immediately and effectively controlled, pollution incidents caused by accidental releases or cumulative pollution can worsen water shortages and scarcity problems, result in environmental and economic damage, and cause widespread concern and social unrest.

This chapter presents an analysis of the systems that are currently in place in China to present and respond to pollution emergencies, as well as to relate, some relevant international experience. It identifies areas for improvement and presents policy recommendations for institutional reform, risk management and prevention, and emergency response and mitigation.

WATER POLLUTION INCIDENTS IN CHINA

As illustrated by several incidents, including the well-known Songhua River toxic chemical spill in November 2005 (Box 9.1) and the Tai Lake algae outbreak in May 2007, which threatened drinking water supplies for Wuxi City, a large number of water pollution incidents have occurred in recent years in China. In 2001–04, there were 3,988 water pollution incidents reported in statistical yearbooks, an average of about 1,000 a year. Besides the two recent well-known incidents, there have been many other major water pollution incidents. For example, there were over 40 major water pollution incidents in the Yellow River from 1993 to 2004, and one incident in Inner Mongolia in June 2004 caused serious damage to ecosystems over the 340-km river course and shut down the Baotou City water supply for four days. In March and May 2004, two major incidents in the Tuo River in Sichuan Province interrupted water supply for about a million people for 26 days (Sheng 2005). According to SEAP (now MEP), in the 5-month period following the Songhua River pollution incident, there were 76 other major environmental incidents across China, or about one every two days (Zhou 2006). Major incidents include the release of toxic smelting waste into the Bei River (in the Pearl

BOX 9.1 Water Pollution Incident in the Songhua River

The Songhua River runs through the old industrial region of northeast China with many industries located along its banks, including many chemical plants, before joining the Amur River and flowing into Russia. It is the main water source for many cities, including Harbin, the capital of Heilongjiang Province.

On November 13, 2005, an explosion took place at the Jilin Chemical Industrial Co. plant (a PetroChina subsidiary) in Jilin city, about 380 km up river from Harbin. Five persons were killed and nearly 70 injured. More than 10,000 residents were evacuated as a precaution against further explosions and severe pollution from the plant.

The explosion, and the attendant firefighting efforts, led to the spilling of about 100 tons of chemicals, mainly benzene, into the Songhua River. Ten days after the explosion, a contaminated stretch of water 80 km long reached Harbin and took 40 hours to pass through it. As a result, the Harbin municipal government had to temporarily shut down its water supply, leaving around 3.5 million people without access to tap water. The incident caused a serious water crisis in the region along the river.

Source: UNEP; www.uneptie.org, January 2006.

River basin) in December 2005, the release of cadmium-containing wastewater into the Xiang River (in the Yangtze River basin), and a spill of diesel oil into the Yellow River in January 2006. As in the case of the Songhua River incident, they all caused not only river pollution but also water shortage problems.

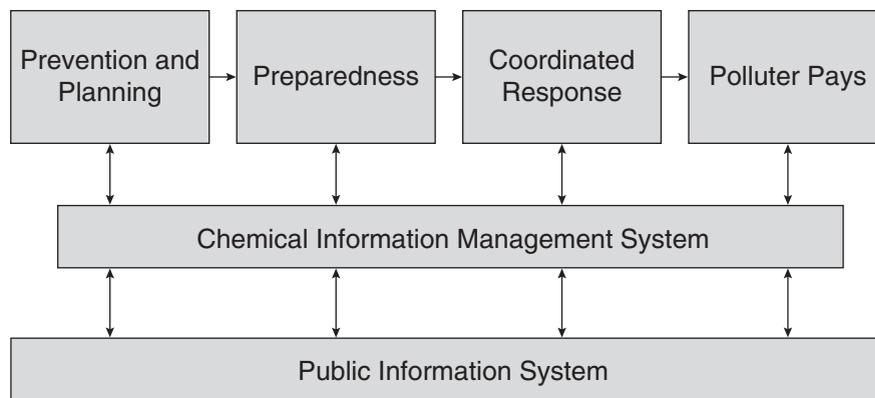
The total cost of water pollution accidents was reported at RMB 254 million yuan in 2004 (*China Statistical Yearbook 2005*). These numbers are likely to be on the low side because polluters

and some local officials tend not to report environmental accidents (Sheng 2005).

CONCEPT AND FRAMEWORK FOR POLLUTION EMERGENCY PREVENTION AND RESPONSE

The basic elements of an effective prevention and response system—as already developed and implemented in many developed countries—are represented in Figure 9.1.

FIGURE 9.1 Common Elements of an Emergency Response System



- *Prevention and planning.* With a focus on risk assessment, prevention, and planning, emergency response plans are compiled and reviewed at the plant site, and local, regional, and national levels. These plans clarify the roles, responsibilities, and communication channels among groups.
- *Preparedness.* An important aspect of effective response is the capacity of responders. Specialized training, the provision of equipment and regular drills to test plans, and inter-organizational communication are essential elements of “being prepared.”
- *Coordinated response.* Clear chains of command and interagency cooperation provide a coordinated and tiered response allowing for a rapid assessment and response at the point of the incident plus appropriate escalation to regional and national teams.
- *Polluter pays principle.* In the event of an accident, the polluter is responsible for clean-up and compensation costs.
- *Chemical information management systems.* Inventory management tracks the flow of manufactured and distributed chemicals, in particular, toxic chemicals. The system also provides the necessary information for a quick and effective response if an accident occurs.
- *Public information systems.* Public information systems provide information to the public about the hazards present under normal operations and timely information in the event of an emergency.

The section below illustrates how the framework has been applied in some developed countries.

INTERNATIONAL EXPERIENCE

The development of emergency prevention and response systems has been an evolutionary process as countries have learned lessons from their own accidents and other countries’ experience. A number of well-known historical incidents have shaped the development of emergency response

policies, regulations, and systems overseas, in particular:

- Two well-known oil tanker disasters—the Torrey Canyon in the United Kingdom (1967) and Exxon Valdez in Alaska (1989)—caused crude oil contamination off the coast of the U.K. and in Prince William Sound, Alaska.
- The Seveso disaster in Italy (1976) led to a release of dioxin in an area near Milan.
- The Union Carbide chemical spill in India (1984) caused a release of methyl isocyanate and killed or injured more than 2,000 residents of Bhopal.
- The Sandoz chemical spill (1986), drawing many parallels with the Songhua River toxic spill, polluted the Rhine River and affected six countries along its course due to mistaken use of water to combat a fire in a chemical factory (Box 9.2).

Institutional Arrangements

National laws

Many developed countries have promulgated national legislation for accidental hazard management, albeit in different ways. Some have a comprehensive national law and others have a coordinated set of laws or regulations. Box 9.3 lists relevant laws and regulations in the United Kingdom and the United States.

In addition, the international community has adopted a number of agreements to improve the management of chemicals and minimize the harm they cause especially toxic and hazardous chemicals. The major agreements are the Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes and Their Disposal, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, and the Stockholm Convention on Persistent Organic Pollutants (POPs). These agreements, which China has ratified, establish

BOX 9.2 The Sandoz Chemical Spill in Switzerland and down the Rhine

On November 1, 1986, an explosion occurred in the Sandoz Chemical factory in Basel, Switzerland, on the banks of the Rhine River. The fire took five hours to extinguish, pouring 10,000 to 15,000 m³ of polluted water into the river. That water contained organic mercury compounds, insecticides, fungicides, herbicides, and other agricultural products, which made their way down 900 km of the Rhine, through six sovereign states and into the Baltic Sea. No one was killed, but the spill killed hundreds of thousands of fish and waterfowl. Ten thousand people marched in the streets of Basel. The economic loss to properties downstream was estimated to be 100 million Swiss francs. Lessons learned from this incident have subsequently contributed to amendments to the European Union's so-called Seveso II Directive, the development of the Basel Convention, and the Convention on the Protection of the Rhine.

an international framework for the management of chemicals, particularly hazardous chemicals.

Organizational structure

Effective emergency response typically depends on the coordinated efforts of a number of functions to optimize prevention and planning measures and to provide timely response and clean-up in the event of an accident. In the U.K., for example, the local Environment Authority and the Health and Safety Executive are often the nominated competent authorities required to provide approval for the emergency response plans for high hazard sites. They ensure that all the health, safety, and environmental risks have been identified, removed, or minimized and that appropriate plans are in place to minimize and mitigate the impact from any potential accidental release. In the event of an accident, they would be on hand to provide technical advice to the police and fire brigade as well as to monitor the impacts of the release. They would also play an important

role in the accident investigation and prosecution of polluters. There also is a graduated escalation system that ensures that response is coordinated at the regional and national levels depending on the size and impact of the accident. Again in the U.K., cabinet-level involvement can be activated for incidents with a national impact.

For transboundary rivers, a number of international river basin commissions have been established in Europe, such as for the Rhine, Danube, Kura, and Neman. Typically, several countries are involved in the commissions, and arrangements are in place to prevent pollution of the rivers, and early warning and alarm systems inform all countries in the event of an incident.

Prevention and Planning

In Europe, industrial sites are categorized according to their potential hazards. Before receiving a license to operate, high-hazard sites are required to produce a major accident prevention policy

BOX 9.3 Examples of National Legislative Systems

In the United Kingdom, the significant national legislation is the 1999 Control of Major Accident Hazards Regulation (COMAH), which enacts the European Union directives (or Seveso Directives) on the Major Accident Hazards of Certain Industrial Activities (82/501/EEC) and the 2004 Civil Contingencies Act.

In the United States, the major regulations include the Clean Water Act (1972), the Oil Pollution Act (1990), the Emergency Planning and Community Right-to-Know Act (1986), the National Oil and Hazardous Substances Contingency Plan (1968, amended 1994), the Clean Air Act (1970; amended 1990), and the Homeland Securities Act (2002).

and a safety management system. These identify the potential accident scenarios that could impact on the environment and/or human safety and the appropriate response. Emergency response plans are compiled and reviewed regularly at plant, local, regional, and national levels. These plans clarify the roles, responsibilities, and communication channels among groups. In this way plant operators are forced to identify and implement preventive measures as well as response and mitigation measures.

Preparedness and Coordinated Response

The local response is coordinated and tiered, allowing for rapid assessment and response at the point of the incident plus escalation to regional and national teams if required. There is coordination between those who physically respond to the incident and those who provide technical advice and public information. Unified command and response are evident in the bronze, silver, and gold command structure of the U.K. and in the unified command of the incident command system in the U.S. Specific emergency response providers are

trained in the treatment of chemical hazards. In the U.K., this takes the form of specially trained HAZMAT (hazardous materials) officers in local fire stations. The United States has also established a well-organized emergency response system. First responders are trained and certified in hazardous waste operations and emergency response and go through regular emergency response drills. Chemical plants are required to prepare and implement a risk management plan (RMP), which provides first responders with information in the event of an accident. The response to the Buncefield incident in the United Kingdom (Box 9.4) demonstrates how the existence of an emergency response plan and training and coordination of first responders can lead to a rapid and successful response.

Implementation of the Polluter-Pays Principle

There are a number of examples in the developed world of financial mechanisms that are employed to recoup the costs of environmental protection beyond the factory fence and legislative enforcement. In the U.S., the Superfund Act (formally known as the Comprehensive Environmental

BOX 9.4 The Buncefield Incident, U.K.

In the early hours of December 11, 2005, a number of explosions occurred at the Buncefield Oil Storage Depot, Hemel Hempstead, Hertfordshire, U.K. At least one of the initial explosions was massive (measuring 2.4 on the Richter scale) and there was a large fire, which engulfed most of the site. Over 40 people were injured; fortunately, there were no fatalities. Significant damage occurred to both commercial and residential properties in the vicinity, and a large area around the site was evacuated.

The fire at the Buncefield oil depot represented a major challenge to the emergency response systems in the U.K. It required a multi-agency, coordinated response to the fire and its aftermath. In this incident, responders were onsite within 10 minutes of the explosion. They knew the site and the chemical risks, had practiced the response, and had immediate access to 24/7 technical support by phone. The scene was immediately declared a “major incident” and activated the site emergency response plan, which had already been submitted and approved by the competent authorities.

Key to the response was good coordination between a number of agencies, including the fire brigade, police, ambulance service, the Environment Agency, the Health and Safety Executive, and the National Chemical Emergency Centre. Together these agencies developed a fire fighting strategy that minimized releases to the local water courses and kept the local public informed of the risks and the measures they needed to take.

Response, Compensation and Liability Act) introduced a tax on the chemical and petroleum industries and liability for spills. The Oil Spill Liability Trust Fund provides for clean-up before responsible parties (the polluters) are identified or when no responsible party can be identified. These mechanisms are just part of the funding mechanisms that are based on the polluter-pays principle, which not only aims to recoup costs associated with pollution but to prevent pollution through financial incentives that reward the minimization of pollution. Typically, individual companies will have insurance to cover environment, health, safety, and fire incidents, with premiums that reflect the hazards and levels of risk management on site. Once an incident happens, the polluter's fine can be high. For instance, for the Exxon Valdez oil spill incident in Alaska, Exxon was ordered to pay a fine of \$5 billion in addition to spending \$2.1 billion on cleanup and \$1 billion on compensation.

Chemical Information Management System

The operators of chemical registries play a vital role in the response system, providing technical information by phone or in person to those at the scene of a chemical incident. In the U.K., this is the role of the National Chemical Emergency Centre (NCEC), which provides a 24-hour telephone hotline and is staffed by appropriately trained and qualified staff. Contact numbers for NCEC are prominently displayed on chemical labels and at facilities.

Across Europe, standardized Material Safety Data Sheets (MSDSs) are commonly produced for every dangerous chemical. A Transport Emergency (TREM) card, which contains selected information from the MSDS about the nature of the hazard and risks presented by the chemicals, is required to accompany dangerous chemicals on the move. It details the personal protection, spillage, fire fighting, first aid, and

immediate actions to be taken by the driver of the vehicle and the first responders at the scene of an accident.

Public Information Systems

In the developed world, provisions for informing the public both at the time of the incident and in preparation for any potential incident are included in the emergency response plan. The emergency response plans for high-hazard sites and local authorities are often shared with the public through a series of public hearings. In addition, a variety of systems, often using the Internet, are used to make monitoring information available to the public. For example, in the U.S., the "Scorecard" (available at www.scorecard.org) allows a member of the public to search for pollution issues by zip code. These public information systems provide a mechanism for local community engagement and an incentive for businesses and local authorities to ensure that pollution is effectively managed.

ENVIRONMENTAL EMERGENCY PREVENTION AND RESPONSE IN CHINA

After the Songhua River toxic spill, the Chinese government took immediate steps to strengthen national environmental emergency prevention and response. The Decision on Implementing the Scientific Concept of Development and Stepping up Environmental Protection released by the State Council in December 2005 highlights drinking water safety, pollution control in key river basins, and water pollution accident prevention and response as the outstanding priority tasks to be solved. The National Plan for Environmental Emergency Response was adopted in January 2006. In early 2006, 11 enterprises located near rivers were officially identified as posing major environmental risks and publicly warned by SEPA, and 127 chemical and petro-

chemical projects with a total investment value of RMB 450 billion yuan underwent urgent environmental risk inspection (SEPA News 2006).

Another major step was the promulgation of China's Emergency Response Law by the National People's Congress in August 2007. An emergency incident as defined in this law is a broad concept that refers to "natural disaster, accidental disaster, public health incident or social safety incident, which takes place by accident, has caused or might cause serious social damage and needs the adoption of emergency response measures." Water pollution emergency response falls within the purview of this law. The law provides a legal basis for emergency response by authorizing governments at different levels to prepare, revise, and implement emergency response plans.

Despite some successful cases of environmental emergency response and the above government actions in China, the high frequency of serious pollution incidents and their associated costs point to the need for continued reform and strengthening of existing institutions for environmental pollution emergency prevention and response in China. The analysis below further shows that the problem is attributable to many factors ranging from weak institutional arrangements, lack of incentives, and poor chemical management systems, to inadequate onsite coordination, monitoring, and reporting.

Institutional Arrangements

National laws

Even with the new Emergency Response Law in place, the environmental emergency prevention provisions in national legislation remain inadequate. Some sectoral laws also contain pollution emergency response requirements. For example, article 28 of the amended Water Pollution Prevention and Control Law contains a simple clause on the responsibilities of polluters with regard to emergency response, information dis-

closure, and reporting. In the Marine Environmental Protection Law and the Radiation Pollution Prevention and Control Law, there are some requirements for emergency prevention plans and emergency response plans, as well as legal liability for pollution incidents. But the emergency response clauses in sectoral laws are not well integrated or coordinated. They are normally short on details that are critical for implementation. Moreover, compliance with and enforcement of these environmental laws and clauses have been very weak.

Organizational structure

Pollution incidents involve governments, companies, and the public, and they often cross administrative boundaries. In China, the groups related to emergency prevention and response include the Public Security Bureau (PSB), the State Administration for Work Safety (SAWS), MWR, MEP, the Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), local police, fire brigades, local departments of environmental protection, transportation, water, construction, and planning, as well as river basin management commissions (RBMCs). The unclear definition of responsibilities and insufficient communication between agencies often result in a failure to disseminate information and the subsequent inability to respond in a timely and well-coordinated fashion to environmental emergencies.

Before the adoption of the National Plan for Environmental Emergency Response, no dedicated national body existed to coordinate and lead prevention and response to environmental pollution emergencies. The National Plan requires the establishment of an inter-ministry coordinating group under the State Council responsible for coordination of environmental emergencies and information sharing. It also requires relevant line ministries and local governments to handle environmental incidents in their respective sectors or areas. The ability of the coordinating group to

quickly and effectively coordinate a major pollution accident is still to be tested.

Incentives

Early in 1987, China promulgated the Preliminary Regulation on Reporting Incidents of Environmental Pollution and Damages. But accidental pollution incidents did not receive sufficient attention from local governments until the Songhua River toxic spill. One reason for the low awareness is because the current overall performance evaluation system for local governments and officials focuses on GDP growth and seldom includes environmental indicators. Without the right incentives in place, maintaining an ongoing effort by local governments to strengthen environmental emergency prevention and response is unlikely to be possible.

Prevention and Planning

In China, new construction projects of polluting industries such as chemical plants are required to undertake an environmental impact assessment (EIA) and sign safety responsibility agreements in order to obtain construction and operation permits. Projects where hazards are present are required to undertake a safety assessment and include environmental risk analysis in their EIAs. EIAs are approved by various levels of the EPB or MEP depending on the size of the plant. However, many EIA reports are not reviewed and checked very strictly, and required measures for risk prevention are not always implemented in practice. Older plants, built before EIAs became mandatory, may have never formally assessed their potential environmental impacts/risks or the steps to minimize those impacts/risks. In addition, the reviews of environmental risk assessment and company management measures are subject to review every three years in order to renew operating licenses. In practice, the reviews are in many cases not strict enough to ensure that the measures remain adequate and up to date.

Due to poor awareness of environmental problems in the past, many old, heavily polluting, or toxically dangerous industries have been located in populous areas or along rivers. A SEPA survey shows that among 7,555 chemical or petroleum projects in China, 81 percent are located in environmentally sensitive areas such as water networks or dense population areas (Xinhua News Agency 2006). Environmental guidance in zoning and site selection in spatial planning is weak, if it exists at all. Strategic environmental assessment of spatial plans, required by the China EIA law since 2003, is not well implemented.

Preparedness and Response

The Songhua River incident also indicated that the first responders had not been provided with adequate training or access to support from experts in chemical management. Those who were first on the scene did not know how to respond differently from a typical firefighting incident. As a result, vast quantities of water were used to dilute the benzene and release it into the river, which only served to spread the pollutant rather than contain it.

Implementation of Polluter-Pays Principle

Current systems provide little incentive for both local officials and potential polluters to pay serious attention to pollution emergency prevention. Although China has accepted the polluter-pays principle, as already discussed in Chapters 3 (see Box 3.5) and 8, the levels of the pollution levy and fines for pollution accidents are low. For the water pollution incident in the Tuo River in 2004, which caused a shutdown of water supply systems for about 1 million local residents for 26 days, the company that caused the pollution paid only 11 million yuan for damage compensation and only 1 million yuan in fines. The low levels of the pollution levy and fines for pollution accidents give little incentive for industries

to abate pollution, reduce pollution discharges, or prevent environmental accidents.

In addition, although environmental law clearly states that the polluter is responsible for the costs of environmental accidents, the current ownership and enforcement systems often fail to establish clear liability and responsibility for cleanup and compensation. China also lacks an adequate insurance system to cover the risks and costs of environmental disasters.

Chemical information management systems

China is currently developing two chemical inventory systems. One is for new and imported/exported chemicals under the administration of MEP, and another is for dangerous chemicals managed by the National Chemical Registration Center under the State Administration for Work Safety (SAWS). Both registries are relatively lightly populated compared to more mature systems found overseas. Moreover, the two systems are separated from each other. How to make them consistent through coordination is still an issue. China is also introducing the MSDS for production, transportation, storage, and use of chemicals. But these are still at an early stage and not fully functioning.

Monitoring and public information system

Water quality monitoring plays an important role in detecting incidents and understanding the impact on human health and the environment. China has much of the equipment and expertise to collect data on water quality but lacks the systems and funding to analyze and distribute the information effectively and to manage the river basin accordingly. As mentioned in the last chapter, several bodies (such as the monitoring centers/stations under MEP, MWR, and local EPBs) undertake monitoring, but there is little coordination of results nor much in the way of a predetermined and coordinated response in the event that pollution levels rise as a result of an accidental release. The Songhua

River incident highlights some serious problems with environmental information collection, reporting, and disclosure in China. The situation may improve under the guidelines of the newly adopted National Plan for Environmental Emergency Response.

RECOMMENDATIONS

The Songhua River incident and a series of subsequent water pollution events have revealed the weakness of the environmental emergency prevention and response system in China. They also present an opportunity for the country to establish and improve the system, thereby strengthening pollution control and environmental protection. Based on the analysis of the institutional and policy weaknesses in China and the experiences of developed countries, China should take a comprehensive approach that adopts risk assessment, risk management, prevention measures, inter-agency coordination, compensation and fines, and post-evaluation. Water pollution prevention, control, and response should be fully integrated into legal and economic instruments, which have been discussed above. Other specific recommendations are provided as follows.

- *Shift from mitigation to prevention and planning.* Environmental protection and work safety agencies should be the competent authorities to approve the adequacy of environment and safety risk assessment, applying a thorough risk management approach that focuses on both prevention and mitigation of the impacts of chemical incidents. Operating licenses, risk assessments, and emergency plans of polluting enterprises should be reviewed on a regular basis or when a major change is proposed. Industrial sites should be categorized according to the hazards present. All high-hazard plants regardless of age should be subject to risk assessment and be required to prepare an emergency response plan.
- *Chemical management information system.* The central government should establish and

maintain comprehensive inventories of all chemicals and pollution sources containing information consistent with international standards. The function and effectiveness of the two existing systems developed by SAWS and MEP separately should be reviewed. Inventories should be consistent, comprehensive, and easily used in public emergency prevention and response. A comprehensive labeling system for chemicals should be established and applied to all parts of the production, storage, and transportation process.

- *Enhance preparedness.* First responders should be well trained for handling chemical incidents and equipped with the mandate and resources to contain pollution releases. The National Chemical Registration Center and its regional offices should establish a unit, independent from enforcement divisions, to provide 24-hour technical support to the emergency services on the properties and appropriate responses to specific chemical releases from a safety and environmental perspective.
- *Establish an environmental disaster fund through the implementation of polluter-pays principle.* An environmental disaster fund with sufficient revenue to support such activities as information management, training, and clean-up for

environmental incidents should be established. Funds could be raised through an increase in the pollution levy on toxic chemicals to reflect their risks and economic costs and/or the introduction of environmental taxes as part of a product tax on toxic chemicals based on their potential environmental risks. In addition, increased fines for pollution accidents to cover the cost of clean-up and compensation should be considered as another source for the fund.

- *Monitoring and public information.* In the event of an incident, local environment and safety authorities should establish appropriate additional monitoring to assess the impact on the health and safety of the local communities and the environment. Following an incident, the local EPB and MEP should be responsible for setting standards and monitoring the effectiveness of the clean-up effort. Accident investigation should be mandated, aiming to identify the polluter and cause of the incident and how the incident can be prevented in the future. Investigation findings should be reported to the central authorities, and a mechanism established to share lessons learned and introduce new legally binding practices and procedures if necessary. The public has the right to be informed of the final investigation results.

Summary, Action Plan, and Issues for the Future

SUMMARY

China has been plagued with water shortages, droughts, and floods since the beginning of its civilization, and per capita availability of water in the country is now only one-fourth of the world average. In recent decades, along with the nation's rapid industrialization and economic growth, water pollution has emerged as another serious issue, further exacerbating the problem of water scarcity. Northern China is already a water-scarce region, and China as a whole will soon join the group of water-stressed countries.

Many studies have shown that the current trend of water consumption is unsustainable and will constrain the growth of the nation. Despite serious water scarcity, China's water utilization efficiency is poor. China's water productivity of \$3.60/m³ is low in comparison with the average of middle-income (\$4.80/m³) and high-income (\$35.80/m³) countries. This gap is largely due to differences in the sectoral structure and efficiency of water consumption. This implies that there is much room for China to address its water scarcity problem by effectively managing its water resources and improving efficiency in water use.

This report concludes that the big challenge in water resource management in China is to establish an effective institutional and policy framework, which requires a broad and deep reform of the current system. In line with China's national strategy of developing a market economy, the nation should strengthen its water management by clearly defining the role of government in addressing social, environmental, and economic objectives, and relying much more heavily on market-based instruments in this process. Institutional and policy reforms in selected thematic areas—legal framework, organizational structure, information disclosure, public participation, water rights, water pricing, eco-compensation in river basins, water pollution control, and pollution emergency prevention—have been discussed in this report. The key messages are as follows:

Legal Framework

The Chinese government should make strenuous efforts to improve water governance, ranging from legal and organizational reform to information disclosure and public participation. On the legal side, the priority is to improve law enforcement. The existing provisions should be enhanced to make laws or regulations operational and enforceable, with detailed implementation procedures stipulated in water-related laws and regulations. Supervision and inspection by national and local congresses and administrative branches should be strengthened, with adequate budget and personnel provided. Laws and regulations should also empower the public to help monitor and track down pollution violators and promote public-private partnerships in water resource management.

Organization

The traditional approach to water management, which is fragmented along sectoral and regional lines, has to be changed. China should make a shift from the current paradigm to a new system of integrated water management. This requires the restructuring of governmental organizations to improve integration, consultation, and coordination. One option is to establish a State Water Resources Commission as a coordinating and steering organization on water-related affairs across the country at the highest level of government. This commission will serve as a high-level water policy-making body. Another option would be to merge major water-related duties currently put under different government agencies (namely MWR, MEP, MOA, MHURC, and MLR) and establish a new super ministry to implement unified management of water quantity and quality, surface water and groundwater, water resource conservation and use, and water environmental protection. River basin management commissions need to be restructured to ensure a broader representation and ownership.

Information and Participation

The right of citizens to have access to environmental information, to participate in water resource management, and to challenge decisions by government should be fully granted, and indeed encouraged. It is important to make information disclosure a compulsory obligation of governmental organizations, water companies, enterprises discharging pollutants, and other major stakeholders. Existing procedures and policies should be amended to make possible the wider involvement of NGOs in water pollution and resource management. In addition, the raising of public awareness and education activities should be widely conducted for all civil groups, including children, in order to build a broad basis for ongoing public participation in water resource management.

Water Rights

Water rights in China have not been clearly defined and fully developed, resulting in water shortages and inefficient use of water at the same time. Despite some progress in recent pilot projects, China needs to improve its water allocation and rights administration and develop water markets. Water allocation plans and water rights should clearly specify the water available for abstraction, the amounts of water consumed, and the amounts that must be returned to the local water system. The administration of water rights needs to be strengthened, with the conditions, procedures, rights, and obligations for water withdrawal and return flows clearly specified in order to reduce existing uncertainties and promote public participation. The ET approach should be promoted, especially in water-stressed areas. Water trading can be an effective mechanism for reallocation of water from low-value to high-value uses and needs to be developed. The government also needs to develop a mechanism to assess the benefits and costs of water rights transfers, especially their impact on third parties, and in general to protect the public interest.

Water Pricing

China's water resource management should shift from supply to demand management. Water pricing is an important means of managing the demand for water. Water prices in China are generally too low to cover full financial costs, let alone economic and environmental costs, although some progress has been made in recent years in raising water tariffs, sewage fees, and water resource fees. Given the magnitude of the water scarcity problem, China should aggressively use pricing policy to internalize the environmental and depletion costs of water exploitation and consumption, based on the marginal opportunity cost (MOC) approach. Water tariffs, including wastewater treatment fees, must increase constantly in the years to come. To make pricing reform successful, its social impact, especially the income impact on the poor, has to be addressed. A number of income or pricing support measures can be used to protect the poor and ensure a win-win result in water tariff reforms. Already adopted in Chinese regulations, the increasing block tariff approach, especially a two-tier tariff structure, is recommended. To achieve social, environmental, and financial targets, the first block has to be adequate to ensure the basic living needs of the poor, with the second block gradually increasing to full MOC.

Ecological Compensation in River Basins

Ecological compensation mechanisms in river basins can play an important role in protecting water sources, especially in the upper reaches of the rivers. Although such mechanisms have been widely accepted and applied at both national and local levels in China, they are primarily supply-driven through government transfers from public funds and lack a direct causal link between ecosystem service providers and ecosystem service beneficiaries. There are some doubts as to the long-term sustainability of the existing programs, and China should vigorously adopt a more market-

oriented approach. The payment for ecosystem services (PES) approach is more market-oriented and self-financing by directly linking ecosystem service providers and beneficiaries. It has much appeal in China; pilot schemes should be undertaken and the approach promoted, beginning with some smaller watersheds.

Water Pollution Control

Serious water pollution must be controlled. The key to water pollution control is primarily the strengthening of law enforcement to improve compliance by industries and other dischargers of waste into water bodies. Given the failure of the free market system to internalize pollution costs, the government must take responsibility for controlling pollution to protect the public interest. Economic measures such as the pollution levy and fines have to be improved in order to provide a strong incentive for polluters to comply with emission standards. Sewage fees need to be increased to provide sufficient funding for municipal wastewater treatment. For transboundary water pollution, the central government needs to assume more financial and supervisory responsibility.

Pollution Emergency Prevention and Response

Pollution emergencies and their threat to water sources need first to be addressed by improving response mechanisms when incidents occur. First responders should be well trained for handling chemical incidents and equipped with the mandate and resources to contain pollution releases. Twenty-four-hour technical support to the emergency services should be provided. Requirements for reporting, monitoring, and public information disclosure of pollution incidents should be well institutionalized and implemented. Besides, prevention is always better than cure. This requires a shift of attention from response and mitigation to prevention and planning. Risk assessments by industry and by site have to be conducted and

regularly updated. To this end, chemical management processes, including inventory, labeling, and monitoring, have to be strengthened. An environmental disaster fund with sufficient revenue to support such activities as information management, training, awareness-raising, and clean-up for environmental incidents should be established. Funds could be raised through an increase in the pollution levy and/or the introduction of environmental taxes on toxic chemicals. In addition, increased fines for pollution accidents to cover the cost of clean-up and compensation should be considered as another source for the fund.

ACTION PLAN

Many policy recommendations have been offered in the selected thematic areas, ranging from organizational setup to participation and from water rights to pricing. An important issue is how to effectively implement them. This requires good coordination and scheduling among various recommended actions. The following summarizes the recommendations in an action plan table with suggestions on implementing agencies and implementation timeline, where S represents a short run up to 3 years, M for a medium run of 4–9 years, and L for a long run of 10–20 years.

ISSUES FOR THE FUTURE

While this report has addressed a number of critically important issues relating to water resource management in China, it does not, as indicated in Chapter 1, claim to cover all aspects of the subject. Moreover, the various studies have highlighted a number of areas where further work is required; in some cases, the implementation of those recommendations will depend on further studies. Some of these important areas—relating to agricultural water, climate change, and strategic assessment and economic analysis for river basin plans and programs—are referred to below.

Water Efficiency, Food Security, and Rural Development

Our case studies have revealed a big variation in the economic value of water by sector and by region, low economic efficiency of agricultural water use, and poor cost-effectiveness of underground water withdrawal in North China. Although the general direction of improving water-use efficiency by reducing demand for water by the agricultural sector is supported, the issue is complicated by and associated with various issues involving the rights and well-being of the rural population, national food security, agricultural sector protection, and poverty alleviation. The central issue is how to reduce rural poverty and secure the nation's food supply while at the same time improving the efficiency of water use. Any further policy recommendations have to address these concerns and will require further study.

Climate Change Adaptation

Global warming caused by human activities can be one of the biggest threats to the natural environment and human well-being. Recent reports of the Intergovernmental Panel on Climate Change (IPCC) deem human causation of climate change to be very likely. The scarcity and vulnerability of China's water system can be negatively affected by climate change, and remedial and adaptation measures need to be taken to ameliorate these effects. How to fully take into account climate change impacts and mainstream adaptation measures in the institutional and policy reform of water resource management in China is an issue for further investigation.

Ecological and Economic Studies of River Basins

Effective applications of water management measures—such as water pricing, water allocation, and water rights administration, ecological

TABLE 10.1 Recommended Action Plan

Recommended Actions	Responsible Agencies	Implementation Timeline
Organization		
<ul style="list-style-type: none"> Establish a State Water Resources Commission as a coordinating and steering organization for water-related affairs. 	State Council	Short term
<ul style="list-style-type: none"> Merge water-related duties currently put under different government agencies into a new super ministry to implement unified management of water quantity and quality. 	State Council	Medium term
<ul style="list-style-type: none"> Restructure river basin commissions to ensure a broader representation and ownership. 	State Council, national government agencies, and river basin commissions	Medium term
Legal		
<ul style="list-style-type: none"> Develop an action plan to amend existing laws and regulations and fill gaps in present legal provisions. 	NPC	Short term
<ul style="list-style-type: none"> Make existing laws or regulations operational and enforceable, with detailed implementation procedures. 	NPC and national government agencies	Short/medium term
<ul style="list-style-type: none"> Strengthen the supervision and inspection of national and local congresses and administrative branches to improve law enforcement and compliance. 	NPC and local congresses	Medium term
Information Disclosure		
<ul style="list-style-type: none"> Make information disclosure a compulsory obligation of governmental organizations, water companies, enterprises, and other major stakeholders. 	State Council and relevant national government agencies	Short term
<ul style="list-style-type: none"> Make water quality information and pollution source databases accessible to the public and communities. 	MEP, MWR, local government, enterprises	Short Term
Public participation		
<ul style="list-style-type: none"> Ease the existing procedure and policy for NGO registration and management to promote a broader involvement of NGOs. 	National government agencies	Short term
<ul style="list-style-type: none"> Encourage the public to participate in water management, with rights of access to information, to participate in decision making, and to challenge decisions by the government. 	State Council and relevant national government agencies	Medium term
<ul style="list-style-type: none"> Raise public awareness of water issues through public education programs and campaigns. 	Governments, civil society, and enterprises	Long term
Water rights and markets		
<ul style="list-style-type: none"> Improve water withdrawal permits and link them to the initial allocation of water established in the water resource plan. 	MWR and local water authorities	Short/medium term
<ul style="list-style-type: none"> Strengthen water rights administration, with the conditions, procedures, rights and obligations for water withdrawal and return flows clearly specified, measured, controlled, and enforced. 	MWR and local water authorities	Long term

(continued)

TABLE 10.1 Recommended Action Plan (Continued)

Recommended Actions	Responsible Agencies	Implementation Timeline
<ul style="list-style-type: none"> • Apply the ET approach to water allocation and rights in water-stressed areas. • Develop and expand water trading markets in water-scarce areas for reallocation of water from low-value to high-value uses. 	<p>MWR, local governments, and river basin commissions</p> <p>MWR and local governments of pilot areas</p>	<p>Medium/long term</p> <p>Long term</p>
Water pricing		
<ul style="list-style-type: none"> • Implement the increasing block tariff approach, especially a two-tier tariff structure, for residential consumers where metering is available. • Apply the MOC approach in regional and national water management and economic planning systems. • Follow the MOC approach so that water tariffs reflect the increasing costs of water and its disposal. • Convert the water resource fee into a tax, with the revenue going to the central government budget for water resource planning based on national priorities. 	<p>Local governments</p> <p>NDRC, river basin commissions, and local governments</p> <p>Local governments</p> <p>State Council and national government agencies (especially MOF and NDRC)</p>	<p>Short/medium term</p> <p>Medium term</p> <p>Medium/long term</p> <p>Medium term</p>
Eco-compensation instruments		
<ul style="list-style-type: none"> • Adopt more market-oriented approaches such as PES for ecological compensation, with pilot projects in small watersheds. • Build political will, governance mechanisms, and institutional arrangements for PES and recognize and reward those who try innovative eco-compensation approaches. 	<p>National government agencies and local governments of piloting watershed</p> <p>National government agencies and local governments of piloting watershed</p>	<p>Short term</p> <p>Medium term</p>
Water pollution control		
<ul style="list-style-type: none"> • Consolidate current water quality monitoring systems and make them independent of any single ministry. • Identify, manage, and control the sources of pollution, including those in small towns and rural areas. • Strengthen the wastewater discharge permit system and promote the trading of permits. • Review and enhance economic incentives (such as the pollution levy and fines) for pollution control. • Improve the litigation system to protect the public interest. • Establish a special budget account for financing water pollution prevention and control. 	<p>State Council and national government agencies</p> <p>MEP and local EPBs</p> <p>MEP and local EPBs</p> <p>State Council and national government agencies (especially MEP)</p> <p>NPC and local congresses</p> <p>MOF, MEP, local finance bureaus and EPBs</p>	<p>Short/medium term</p> <p>Medium term</p> <p>Short/medium term</p> <p>Short/medium term</p> <p>Medium term</p> <p>Medium term</p>
Water pollution incident prevention		
<ul style="list-style-type: none"> • Provide 24-hour technical support to the emergency services. • Enhance safety risk assessment and approval systems. • Establish and maintain comprehensive inventories of all chemicals and pollution sources. • Introduce a comprehensive labeling system for chemicals. • Establish an environmental disaster fund. 	<p>National Chemical Registration Center and its regional offices</p> <p>MEP and SAWS as well as their local bureaus</p> <p>MEP and SAWS as well as their local bureaus</p> <p>MEP and SAWS as well as their local bureaus</p> <p>MEP</p>	<p>Short term</p> <p>Short/medium term</p> <p>Medium term</p> <p>Medium term</p> <p>Medium term</p>

compensation, and water quality management in a river basin—all depend on good analysis and understanding of the ecosystems and the economic value of competing water uses, such as agriculture, energy, municipal water supply, and flood control in the river basin. In many cases, the important analytical work has not been done, to the detriment of efficient river basin management. Developing a sophisticated analytical system—using advanced economic, geographic, and ecological tools—is required for sound policy making.

Development Strategies, Policies, and Plans and Their Long-Term Impacts on Water Scarcity

The China Environmental Impact Assessment Law, effective in 2003, required strategic environmental assessments (SEAs) to be undertaken for regional and sectoral development plans. These include land use, water resource management, and water pollution control plans for river basins. However, such SEAs have rarely been carried out due to the lack of knowledge, expertise, and capac-

ity of planning agencies and local environmental bureaus and research institutes. As a result, the long-term impacts of these plans on water scarcity conditions and the natural environment are in question. This situation has to be changed.

CONCLUDING REMARKS

There is no doubt that China is facing a major challenge in managing its scarce water resources to sustain economic growth in the years ahead. This is a daunting task for the Chinese leadership, but past experience in China and in other countries provides some lessons as to the way ahead. Of course, China is unique in many ways, and will have to adapt techniques and policies developed elsewhere to suit its own circumstances. But there are grounds for optimism; the Chinese, who have demonstrated immense innovative capacity in their successful program of economic reform, can and should take another bold move in reforming the institutional and policy framework to make it become a world leader in water resource management.



Appendix

Background Papers to this Report

International Experience in WRM

- Cao, Y. S., and J. Warford. 2006. "Evolution of Integrated Approaches to Water Resource Management in Europe and the United States—Some Lessons from Experience."
- Murakuni, Satoshi, and J. A. Dixon. 2006. "Water Resources Management in Japan—Policy, Institutional and Legal Issues."
- Zhou, Gangyan, and J. Warford. 2006. "Water Resources Management in an Arid Environment—The Case of Israel."
- Cao, Y. S., and J. Warford. 2006. "Dealing with Water Scarcity in Singapore: Institutions, Strategies, and Enforcement."
- Wang, M., and X. Wang. 2006. "International Experience in Water Resource Management and the Lessons for China: A Synthesis Note."

Water Governance

- Zhang, J. K., S. J. Gao, J. Fen, and L. L. Yan. 2007. "China's Water Resource Management: Strategic Issues, Governance, and Government Capabilities."
- Pu, Yufei, et al. 2007. "Transparency and Public Participation in Water Resources Management in China."
- Zhou, Gangyan. 2006. "Institutional Arrangements for River Basin Management: A Case Study Comparison of the United States and China."
- Ma, Zhong. 2006a. "Evaluation of the Implementation of Water Pollution Prevention and Control Plans in China: The Case of the Huai River Basin."

Water Rights

- The Development Research Center of the Ministry of Water Resources. 2007a. "The Analysis Report on GEF Haihe River Project and Water Right Research & Practice in China."
- The Development Research Center of the Ministry of Water Resources. 2007b. "Design and Implementation of Water Rights Administration System in China."

Water Pricing

- Almec Corporation. 2006. "Case Study on Water Tariffs in Small Cities in China."
- Chinese Academy of Hydraulic and Hydropower Research. 2007. "Economic Value of Water and Policy Intervention in Hai Basin."

- Chongqing University. 2007. "A Willingness to Pay (WTP) Survey and Study for Water Tariff Reform in Western Chongqing."
- Chongqing World Bank Project Management Office. 2007. "Pricing for the Poor: A 'Five Orientations' Approach to Protect Low-Income Groups during Water Tariff Reforms in Chongqing."
- Zhang, Shiqiu, et al. 2007. "Study on Water Tariff Reform and Income Impacts in China's Metropolitan Areas: the Case of Beijing."
- Zhou, Linjun. 2007. "Reform of Water Supply Tariffs in Chongqing."

Ecological Compensation in River Basins

- FEEM Servizi. 2006. "Best Practices Approaches on PES."
- FEEM Servizi. 2007. "A Pilot Study for Payment for Ecological and Environmental Services in Lashihai Nature Reserve, China."
- Conservation International, the Nature Conservancy, and FEEM Servizi. 2007. "Toward More Sustainable and Market-based Ecological Compensation Mechanisms: A Pilot Project of Payments for Ecological and Environmental Services in Lijiang, China."
- Zheng, Haixia, and L. Zhang. 2006. "Chinese Practices of Ecological Compensation and Payments for Ecological

and Environmental Services and Its Policies in River Basins."

Water Pollution Emergency Prevention and Response

- Ma, Zhong. 2006b. "Strengthening the National Capability of Water Pollution Emergency Prevention and Control: Lessons Learned from Songhuajiang River Water Pollution Incident."
- Gong, Y. 2006. "United States Experience in Environmental Emergency Planning and Response."
- The UK National Chemical Emergency Centre and Jennifer Coleman. 2006. "The UK Emergency Response Systems: The Case of the Buncefield Incident and Lessons Learned."
- Zhang, Hongjun. 2006. "International Experience with Toxic Chemical Management."
- Liu, Guozhi. 2006. "An Overview of Major Multilateral Environmental Agreements on Hazardous Chemical Management."

Note: All of the background studies prepared for this report can be accessed online at www.worldbank.org/eap/environment/ChinaWaterAAA.



References

- ADB (Asian Development Bank). 2005. *Trans-jurisdictional Environmental Management*. Manila: ADB.
- Allan, J. A. 2001. *The Middle East Water Question; Hydropolitics and the Global Economy*. London: I B Tauris.
- An, Z. R. 1997. *Hydraulic Infrastructure and BOT*. Beijing: China Water and Power Press.
- Barrantes, Gerardo, and Luis Gamez. 2007. "Programa de Pago por Servicio Ambiental Hidrico de la Empresa de Servicios Publicos de Heredia." In Gunars Platais and Stefano Pagiola, eds. *Ecomarkets: Costa Rica's Experience with Payments for Environmental Services*. Forthcoming.
- Bauer, C. J. 1997. "Bringing Water Markets Down to Earth: The Political Economy of Water Rights in Chile, 1976–95." *World Development* 25(5): 639–656.
- . 2004. "Siren's Song: Chilean Water Law as a Model for International Reform." Washington, DC: Resources for the Future.
- Berkoff, J. 2005. "China: The South-North Water Transfer Project—Is It Justified?" *Water Policy* 5: 1–29.
- Blanke, A., S. Rozelle, B. Lohmar, J. Wang, and J. Huang. 2006. *Water Saving Technology and Saving Water in China*. Unpublished draft. Davis, CA: University of California, Davis. Beijing: Center for Chinese Agricultural Policy, Chinese Academy of Sciences.
- Briscoe, J. 1997. "Managing Water as an Economic Good: Rules for Reformers." *Water Supply* 15(4): 153.
- Bureau of the Lake Tai Basin. 1998. *Outlines of the Water Resources Development Planning for the Lake Tai Basin*. Beijing: China Water and Power Press.
- CAEP (Chinese Academy of Environmental Planning), Renmin University, Policy Research Center for Environment and Economics. 2006. *Technical Guidelines of Environmental and Economic Calculations*. Beijing: Chinese Academy of Environmental Planning.
- Calow, R., Y. Zhao, R. Anscombe, H. Wang, and L. An. 2006. "Managing Groundwater in Rural Hebei: Lessons from the Water and Agricultural Management in Hebei (WAMH) Project." WAMH Project Briefing Paper, based on paper published for the 34th IAH Congress, Beijing, October 2006.
- Castro, Edmundo. 2000. "Costa Rican Experience in the Charge for Hydro Environmental Services of the Biodiversity to Finance Conservation and Recuperation of Hillside Ecosystems." Mimeo.
- Chen, G. L. 1997. *Water Resources Development and Economic Policy*. Beijing: China Water and Power Press.
- China Research Society of Urban Development. 2004. *China Urban Yearbook 2004*. Beijing: China Urban Press.
- China Statistical Yearbooks 2004, 2005, and 2006*. Beijing: China Statistics Press.

- Chinese Academy of Hydraulic and Hydropower Research. 2004. *Study on Coordinated Growth of Hydraulics and National Economy*. Research report.
- . 2007. “Economic Value of Water and Policy Intervention in Hai Basin.” Background paper prepared for this report. Available at www.worldbank.org/eapenvironment/ChinaWaterAAA.
- Chinese Academy of Sciences (CAS). 2007. *China Sustainable Development Strategy Report—2007. Water: Governance and Innovation*. Beijing: Science Publishing House.
- Chong, H., and D. Sunding. 2006. “Water Markets and Water Trading.” *Annual Review of Environmental Resources* 31: 239–64.
- Comprehensive Financial Department, Ministry of Construction. 2006. *China Urban Development Statistics Yearbook 2005*. Beijing: China Building Industry Press.
- Conservation International, the Nature Conservancy, and FEEM Servizi. 2007. “Toward More Sustainable and Market-based Ecological Compensation Mechanisms: A Pilot Project of Payments for Ecological and Environmental Services in Lijiang, China.” Background paper prepared for this report. Available at www.worldbank.org/eapenvironment/ChinaWaterAAA.
- Cornish, G., B. Bosworth, and C. Perry. 2004. “Water Charging in Irrigated Agriculture: An Analysis of International experience.” FAO Water Report No. 28. Rome: FAO.
- Dellapena, J. W. 2000. “The Importance of Getting Names Right: The Myth of Markets for Water.” *William and Mary Environmental Law and Policy Review* 25: 317.
- Dinar, A., M. W. Rosegrant, and R. Meinzen-Dick. 1997. “Water Allocation Mechanisms—Principles and Examples.” *World Bank Policy Research Working Paper* No. 1779. Washington, DC: World Bank.
- Easter, K. W., M. W. Rosegrant, and A. Dinar. 1998. *Markets for Water: Potential and Performance*. Boston, MA: Kluwer Academic Publishers.
- Economy, Elizabeth. 2004. *The River Runs Black*. Ithaca, NY: Cornell University Press.
- Editorial Committee of China Environment Yearbook. 1997–2001. *China Environment Yearbook*. Beijing: China Environment Yearbook Press.
- EIA (U.S. Energy Information Administration). 2003. *Country Analysis Briefs*. Available at <http://www.eia.doe.gov/emeu/cabs/chinaenv.html>.
- FAO (Food and Agriculture Organization of the United Nations). 2001. *Modern Water Rights: Theory and Practice*. FAO Legislative Study No. 92. Rome: FAO.
- FEEM Servizi. 2006. “Best Practices Approaches on PES.” Background paper prepared for this report. Available at www.worldbank.org/eapenvironment/ChinaWaterAAA.
- FEEM Servizi. 2007. “A Pilot Study for Payment for Ecological and Environmental Services in Lashihai Nature Reserve, China.” Background paper prepared for this report. Available at www.worldbank.org/eapenvironment/ChinaWaterAAA.
- Foster, S., H. Garduño, R. Evans, D. Olson, Y. Tian, W. Zhang, and Z. Han. 2004. “Quaternary Aquifer of the North China Plain—Assessing and Achieving Groundwater Resource Sustainability.” *Hydrogeology Journal* 12: 81–93.
- Foster, S., and H. Garduno. 2004. “Towards Sustainable Groundwater Use for Irrigated Agriculture on the North China Plain.” GW-MATE Case Profile Collection No. 8. Washington, DC: World Bank.
- Frederick, K. D. 1993. “Balancing Water Demands with Supplies: The Role of Management in a World of Increasing Scarcity.” World Bank Technical Paper. Washington, DC: World Bank.
- General Office of the State Council of PRC. 2005. “Decision on Implementing Scientific Development Strategy and Strengthening Environmental Protection, Dec 3rd, 2005.” Available at http://www.gov.cn/zwgc/2005-12/13/content_125680.htm
- Gillespie, Brendan. 2007. *Achieving Environmental Policy Objectives for Industrial Pollution: An Overview of OECD Practices*. Paris: OECD.
- Gislev, Magnus. 2007. “The Importance of EU Law for Protection of Water Resources in Europe.” Note presented at the International Forum of Environmental Legislation and Sustainable Development, Beijing, December 2007.
- GLOBOCAN 2000. 2001. *Cancer Incidence, Mortality and Prevalence Worldwide. Version 1.0 IARC CancerBase No. 5*. Lyon: IARC Press. Available at <http://www.dep.iarc.fr/>.
- Hai River Commission. 1998. *Outlines of the Hai River Basin Planning*. Beijing: China Water and Power Press.
- Hearne, R., and K. W. Easter. 1997. “The Economic and Financial Gains from Water Markets in Chile.” *Agricultural Economics* 15 (1997): 187–199.
- He, Jing, and Chen Xikang. 2005. “Calculation of Chinese Shadow Price of Water Resources Based on Dynamic Computable Equilibrium Models.” *Systems Engineering & Practice* 25(5): 49–54.
- Hodgson, S. 2006. “Modern Water Rights: Theory and Practice.” FAO Legislative Study 92. Rome: FAO.
- Hoekstra, A. Y., ed. 2003. “Virtual Water Trade. Proceedings of the International Expert Meeting on Virtual Water Trade.” Value of Water Research Report No. 12. Delft, Netherlands: IHE.
- Huang, J., R. Hu, J. Cao, and S. Rozelle. 2006a. “Non-point Source Agricultural Pollution.” In OECD. *Issues and Implications, Environment, Water Resources, and Agricultural Policies: Lessons from China and OECD Countries*. Paris: OECD.
- Huang, Q., S. Rozelle, R. Howitt, J. Wang, and J. Huang. 2006b. *Irrigation Water Pricing Policy in China*. Unpublished draft. Davis, CA: University of California. City Center for Chinese Agricultural Policy, Chinese Academy of Sciences.

- Huang River Commission. 1998. *Outlines of the Huang River Basin Planning*. Beijing: China Water and Power Press.
- Huang, Y. R. 1997. *Resettlement Due to Reservoir Construction*. Beijing: China Water and Power Press.
- Jiang, D. S. 1997. *Soil and Water Erosion and Control in Loess Plateau*. Beijing: China Water and Power Press.
- Jin, Xiangcan. 2003. "Analysis of Eutrophication State and Trend for Lakes in China." *Journal of Limnology* 62(2): 60–66.
- Jin, Xiangcan, S. Liu, and Z. Zhang, et al. 1995. *Lakes in China—Research of Their Environment*. Qingdao: China Ocean Press.
- Jin, Xiangcan, Qiuju Xu, and Changzhu Huang. 2005. "Current Status and Future Tendency of Lake Eutrophication in China." *Science in China Series C Life Sciences* 48: 948–954.
- Lam, W. 2005. *China's 11th Five-Year Plan: A Roadmap for China's Harmonious Society?* Washington, DC: The Jamestown Foundation. Available at <http://www.asianresearch.org/articles/2756.html>.
- Landell-Mills, N., and I. T. Porras. 2002. *Silver Bullet or Fools' Gold: A Global Review of Markets for Forests Environmental Services and Their Impact on the Poor*. London: International Institute for Environment and Development.
- Landry, C. J., and T. L. Anderson. 1997. "The Rising Tide of Water Markets." Online article available at <http://www.itfluidtechnology.com/waterbook/tide.asp> (accessed October 2007).
- Li, Yuan Yuan. 2004. *Water Development and Management Strategy of China*. Beijing: Ministry of Water Resources.
- Liu, C. M., and X. W. He. 1996. *Strategies for Sustainable Water Resources Development in China in the Early 21st Century*. Beijing: Beijing Science and Technology Press.
- Liu, Jiang. 2002. *Study on China's Strategy of Resources Utilization*. Beijing: China Agriculture Press.
- Lohmar, B., J. Wang, S. Rozelle, J. Huang, and D. Dawe. 2003. "China's Agricultural Water Policy Reforms: Increasing Investment, Resolving Conflicts and Revising Incentives." *Agricultural Information Bulletin* No. 782. Washington, DC: Economic Research Service, U.S. Department of Agriculture.
- Louis Berger Group. 2007. *Evaluation of Environmental Policy and Investment for Water Pollution Control in the Huai River and Tai Lake Basins*. Draft Final Report under TA4447, ADB/SEPA.
- Ma, Z., Y. Wang, X. Wang, and J. Wu. 2006. "Setting up the Environmental Financial Mechanism and Increasing Environmental Investment—The Key to Implement 'Decision' by the State Council." *China Environmental News*, September 7.
- Ma, Zhong. 2006a. "Evaluation of the Implementation of Water Pollution Prevention and Control Plans in China: The Case of the Huai River Basin." Background paper prepared for this report. Accessible at www.worldbank.org/eapenvironment/ChinaWaterAAA.
- . 2006b. "Strengthening the National Capability of Water Pollution Emergency Prevention and Control: Lessons Learned from Songhuajiang River Water Pollution Incident." Background paper prepared for this report. Accessible at www.worldbank.org/eapenvironment/ChinaWaterAAA.
- Marino, M., and K. E. Kemper. 1999. "Institutional Frameworks and Successful Water Markets: Brazil, Spain, and Colorado, USA." World Bank Technical Paper No. 427. Washington, DC: World Bank.
- McNeely, J. 2006. "Conserving Agricultural Biodiversity through Water Markets in China: Lessons from the Millennium Ecosystem Assessment." In OECD. *Issues and Implications. Environment, Water Resources, and Agricultural Policies: Lessons from China and OECD Countries*. Paris: OECD.
- Meinzen-Dick, R., and B. R. Bruns. 2000. "Introduction." In B. R. Bruns and R. S. Meinzen-Dick. *Negotiating Water Rights*. New Delhi: Vistaar. London: Intermediate Technology Press.
- Michelsen, A. M. 1994. "Administrative, Institutional, and Structural Characteristics of an Active Water Market." *Water Resources Bulletin* 30 (6): 971–982.
- Ming, C. 2005. "The Mixed Mechanism in the Management of Water Resources in China." *Chinese Journal of Population, Resources and Environment* 3(4): 3–12.
- MOH (Ministry of Health). 2004. *Annual Health Statistics of China*. Beijing: MOH.
- MWR (Ministry of Water Resources). 2004a. *Water Resources in China*. Available at <http://www.mwr.gov.cn/english/20040802/38161.asp>.
- . 2004b. *2004 Statistical Bulletin on the National Water Activities*. Beijing: Ministry of Water Resources. Available at <http://www.mwr.gov.cn/english/pdf/2004Bulletin.pdf>.
- . 2005. *Statistical Bulletin of China Water Activities*. Available at <http://www.mwr.gov.cn/gb/tj/egbmenu.asp>.
- NIWRH (Nanjing Institute for Water Resources and Hydrology) and CIWRHR (China Institute of Water Resources and Hydropower Research). 1998. *Water Demand and Supply in China*. Beijing: China Water and Power Press.
- NBS (National Bureau of Statistics). 2004. *China Statistical Yearbook 2004*. Beijing: National Bureau of Statistics.
- . 2006. *China Statistical Yearbook 2006*. Beijing: National Bureau of Statistics.
- NDRC (National Development and Reform Commission), MWR (Ministry of Water Resources), and MOC (Ministry of Construction). 2007. *The 11th Five-Year Plan of National Water Resources Development*. Beijing: Ministry of Water Resources.
- NDRC (National Development and Reform Commission). 2007a. *China's National Climate Change Program*. Beijing: National Development and Reform Commission.
- . 2007b. "Implementation Status of Water Pollution Control in Key River Basins during the 10th Five-Year

- Plan, 2005." Available at http://www.sdpc.gov.cn/zjgx/t20050718_37381.htm.
- . 2007c. "The Implementation of the 2006 National Plan of Economic and Social Development." Submitted to the China National People's Congress at its 5th Plenary, March 5, 2007.
- O'Brien, P., and A. Vouvéh. 2001. *Encouraging Environmentally Sustainable Growth in the United States Economics Development*. Working Paper No. 278. Paris: OECD.
- OECD (Organisation for Economic Co-operation and Development). 1997. *Final Report of the Ad Hoc Working Group on Participatory Development and Good Governance, Part 1*. Available online at <http://www.oecd.org/dataoecd/44/12/1894642.pdf>
- . 1999. *The Price of Water: Trends in OECD Countries*. Paris: OECD.
- . 2001. *Environmentally-Related Taxes in OECD Countries: Issues and Strategies*. Paris: OECD.
- . 2003. *Social Issues in the Provision and Pricing of Water Services*. Paris: OECD.
- . 2007. *Environmental Performance Reviews: China*. Paris: OECD.
- Pan, Xiaochuan, and Jinhua Jiang. 2004. *A Study of the Exposure-Response Relationship between Human Health and Water Pollution in the Yangtze and Huai River Basins of China*. Internal Project Report. (For details on study methods and data sources, see section A.2 of the CD-ROM associated with World Bank—2007).
- Pagiola, Stefano, and Gunars Platais. 2002. *Payments for Environmental Services*. Environment Strategy Note No. 3. Washington, DC: The World Bank.
- . 2007. *Payment for Environmental Services: From Theory to Practice*. Washington, DC: The World Bank.
- Pagiola, Stefano, Joshua Bishop, and Natasha Landell-Mills, eds. 2002. *Selling Forest Environmental Services: Market-Based Mechanisms for Conservation and Development*. London: Earthscan Publications.
- Pearce, David, and Anil Markandya. 1989. "Marginal Opportunity Cost as a Planning Concept in Natural Resource Management." In J. Warford and G. Schramm, eds. *Environmental Management and Economic Development*. Washington, DC, and Baltimore, MD: World Bank, Johns Hopkins University Press.
- Pearl River Basin Management Commission. 1998. *Outlines of the Pearl River Basin Planning*. Beijing: China Water and Power Press.
- Perry, C. J. 2007. "Efficient Irrigation; Inefficient Communication; Flawed Recommendations." *Irrigation and Drainage* 56: 367–378.
- Perry, C. J., M. Rock, and D. Seckler. 1997. Water as an Economic Good: A Solution or a Problem? Research Report 14. Colombo, Sri Lanka: International Irrigation Management Institute (IWMI).
- Rogers, P., and A. Hall. 2002. "Effective Water Governance." Background paper for Global Water Partnership. Available online at http://www.gwpforum.org/gwp/library/Effective_Water_Governance.pdf.
- Saleth, R., and A. Dinar. 2004. *The Institutional Economics of Water: A Cross-Country Analysis of Institutions and Performance*. Cheltenham, UK: Edward Elgar.
- SCCG (The State Council of the Chinese Government). 1996. *The 9th Five-Year Plan for National Social and Economic Development*. Beijing: People's Publishing House.
- . 2001. *The 10th Five-Year Plan for National Social and Economic Development*. Beijing: People's Publishing House.
- . 2006. *The 11th Five-Year Plan for National Social and Economic Development*. Beijing: People's Publishing House.
- Scherr, Sara J., Michael T. Bennett, Kerstin Canby, and Molly Loughney. 2006. *Developing Future Ecosystem Service Payments in China: Lessons Learned from International Experience*. A Report Prepared for the China Council for International Cooperation on Environment and Development (CCICED) Taskforce on Eco-compensation. Washington, DC: Forest Trends.
- SEPA (State Environmental Protection Administration—now MEP). 1996. *The 9th Five-Year Plan for National Environmental Protection and the Program for Perspective Goals in 2010*. Available at www.sepa.gov.cn/plan/hjgh/95/200211/t20021113_83083.htm.
- . 2006a. "Report of Survey on the Current Status of Environmental NGOs in China." Available online at http://cn.chinagate.com.cn/reports/2007-06/18/content_8406921.htm.
- . 2006b. *The 2005 State of Environment in China*. Beijing: State Environmental Protection Administration.
- . 2007a. *2006 State of the Environment*. Beijing: Environmental Science Press.
- . 2007b. *China Environment Bulletin 2006*. June 5, 2007.
- . 2007c. *Annual Report on National Urban Environmental Management and Comprehensive Control*. 2006. Available at <http://news.sina.com.cn/c/2007-06-11/164013203669.shtml>.
- SEPA (State Environmental Protection Administration—now MEP) and NBS (National Bureau of Statistics). 2006. *Study Report on Green National Accounting 2004*. Beijing: China Academy of Environmental Planning.
- SEPA News. 2006. "SEPA Comprehensively Checks New Petrochemical Plants." Available at http://www.sepa.gov.cn/xcyj/zwhb/200602/t20060207_73762.htm. February 7.
- SEPA News. 2007. "The Total Emissions of Major Pollutants in the First Three Quarters of the Year Dropped for the First Time." November 14, 2007. Available at http://www.zhb.gov.cn/xcyj/zwhb/200711/t20071114_112873.htm.
- SEPA Policy Research Center. 2006. "Improving Resource Utilization Efficiency in Key Sectors." Technical Paper

- for Study on Policies for Promoting Circular Economy in China.
- Shah, T., A. Deb Roy, A. S. Qureshi, and J. Wang. 2003. "Sustaining Asia's Groundwater Boom: An Overview of Issues and Evidence." *Natural Resources Forum* 27 (2003): 130–141.
- Shah, T., M. Giordano, and J. Wang. 2004. "Irrigation Institutions in a Dynamic Economy: What is China Doing Differently to India?" *Economic and Political Weekly*, July 31, 2004.
- Shalizi, Zmarak. 2006. *Addressing China's Growing Water Shortages and Associated Social and Environmental Consequences*. World Bank Policy Research Working Paper 3895. Washington, DC: World Bank.
- Sheng, Huaren. 2005. "The Inspection Report of the Implementation of China Water Pollution Prevention Law." A Report to the 16th Plenary of the Standing Committee of the NPC on June 26, 2005. *China Environment News*, June 29.
- Song-Liao River Basin Management Commission. 1998. *Outlines of the Song-Liao River Basin Planning*. Beijing: China Water and Power Press.
- Spofford, W., and Y. Wu. 1998. "Water Supply Pricing in Beijing and Shanghai." In Li Yining and J. Warford, eds., *Natural Resource Pricing in China: Water Supply, Coal and Timber*. Silver Spring, MD: MRM International Press.
- Sturgess, G. L., and M. Wright. 1993. *Water Rights in Rural New South Wales: The Evolution of a Property Rights System*. Sydney: Center for Independent Studies.
- Tripp, James T. B. 2007. "U.S. Clean Water Act (CWA) Enforcement." Note presented at the International Forum of Environmental Legislation and Sustainable Development, Beijing, December 2007.
- Turrall, H., T. Etchells, M. Malano, H. Wijedesa, and P. Taylor. 2005. "Water Trading at the Margin: The Evolution of Water Markets in the Murray-Darling Basin." *Water Resources Research* 41: W07011.
- Uchida, E., S. Rozelle, and J. Xu. 2007. "Conservation Payments, Liquidity Constraints, and Off-Farm Labor: Impact of the Green for Grain Program on Rural Households in China." Mimeo.
- UNDP (United Nations Development Programme). 2003. *Environmental Governance Sourcebook*. Bratislava, Slovak Republic: UNDP.
- . 2006a. "Water Governance." Available online at http://rbec.undp.org/WaterWiki/index.php/Water_Governance
- . 2006b. *UN Human Development Report 2006—Beyond Scarcity: Power, Poverty, and the Global Water Crisis*. New York City: UNDP.
- UNESCO. 2003. *Water for People, Water for Life: The United Nations World Water Development Report*. New York: UN.
- United Nations. 2006. *World Water Resource Report*. New York: UN.
- USEPA (U.S. Environmental Protection Agency). 2006. *Solving Environmental Problems through Partnership: A Case Study—New York City Watershed Partnership*. Washington, DC: USEPA.
- U.S. National Research Council. 2004. *Review of the Desalination and Water Purification Technology Roadmap*. Washington, DC: National Academies Press. Available at http://books.nap.edu/openbook.php?record_id=10912&page=19.
- Wang, J., Z. Xu, J. Huang, and S. Rozelle. 2005. "Incentives in Water Management Reform: Assessing the Effect on Water Use, Production and Poverty in the Yellow River Basin." *Environment and Development Economics* 10: 769–799.
- Wang, J., H. Li, J. Huang, and M. Zhao. 2007a. "Water Scarcity in China: Future Trend and Potential Solutions." Draft CEM background paper for the World Bank. Beijing.
- Wang, J., J. Huang, A. Blanke, Q. Huang, and S. Rozelle. 2007b. "The Development, Challenges and Management of Groundwater in Rural China." In Mark Giordano and Karen G. Villholth, eds., *The Agricultural Groundwater Revolution—Opportunities and Threats to Development*. Colombo, Sri Lanka: IWMI.
- Wang, Y., et al. 2007c. *Taking Stock of Integrated River Basin Management in China*. Beijing: China Science Press.
- Warford, J., and Y. Li, eds. 2002. *Economics of the Environment in China*. Boyds, MD: Aileen International Press.
- WET. 2006. Water Entitlements and Trading Project (WET Phase 1). Final Report, November 2006. Beijing and Canberra: Ministry of Water Resources, P.R. China, and Department of Agriculture, Fisheries and Forestry, Australia.
- . 2007. Water Entitlements and Trading Project (WET Phase 2). Final Report, December 2007. Beijing and Canberra: Ministry of Water Resources, P.R. China, and Department of Agriculture, Fisheries and Forestry, Australia.
- Working Group of Weihe River Basin Comprehensive Control Plan. 2002. *Weihe River Basin Comprehensive Control Plan in Shaanxi Province*. Xian, Shaanxi.
- World Bank. 1997. *Clear Water, Blue Skies: China's Environment in the New Century*. Washington, DC: World Bank.
- . 2001a. *China: Air Land, and Water—Environmental Priorities for a New Millennium*. Washington, DC: World Bank.
- . 2001b. *China: Water Resources Assistance Strategy 2002*. Washington, DC: World Bank.
- . 2002a. *World Development Report 2003*. Washington, DC: World Bank.
- . 2002b. *China Agenda for Water Sector Strategy for North China—Summary Report*. Washington, DC: World Bank.
- . 2005a. *North China Water Quality Management Study*. Washington, DC: World Bank.

- . 2005b. *Re-engaging in Agricultural Water Management: Challenges, Opportunities, and Trade-offs*. Washington, DC: World Bank.
- . 2006a. *China Water Quality Management—Policy and Institutional Considerations*, Discussion Paper, Environment and Social Development—East Asia and Pacific Region. Washington, DC: World Bank.
- . 2006b. “Good Governance for Good Water Management.” *Environment Matters 2006*. Washington, DC: World Bank.
- . 2007a. *Cost of Pollution in China: Economic Estimates of Physical Damages*. (Conference edition.) Washington, DC: World Bank.
- . 2007b. *Stepping Up: Improving the Performance of China’s Urban Water Utilities*. Washington, DC: World Bank.
- . 2007c. *World Development Indicators 2006*. Washington, DC: World Bank.
- . 2007d. *Water Pollution Emergencies in China—Prevention and Response*. Washington, DC: World Bank.
- Wouters, P., D. Hu, J. Zhang, D. Tarlock, and P. Andrews-Speed. 2004. “The New Development of Water Law in China.” *University of Denver Water Law Review* 7(2): 243–308.
- WRI (World Resources Institute). 2001. *World Resources 2000–2001*. Washington, DC: WRI.
- Yang, H., X. Zhang, and A. Zehnder. 2003. “Water Scarcity, Pricing Mechanism and Institutional Reform in Northern China Irrigated Agriculture.” *Agricultural Water Management* 61: 143–161.
- Xinhua News Press. 2006. “Municipal Environment Generally Worse and Three Main Pollution Sources out of Control.” Available at http://news.xinhuanet.com/video/2006-08/22/content_4992141.htm.
- Xinhua News Agency. 2006. “Half of China’s Chemical Plants Endanger Environment.” Available at http://news.xinhuanet.com/english/2006-07/11/content_4818672.htm. July 11.
- Xu, Z. 2001. “Study on Increasing Water Use Efficiency.” *Journal of China Water Resources* 455: 25–26.
- Xu, Jintao, Ran Tao, Xu Zhigang, and Michael T. Bennett. 2006. “China’s Sloping Land Conversion Program: Does Expansion Equal Success?” Working Paper. Yangtze River Basin Management Commission. 1998. *Outlines of the Yangtze River Basin Planning*. Beijing: China Water and Power Press.
- Zhang, J. K., S. J. Gao, J. Fen, and L. L. Yan. 2007. “China’s Water Resource Management: Strategic Issues, Governance, and Government Capabilities.” Background paper prepared for this report. Available at www.worldbank.org/eapenvironment/ChinaWaterAAA.
- Zhou, Gangyan. 2006. “Institutional Arrangements for River Basin Management: A Case Study Comparison of the United States and China.” Background paper prepared for this report. Available at www.worldbank.org/eapenvironment/ChinaWaterAAA.
- Zhou, Shengxian. 2006. “Speeding up Facilitating Historical Transition and Creating a New Situation of Environment Protection.” A Speech at the 2006 Meeting of Director-General of Local EPBs across China, April 18.
- Zhu, R. 2006. *China’s South-North Water Transfer Project and Its Impacts on Economic and Social Development*. Beijing: Ministry of Water Resources. Available at <http://www.mwr.gov.cn/english1/20060110/20060110104100XDENTE.pdf>.



Index

A

Agriculture

- determinants of water productivity, 26
 - economic value of water, 26, 37, 38*t*
 - ecosystem restoration projects, 99
 - geographical distribution of arable land, 9–10
 - payments for ecosystem services, case study, 107, 108–9
 - significance of, in water pollution, 1–2, 13
 - water content of products, 37, 38*t*
 - water productivity, *xviii*, 25, 35
 - water use goals of 11th Five Year Plan, 2, 27
 - water withdrawals, 25
- See also* Irrigation

Allocation of resource

- annual, 68
 - boundary setting for, 64
 - current governance shortcomings, *xxii*
 - environmental flow considerations, *xxiii*, 65–66, 80
 - evapotranspiration approach, *xxiii*, *xxiv*, 62, 69–71, 79, 138
 - infrastructure support, 79
 - international experience, 64–65, 66
 - legal and regulatory framework, 67–68
 - measurement technology, 79
 - monitoring, 68–69, 79
 - permits for withdrawal, *xxiii*, 80
 - rationale, 61
 - recommendations for governance, *xxiii*, 80
 - requirements for water rights-based system, 64
 - research needs, *xxx*
 - share determination, 64, 66, 68
 - water productivity and, *xviii*
- See also* Markets, water; Rights-based water management

- Analytical and advisory assistance program, *xvii–xviii*, 2, 3*f*
- Australia, 74

B

- Banking, water, 74
- Bei River pollution incidents, 14, 127–28
- Beijing
 - groundwater tables, 17
 - water pricing, 84, 86, 87, 90
 - water tariff reforms, 3
- Bishan, 90

C

- Cancer, 19, 20*f*
- Chemical oxygen demand, *xxvi*, *xxvii*, 12, 111
- Chile, 74
- China Water Pollution Map, 56
- Chongqing, 3, 84, 88–90, 92, 93
- Clean Water Act, 44*f*, 48
- Climate change
 - research needs, *xxx*, 140
 - water supply and, 11
- Coliform bacteria, 19
- Compendium of Implementation for Fully Promoting Law-Based Administration*, 46
- Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, 53, 57–58
- Costa Rica, 104–5

D

- Demand-side management, *xvii*
 - shortcomings of current governance system, 48
 - water rights system and, 35

- Desalination technology, 27
- Development
- China's economic growth, 21
 - costs of water scarcity, 21
 - pollution management and, 112–13
 - water problems related to, 21
- Diarrhea, 19, 20*f*
- Domestic consumption
- basic need estimates, 91
 - current wastewater treatment capacity, *xxvii*
 - drinking water quality, 18–19, 20*f*
 - urban areas, 21–23, 36
 - wastewater discharge, *xix*, 12–13
 - water pricing, *xxv*, 36
- Dujiangyan Water Project, 41
- E**
- Ecological compensation mechanisms, *xxvi*
- current application, 99
 - historical and conceptual development, 98–99
 - legal framework, 99, 110 n.2
 - payment for ecosystem services and, 97
 - potential limitations, 97, 99–100
 - purpose, 97
 - rationale, 98
 - recommendations, 109, 139
- Economic functioning
- China's growth rate, 21
 - costs of water pollution, *xvii*, *xix*, 2, 19, 112, 128
 - costs of water supply shortages, *xix*, 2, 19
 - development costs of water scarcity, 21
 - ecological compensation mechanisms, 98, 99
 - environmental disaster fund, *xxix*, 136, 139–40
 - government financing for pollution prevention and control, *xxviii–xxix*, 37–38, 48
 - pollution levies and fines, *xxviii*, 39, 120, 122–23, 134–35
 - regional socioeconomic patterns, 23
 - urban wastewater treatment investment, 37–38
 - water pricing effects on poor consumers, *xxv*, 88–93
 - See also* Payments for ecosystem services; Pricing, water
- Economic value of water
- case analysis, 87, 88*f*
 - current shortcomings of water rights system, 36–37
 - international comparison, 35
 - sectoral differences, *xviii*, 26, 37
 - See also* Productivity, water
- Emergency Response Law, 133
- Enforcement of regulations
- compliance with pollution control measures, 113–14, 119–21, 139
 - current weaknesses, 43–44
 - institutional framework, 43
 - mechanisms and procedures, 43
 - pollution control recommendations, *xxvii*, 123, 124–25
 - pollution fines and levies, 39, 120, 122–23, 134–35
 - public disclosure requirements, 53
 - public participation, *xxi*, 43–44, 46
 - recommendations for improving, *xxvii*, 45–46
 - shortcomings of current pollution prevention, *xxvii*
 - supervision and inspection, 46
 - U.S. model, 44
 - water rights system, *xxii*, 68–69, 78
- Environmental effects of water crisis
- costs, *xix*, 2
 - research needs, *xxx*
 - water withdrawal effects, 16–17
- Environmental Impact Assessment Law, *xxxi*, 55, 143
- Environmental Information Disclosure Decree, 53
- Environmental protection bureaus, 32, 121
- Environmental Protection Law, *xxii*, 99, 115
- European Union, 48, 49*f*; 53–54, 57–58
- Evapotranspiration-based water management
- advantages, *xxiv*, 35*f*, 62, 69–70, 79
 - case example, 62, 63*f*; 70–71
 - principles, *xxiii*, 35*f*, 62
 - recommendations, *xxiii*, *xxiv*, 138
 - research needs, 79
 - water balance theory, 62
- F**
- Fisheries resources, pollution costs, 19–21
- Five Year Plan, 9th (1996–2000), 27, 29, 37–38
- Five Year Plan, 10th (2001–05), 27, 29, 37–38
- Five Year Plan, 11th (2006–10)
- enforcement of environmental law and regulations, 43
 - pollution control investment, 37
 - wastewater treatment targets, 116
 - water resource management goals, *xvii*, 2, 27–28
- Fluorine contamination, 18–19
- Forest Ecosystem Compensation Fund, 99
- Forestry management, 99
- Framework for Water Rights System Development, 34
- France, 33, 48–49, 58
- Friends of Nature, 56
- Future challenges and opportunities, *xxxi*, 1, 23
- research needs, 140–43
- G**
- Gaomi, 90
- Geographic information systems, *xxiii*
- Geographical distribution. *See* Regional differences
- Germany, 120

- Governance, water
- action plan for reform implementation, 140
 - administrative versus market-based management, 36–37, 40, 48
 - analytical methodology, 6
 - causes of water pollution, 113
 - challenges and opportunities, *xxxi*, 137, 143
 - conceptual basis, *xix–xx*, 42
 - current shortcomings, *xviii*, *xx–xxi*, 1, 40, 48
 - definition, 42
 - goals of 11th Five Year Plan, *xviii*, 2, 27–29
 - good qualities, 42, 59
 - impact assessment, *xxxi*
 - institutional structure, *xx–xxi*, 29–34
 - legal framework for, *xx*, *xxi*, 42, 60
 - local resistance to central authority, 47–48
 - management strategies, 2
 - national-level coordination, *xxi–xxii*, 138
 - policy failures, 34–39
 - recognition of water supply problems, 27
 - recommendations for improving, *xxi–xxii*, 59–60, 137–40
 - reported compliance with pollution control regulations, 113–14
 - research needs, 140–43
 - thematic areas, *xx*, 2–3
- See also* Allocation of resource; Enforcement of regulations; Institutional structure of water governance system; Legal system; Public participation in policy development; Transparency of water system governance
- Government Information Disclosure Regulation, 52
- Grassland Law, 99
- Groundwater depletion
- current rates, 9
 - economy, 21
 - governance shortcomings, *xxii*
 - pollution and, *xix*, 17, 26
 - salinity levels and, 17–18
 - subsidence effects, 18
 - trends, *xix*, 2, 17
- Guidelines on Deepening Reform of Economic System, 2
- H**
- Hai basin
- economic value of water, *xviii*, 3, 26, 36–37, 87, 88*f*
 - groundwater extraction, 17
 - water flow trends, 11, 16–17
 - water resources, 10
- Hangzhou City, 115
- Health risks of water pollution
- drinking water quality, 18–19
 - mortality, 20*f*
- social and economic costs, *xix*, 2, 19
- Heihe basin, 71, 76
- Hu Jintao, 34
- Huai basin
- economic value of water, 26
 - pollution control outcomes to date, *xxvii*
 - pollution control planning, 3, 114
 - water flow trends, *xviii*, 11
 - water quality data, 32
 - water resources, 10
- Huang Basin (Yellow River)
- economic value of water, 26
 - pollution incidents, 14, 127, 128
 - wastewater treatment capacity, 116–17
 - water flow trends, 11, 16–17
 - water resources, 10
 - water rights, 69
- I**
- Industry sector
- economic value of water, 26, 37, 38*t*
 - wastewater discharge, *xix*, 1, 12
 - water productivity, *xviii*, 25, 26, 35
 - water use goals of 11th Five Year Plan, 27
 - water withdrawals, 25
- Institutional structure of water governance system
- current shortcomings, *xx–xxi*, 29–33, 40, 47–48
 - enforcement of laws and regulations, 43
 - integrated approach, 33–34, 51
 - inter-agency relationships, 51
 - international comparison, 48–50
 - legal framework, 42–43, 46
 - national level, 51, 60, 138
 - payments for ecosystem services, 103
 - pollution control system, 121
 - pollution event response, 130, 133–34
 - recommendations for improving, *xxi–xxii*, 51–52, 60, 138
 - significance of, in improving water resource management, 47
- Integrated river basin management, 50, 95, 98, 115
- Irrigation
- current practice, 21
 - economic value of water, *xviii*
 - efficiency, 26
 - marginal opportunity costs, 88
 - regulation, 34
 - tradable water rights markets, 75–76
 - waste in, *xviii*
 - wastewater use, 19
 - water abstraction permits, 68
 - water pricing, 36, 88
- Israel, 64, 65*f*

J

Japan, 119
 Jiakou, 86
 Jiangjin, 90

L

Lanzhou, 86
 Lashihai Nature Reserve, *xxvi*, 106–9
 Law on Environment Protection, 59
 Legal system

- action plan for reform, 45
- ambiguous provisions, 45, 46
- conflicting provisions, 45, 46
- current shortcomings, *xx*, 43
- ecological compensation mechanisms, 99
- for water governance, *xx*
- incomplete coverage, 44–45
- information disclosure requirements, 53
- legislative process, 46
- payments for ecosystem services, 99, 103
- pollution control, 121, 122–25, 129–30, 133
- recommendations for improving, *xxi*, 45–47, 60, 138
- recommendations for improving pollution prevention, *xxvii*, *xxviii*
- requirements for nongovernmental organizations, 57, 59
- requirements for public participation in governance, 55–56, 57, 59
- scope of water governance, 42
- structural framework, 42–43
- transparency of water system governance, *xxi*, 53, 55
- water pricing, 84
- water rights system, 34, 67–68, 79–80

See also Enforcement of regulations
 Lijiang City, 3, 91–92, 106–9

M

Marginal opportunity costs of water supply, *xxiv*, 86–88, 91
 Markets, water

- administration, 80–81
- benefits, 72
- case studies in China, 74–77
- challenges for implementing system of, *xxiii*, 80
- conceptual basis, 71–72
- disadvantages, 72
- dispute resolution, 79–80
- infrastructure support, 79
- international experience, 73–74
- recommendations for, *xxii*, *xxiv*, 138
- spot markets, 72

tradable water rights, 72
 water banking, 74

Mexico, 66
 Ministry of Agriculture, 32
 Ministry of Environmental Protection (MEP), *xxx*, 30–31, 32, 51, 52, 121
 Ministry of Transportation, 32
 Ministry of Water Resources, *xxi*, *xxii*, 30–32, 34, 43, 51, 52, 56, 67, 74
 Mongolia, 69, 75–76, 127
 Mortality, water pollution-associated, 20^f
 Municipal sewage, *xix*, 1, 12–13

N

Nanjing, 86
 National Chemical Registration Center, *xxix*
 National People's Congress, 43, 46
 National Plan for Environmental Emergency Response, 132
 Natural Forest Protection Project, 99
 New Countryside Development program, 124
 NH₃-N discharges, 12
 Nongovernmental organizations

- environmental, in China, 56
- government-sponsored, 57
- recommendations for regulatory reform, 59, 138
- regulatory challenges for, 57

 Nu River, 56

O

Organic pollutants, 12, 13–14
 Organisation for Economic Co-operation and Development (OECD), 119

P

Payments for ecosystem services

- advantages, *xxvi*, 97, 110
- beneficiary identification, 100
- case study, 106–9
- conceptual basis, *xxvi*, 100
- economics, 100–101
- implementation, 102–3
- international experience, 103–5
- legal framework, 99, 103
- management costs, 103
- mechanics, 101, 102^f
- number of providers and beneficiaries, 103
- payment levels, 100
- political economy, 106, 110
- potential applications in China, 105–6
- recommendations, 109–10, 139
- scope of services, 100, 101^f

 Permits

- irrigation, 34

- pollution control revenues from, 120–21
- wastewater discharge, *xxviii*, 124
- water withdrawal, *xxiii*, 67–68, 80
- Pollution event response
 - basic elements, 128–29
 - current system, *xxix*, 132–35
 - environmental disaster fund for, *xxix*, 136, 139–40
 - financial responsibility, 131–32, 134–35
 - first responder training, 134, 136
 - information system for, *xxix–xxx*, 129, 132, 135–36
 - institutional responsibility, *xxix*, 130, 133–34
 - international agreements, 129–30
 - international experience, 129–32
 - legal framework, 129–30, 133
 - outcome monitoring, 135, 136
 - planning and preparedness, 130–31, 134
 - pollution prevention versus, 122
 - public disclosure, *xxx*, 132, 135, 136
 - recent history, 14, 127–28
 - recommendations for improving, *xxix–xxx*, 135–36, 139–40
 - risk assessment, 132–33
 - system elements, *xxix*
- Pollution, water
 - associated mortality, *20f*
 - central government enforcement, 123–24, 139
 - chemical oxygen demand, *xxvi*, *xxvii*, 111
 - command-and-control methods for controlling, 119–20
 - components of pollution control plans, 114
 - control mechanisms, 119–21
 - control planning, *xxviii*, 124
 - costs, *xvii*, *xix*, 2, 19–21, 112, 128
 - current and emerging threats, 98, 111–12
 - distorted economic incentives, *39f*
 - drinking water, 18–19, 112, 122
 - finances and levies, *xxviii*, *xxix*, 39, 120, 122–23, 134–35
 - goals of 11th Five Year Plan, 27–28
 - governance failures contributing to, *xxvii*, 113, 114–16
 - governance structure, 32
 - government financing for prevention and control, *xxviii–xxix*, 37–38, 48, 125
 - groundwater extraction and, 17
 - in rural areas, *xxviii*, 124
 - legal framework, *xx*, 121, 122–25
 - local responsibility, 115–16, 123
 - market-based mechanisms for controlling, 124
 - monitoring system, *xxviii*, *xxx*, 124
 - nonpoint sources, 1–2, 13–14
 - obstacles to improving control, 40
 - prevention planning, 130–31, 134, 135, 139
 - recommendations for improving prevention of, *xxvii–xxix*, 123–25, 139
 - regional differences in capacity to control, 112–13
 - reported compliance with control measures, 113–14
 - role on environmental NGOs in China, 56
 - shortcomings of current prevention system, *xxvii*, 48, 111
 - source information, 121–22
 - taxes on products that pollute, 120
 - trends, *xviii–xix*, 11–12, 112
 - wastewater discharges, 1, 11–12
 - wastewater treatment costs based on effluent quality, 88
 - water supply and, *xix*, 11, 21, 26
 - See also* Health risks of water pollution; Quality of water
- Population patterns and trends
 - per capita water supply/use, *xviii*, 1, 9–10
 - projections, 1, 23
 - regional differences, 23
 - socioeconomic patterns, 23
 - urbanization trends, 21
- Precipitation patterns, *xviii*, 10
- Pricing, water
 - affordability considerations, 89–91
 - consumption metering, 94, 95
 - current system, *xxiv*, 36, 83–86
 - delivery cost, 86–87
 - depletion costs, 87, 95–96
 - determinants, *xxiv*, *xxv*
 - environmental cost, 87
 - goals of reform, 95
 - gradual implementation, 94, 96
 - implementation strategies, *xxv*, 94
 - in rural communities, 92–93
 - increasing block tariffs, 84, 91–92, 96
 - international experience, 96
 - legal basis, 84
 - marginal opportunity costs, *xxiv*, 86–88, 91, 94, 95, 96, 139
 - performance incentive systems in reform of, 94
 - price trends, 83, 84
 - profits generated from, 94–95
 - public resistance to reform, 93
 - recommendations for, *xxiv*, *xxv–xxvi*, 88, 95–96, 139
 - regional variation, *85f*, 86, 87
 - revenue distribution, 84
 - social impact considerations, *xxv*, 88–89, 96
 - sociopolitical obstacles to reform, 88
 - strategies for protecting poor consumers, 91–93
 - vouchers for low-income consumers, 92
 - water development fee, 84
 - water resource fee, *xxv–xxvi*, 84, 87, 95, 96

- Productivity, water
 current shortcomings, *xviii–xix*, 35, 137
 determinants, *xviii*, 25
 international comparison, *xviii*, 35
 pollution effects, 21
 research needs, 140
 role of water markets, 72
 sectoral patterns, *xviii*, 25–26
 technical interventions to improve, 25
 urban distribution losses, 26
 water pricing effects, 36
See also Economic value of water
- Public participation in policy development
 current status, *xxi*, 55–56
 environmental NGOs, 56, 57
 forms of, 56
 goals of good governance, 42
 government role in promoting, 58–59
 international experience, 57–58
 legal requirements, 55–56, 57, 59
 procedural distortions, 57
 public awareness of opportunities for, 56–57
 rationale, 55, 58
 recommendations for improving, *xxii*, 58–59, 138
 shortcomings of current governance system, 56–57
 water management organizations, 59
 water rights system, 66–67, 78
- Public perception and understanding
 enforcement of laws and regulations and, 43–44, 46
 of opportunities for public participation in governance, 56–57
 of right to information, 55
 pollution event information, 132, 135, 136
 recommendations for improving, *xxii*
 resistance to water pricing reforms, 93
 transparency of water system governance, *xxi*, *xxii*
See also Public participation in policy development;
 Transparency of water system governance
- Q**
- Qixinghe Natural Reserve, 116
- Quality of water
 current status, *xix*, 14, 111–12
 drinking water, 18–19
 governance responsibility and oversight, 30
 grades, *xix*, 14, 111–12
 lakes and reservoirs, 15*t*
 monitoring, 135
 public disclosure of data, 52–53
 regional differences, 14
 river sections, 15*f*, 16*f*
 surface water, 16*f*, 23–24*n.7*
 trends, 14
See also Pollution, water
- R**
- Recycling and reuse of wastewater, *xviii*, 36, 40*n.5*
- Regional differences
 economic value of water, 26
 population distribution, 23
 wastewater treatment capacity, 116–19
 water pricing, 86, 87
 water quality, 14
 water rights allocation, 67
 water supply, *xviii*, 9–10
- Regional Environmental Supervision Centers, 43
- Regional management, river basin management and, *xvii*
- Research
 case studies, 3. *See also specific case study*
 data sources and methodology for assessing current
 water management system, *xvii–xviii*, 2, 3–5, 4*f*
 needs, *xxx*, 140–43
- Rights-based water management
 administrative structure, 31–32, 80–81, 138
 case examples in China, 69, 70
 challenges to comprehensive implementation, 77–78
 conceptual components, 61–62
 contracts and claims system, 63*f*
 current pricing strategies, 36–37
 definition, 61
 definition of water ownership, 48, 77, 78–79
 environmental sustainability considerations, 78
 legal framework, 34, 67–68, 79–80
 levels of, 68
 local conditions in development of systems for, 69
 measurement of usage, 34–35
 monitoring systems for, 64, 65*f*, 78
 public participation in system of, 66–67, 78
 rationale for rights-based management, 62–64
 recommendations for improving governance,
xxiii–xxiv, 80–81, 138
 registration systems for, 64
 requirements for system of, 64–65
 resource assessment, 64
 shortcomings of current governance, *xxii*, 34–35, 48,
 68–69
 supply-side focus, 35
 system inconsistencies, 77–78
 transfer provisions, 34
 transparency, 62, 64, 78
See also Allocation of resource; Markets, water
- River basin management
 commission structure and function, 32–33
 current governance shortcomings, *xx–xxi*
 ecological compensation mechanisms, *xxvi*
 institutional structure, 30–31, 49–50, 51–52, 60, 67
 integrated approach, 50, 95, 98, 115
 legal framework, 46

- pollution control failures, 114, 115
 public participation, 59
 recommendations for improving, *xxii*, 46–47, 51–52, 60
 regional management and, *xvii*
 research needs, *xxx*
 U.S. model, *47f*, 49–50
 water rights system, 34
- Rural areas
- pollution control in, *xxviii*, 116, 124
See also Agriculture
- S**
- Saltwater intrusion, 17–18
- Sand Control Law, 99
- Service sector
- economic value of water, 37, 38*t*
 water productivity, 25
 water withdrawals, 25
- Shanghai, 14, 86, 87
- Shortages, water
- causes, 21–23, 35, 41
 costs, *xix*, 2
 definition of scarcity, *xxviii*, 10
 future risk, *xxvii*, 1
 implications for China's development, *xvii*, 21
 pollution and, *xviii–xix*, 21, 26
 shortcomings of supply-side management, 35
 technical solutions, 25, 26–27
See also Supply, water
- Singapore, 49
- Sloping Land Conversion Program, 99
- Song-Liao River basin, 71
- Songhua River chemical spill, 3, 14, 19, 122, 127, 128*f*, 134
- South Africa, 66
- State Administration for Worker Safety, *xxx*
- State Council, 34, 46
- State Environmental Protection Administration
- monitoring and enforcement activities, 43
 public disclosure rules, 52, 55–56
- State Water Resources Commission, *xxi–xxii*, 51, 138
- Strategic environmental assessments, *xxxi*, 143
- Subsidence, 18
- Supply, water
- climate change and, 11
 current resources, *xviii*, 1
 future challenges, 98
 geographical distribution, *xviii*, 1, 9–10
 government recognition of problems in, 27
 historical significance, 41, 137
 international comparison, *xviii*
 modeling, 4–6
 per capita, *xviii*, 1, 9
 productivity, *xviii–xix*
 projected demand, 22*t*, 23
 sources, 9, 98
 temporal distribution, *xviii*, 10
See also Quality of water; Shortages, water
- Surface water quality, 16*f*, 23–24*n.7*
- Switzerland, 129, 130*f*
- T**
- Tai Lake, 41, 112, 122, 127
- Technology for water management
- analytical methodology, 6
 desalination projects, 27
 evapotranspiration approach, *xxiii*
 to increase supply, 25, 26–27
- Temporal distribution of water supply, *xviii*, 10
- Tongxu, 90
- Total nitrogen, 12, 14
- Total phosphorous, 12, 14
- Township and village industrial enterprise wastewater discharges, 12, 116, 124
- Trading water rights. *See* Markets, water
- Transboundary rivers, *xx–xxi*, 32, 115
- Transparency of water system governance
- ambiguity of requirements, 53
 current system, *xxi*, 52–53
 goals of reform, 54
 good qualities, 42, 52
 in water rights-based management, 62, 64, 78
 information systems for, 55
 international experience, 53–54
 law enforcement and, 43–44
 legal requirements, *xxi*, 53, 55
 public awareness and understanding of requirements for, 55
 recommendations for governance reform, *xxii*, 54–55
 water quality data, 52–53
- Tuo River, 127
- Tuojiang River, 122
- Typhoid, 19
- U**
- United Kingdom, 48, 129, 130*f*, 131, 132
- United States
- law enforcement model, 44*f*
 payments for ecosystem services systems, 103–4
 pollution control system, 48
 pollution incident response, 129, 130*f*, 131–32
 public disclosure requirements, 54
 public involvement in governance, 58
 river basin management, 47*f*, 49–50
 water markets, 73–74
 water rights management model, 62, 63*f*

- Urban areas
- population patterns, 21
 - regional variations in wastewater treatment capacity, 117–19
 - wastewater treatment, *xix*, 1, 12–13, 21–23, 37–38
 - water distribution losses, 26
 - water markets, 74–75
 - water pricing, 36, 84–86
 - water use goals of 11th Five Year Plan, 27
- W**
- Wastewater management
- current discharges, 1, 11–12
 - current treatment capacity, *xxvii*
 - discharge permitting, *xxviii*, 124
 - goals of 11th Five Year Plan, 116
 - in small towns and villages, 116
 - incentives for improving, 120, 121
 - international experience, 119–21
 - irrigation with wastewater, 19
 - marginal environmental cost of water, 87
 - recommendations for rural areas, 124
 - recycling and reuse, *xviii*, 36, 40n.5
 - regional variation in capacity, 116–19
 - regional variation in fees, 86
 - spending, 37–38
 - treatment costs, *xxiv*, 36, 84, 86, 87
 - treatment costs based on effluent quality, 88
 - trends, *xix*, 86
 - untreated discharges, 1, 12–13, 116
 - urban areas, 21–23, 37
 - water pricing effects on, 36
- Water affairs bureaus, 31–32
- Water and Soil Conservation Act, 99
- Water development fee, 84
- Water Law, 34
- administrative structure, 46
 - amendments (2002), 28
 - in legal framework for water governance, 43, 45
 - public participation provisions, 57, 59
 - recommendations for improving, *xx*, *xxii*, 51
 - water rights system, 67, 68–69
- Water Pollution Prevention and Control Law
- amendments (2008), 28
 - emergency response provisions, 133
 - enforcement provisions, 43, 122–23
 - local government responsibility under, 115
 - public disclosure requirements, 53
 - recommendations for, 123–24
 - water pricing provisions, 84
 - weaknesses, 44–45, 115, 121
- Water resource fee, *xxv–xxvi*, 84, 87, 95, 96
- Water Resource Management Commission, 60
- Water users associations, 56, 80–81
- Wei River, 115
- Weishi, 90
- Wuxi water crisis, 19, 41, 122, 127
- X**
- Xi'an City, 86
- Xiang River, 14, 128
- Xining, 86
- Y**
- Yellow River. *See* Huang Basin
- Z**
- Zhangye City, 71, 76
- Zhejiang Province, 14, 74–75, 84

ECO-AUDIT

Environmental Benefits Statement

The World Bank is committed to preserving endangered forests and natural resources. The Office of the Publisher has chosen to print *Addressing China's Water Scarcity* on recycled paper with 30 percent post-consumer waste, in accordance with the recommended standards for paper usage set by the Green Press Initiative, a nonprofit program supporting publishers in using fiber that is not sourced from endangered forests. For more information, visit www.greenpressinitiative.org.

Saved:

- 8 trees
- 378 lbs. of solid waste
- 2,945 gallons of waste water
- 710 lbs. of net greenhouse gases
- 6 million BTUs of total energy



For years, water shortages, water pollution, and flooding have constrained growth and affected public health and welfare in many parts of China. Given continuing economic trends and population growth, the pressures on the country's water resources are likely to worsen. The widening gap between water supply and demand, along with deteriorating water quality caused by widespread pollution, suggests that a severe water scarcity crisis is emerging.

Addressing China's Water Scarcity addresses the emerging water crisis and the need for China to reform and strengthen its water resource management framework. It covers key issues including water governance, water rights, water pricing and affordability, watershed ecological compensation, water pollution control, and emergency prevention, and it identifies the measures needed to effectively move forward in these areas. In line with the broad strategy of developing a market economy, the book concludes that the focus of the reform needs to be on clarifying the role of and relationships among the government, markets, and society; improving the efficiency and effectiveness of water management institutions; strengthening the compliance and enforcement of water pollution control; and fully embracing and using market-based instruments as much as possible.



THE WORLD BANK

