A New Era of Water Governance in China — Thematic Report

Watershed

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Development Research Center of the State Council

A New Era of Water Governance in China — Thematic Report

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The Development Research Center of the State Council (DRC) is mainly responsible for conducting research on strategic and long-term issues related to economic and social development in China, as well as key challenges related to reforms and policy options, providing advice to the CPC Central Committee and the State Council.

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Foreword

Victoria Kwakwa
Vice President for East Asia and the Pacific
The World Bank

Globally many countries are placing unprecedented pressure on water resources. The global population is growing fast, and estimates show that with current practices, the world will face a 40% shortfall between forecast demand and available supply of water by 2030. Furthermore, chronic water scarcity, hydrological uncertainty, and extreme weather events (floods and droughts) are perceived as some of the biggest threats to global prosperity and stability.

To strengthen water security against this backdrop of increasing demand, water scarcity, growing uncertainty, greater extremes, and fragmentation challenges, the World Bank is supporting clients to invest in institutional strengthening, information management, and infrastructure development. Institutional tools such as legal and regulatory frameworks, water pricing, and incentives are needed to better allocate, regulate, and conserve water resources. Information systems are needed for resource monitoring, forecasting, decision making under uncertainty, and systems analyses. Investments in innovative technologies for enhancing productivity, conserving and protecting resources, recycling and developing non-conventional water sources should be explored in addition to seeking opportunities for enhanced water storage.

Water is central to the realization of China's sustainable economic prosperity and has the potential to provide important contributions to the global discourse. Despite being the world's second-largest economy and most populous country, China possesses only 6 percent of the world's freshwater resources with availability per capita one-fourth the global average. To address these challenges the Government invested more than RMB 717.6 billion in 2017 alone and yet scarcity, pollution, and flooding continue to threaten sustainable development.

The commitments to development of an era of ecological civilization reflect the next generation of reforms to reposition the structure of the economy. China has experienced a period of rapid economic growth and social development since the introduction of reforms that shifted the country from a centrally planned to a market-based economy with Chinese characteristics. GDP growth has averaged more than 7 percent a year over the past decade—the fastest sustained expansion by a major economy in history—and has lifted more than 800 million people out of poverty.

This rapid economic ascendance to the upper middle-income status achieved today has brought with it many challenges. These include rapid urbanization, uneven regional development, challenges to ecological and environmental sustainability, external imbalances and high inequality. To meet these challenges significant policy adjustments are required to ensure a sustainable growth trajectory.

These policy measures are articulated through the concept of 'ecological civilization' embedded in China's 13th Five-Year Plan (2016-2020). This addresses many of these challenges and highlights the development of services and measures to address environmental and social imbalances. It includes specific targets to reduce over-exploitation of water resources and pollution, increase energy efficiency, improve access to education and healthcare, and expand social protection.

The China Water Governance Study represents a major contribution to the proposed policy and institutional reforms in China's water sector and builds on a long history of collaboration between the World Bank and the Development Research Center of the State Council. This collaboration leverages the Chinese experience to combine with the Bank's global knowledge in providing a framework for enhancing water governance in support of sustainable social and economic development.

The Chinese experience in managing the development of water resources also has important lessons for other transitioning economies and informing efforts to address global risks to economic progress, poverty eradication, peace and security, and sustainable development.

Wang Yiming
Vice Minister Development Research Center of the State Council of the People's Republic of China

China is a country with serious water scarcity and frequent water related disasters, such as floods and droughts. Historically, each of the Chinese dynasties has paid significant attention to water management, culminating in a wealth of knowledge and experience which continues to make important contributions to national development and the global agenda. In a sense, Chinese history is also a history of water governance.

The China Water Governance Study jointly carried out by the Development Research Center of the State Council and the World Bank, which reflects important contributions from various ministries from across the Chinese government and the joint efforts of both Chinese and international experts, represents another important contribution to the continued development of institutions for economic and social development in China.

China continues to attach importance to the development of an ecological civilization and green development as it embarks upon a new era of economic development. This is centered on sustainable resource management, environmental protection and ecological conservation with sustainable water management central to the realization of China's sustainable economic prosperity. A clear direction for the governance of water in China is found in the 16 words of wisdom issued by President Xi Jinping, specifically in relation to the "priority on water-saving, spatial equilibrium, systematic governance, and the combined efforts of government and the market".

China's water governance faces a rapidly changing context with increasingly serious challenges, with more complicated problems and more ambitious goals. In this context, the joint study provides practical advice to improve water management in the new era of an ecological civilization. China's experience and strategy for the governance of water also has important lessons for other countries and will make an important contribution to enhance global water governance through Chinese wisdom.

Continuous innovation and adaptation of the governance mechanisms, through implementation of institutional measures and incentives are helping to better allocate, regulate, and conserve water resources. These are also providing exciting opportunities to drive innovative technologies for improving productivity, as well as conserving and protecting environmental and ecological functions.

The China Water Governance Study provides an important analysis and informs the institutional reforms intended to enhance the process of continuous improvement in the management of water resources in China. After reading through all the reports, it is clear that it provides a comprehensive review of key challenges and a systematic evaluation of the current context of water management. In doing so, the study makes an important contribution to enhancing the framework for China's water management and provides a practical set of tools and policy guidance. We believe these recommendations will be substantially helpful to further enhance the level and capacity of China's water governance.

Together, these measures make up a new water governance strategy that will support China's efforts to move toward a higher quality, more environmentally conscious economic structure. However, water governance is a continuous process, as is the process of research and refinement. The epistemology and methodology of water governance in China needs to be continuously revisited. Let us make a joint effort and take the opportunity of an ecological civilization and green development to fully absorb and integrate the experience of water governance in China and internationally. Through progressive advancement and enhancement, China will continue to play an important and effective role in shaping the global water governance system.

Acknowledgments

This report represents the culmination of joint research conducted by the Development Research Center of the State Council of the People's Republic of China (DRC) and the World Bank that builds on a long history of cooperation and collaboration. The objective was to provide Chinese policy makers with detailed institutional and policy options to support water security and sustained economic development. The report fills a critical gap highlighted in the World Bank 2013 China Country Water Resources Assistance Strategy by proposing legal, technical, and institutional changes to the current framework for water resource management. A new approach to the governance of water is recommended that is aligned with the goals of an ecological civilization and its aims to balance economic growth against increasing water demand under conditions of water scarcity. By closely examining key water management issues in the context of China's rapid development, the report also aims to provide lessons relevant to other countries facing similar water-related challenges.

The team benefited from comments and discussions with colleagues within the World Bank, officials from the Government of China, and representatives from non-governmental organizations and universities working on water resource issues. The research was carried out under the leadership of Victoria Kwakwa (Vice President for East Asia and the Pacific), Guangzhe Chen (Senior Director of the Water Global Practice), and Bert Hofman (Country Director for China) from the World Bank and Vice Minister Wang Yiming from the DRC along with his ministerial colleagues from the Government of the Peoples Republic of China. Guidance was provided during implementation by a Steering Committee comprising Wang Yiming (DRC), Guangzhe Chen (World Bank), Bert Hofman (World Bank), Guan Fengjun (Ministry of Land and Resources), Gu Mengzuo (Ministry of Water Resources), Liu Weihua (Ministry of Finance), Zhang Linwei (Ministry of Housing and Urban-Rural Development), Gao Shiji (DRC), and Wang Jiuchen (Ministry of Agriculture). In addition, the development of policy recommendations was overseen by an Advisory Committee comprising Wang Hao (Institute of Water Resources and Hydropower Research), Jane Doolan (University of Canberra), Fu Bojie (Chinese Academy of Sciences), Claudia Sadoff (World Bank), Xia Qing (Chinese Research Academy of Environmental Sciences), and Patricia Mulroy (University of Nevada, Las Vegas). The team also discussed with and obtained valuable advice from other experts within the World Bank, officials from the Government of the Peoples Republic of China, along with universities and non-government organizations working on water resources related research in China.

The water governance work was initiated by Ousmane Dione (then Practice Manager and now Country Director for Vietnam) and completed under the guidance of Sudipto Sarkar (Practice Manager, East Asia and the Pacific Region, Water Global Practice); and Gao Shiji (Director of the Institute for Environment and Natural Resources of the DRC). The Thematic Reports were prepared by a joint team from the World Bank led by Winston Yu (Senior Water Resource Specialist), Liping Jiang (Senior Water Resource Specialist) and Marcus Wishart (Lead Water Resource Specialist) and including Scott Moore, Qi Tian, Xiawei Liao; Regina Rossmann, Si Gou, Dan Xie, Liteng Dong, and Anqi Li (World Bank); and the Government of the Peoples Republic of China led by Gu Shuzhong (Task Team Leader from the DRC of the State Council), and including Li Weiming, Jiwen Chang, and Zhou Hongchun (DRC of the State Council); Li Jing, Zhong Yuxiu, and Wang Yining (DRC of the Ministry of Water Resources); Jia Shaofeng (Chinese Academy of Sciences); and Wang Jianhua, Ding Liuqian, and Zhao Yong (Institute of Water Resources and Hydropower Research of the Ministry of Water Resources). The team also acknowledges the strategic guidance and comments provided by Bert Hofman, Jennifer Sara, Bekele Debele, Harold Bedoya, Richard Damania, Greg Browder, Ximing Zhang, Abedalrazq Khalil, and Irene Bescos. Their contributions have helped to enhance the quality.

Each of the chapters presented here is based on a series of 15 Thematic Reports prepared by the following teams. These provided the basis for the joint identification of key priority reforms by the World Bank and the DRC that were bought together and published in an accompanying Synthesis Report (https://openknowledge.worldbank.org/handle/10986/31928).

Topic 1: Overview of Water Governance in China was prepared by the Institute for Environment and Natural Resources of the Development Research Center of the State Council under the leadership of Li Weiming and Gu Shuzhong;

Topic 2: Evaluation of China's Water Security Status and Issues was prepared by the Geographic Science and Resources Research Institute under the Chinese Academy of Science and leadership of Jia Shaofeng;

Topic 3: Advancing Water Quality Markets in China was prepared for the World Bank by the Willamette Partnership and the World Resources Institute under the leadership of Bobby Cochran;

Topic 4: Macro-Economic Impacts of Water Scarcity and Redlines in China: Results from an Integrated Regional CGE Water Model was prepared for the World Bank by the International Food Policy Research Institute in Beijing under the leadership of Kevin Chen;

Topic 5: Re-Examining the Three Red Lines Policy was prepared by the Institute of Water and Hydropower Research under the Ministry of Water Resources and leadership of Wang Jianhua;

Topic 6: Water Rights Verifications and Transactions was prepared by the Development Research Center under Ministry of Water Resources and leadership of Li Jing;

Topic 7: Best Practices in Cost-Benefit Analysis for Water Investments was prepared for the World Bank by Mark Radin at the University of North Carolina Chapel Hill;

Topic 8: Water Prices, Taxes, and Fees was prepared by the Development Research Center of the Ministry of Water Resources and the leadership of Zhong Yuxiu;

Topic 9: Flood Risk Management and Protection was prepared by the Institute of Water Resources and Hydropower Research under the Ministry of Water Resources and leadership of Ding Liuqian;

Topic 10: Ecology Compensation and Governance was prepared by the Institute of Water Resources and Hydropower Research under the Ministry of Water Resources and leadership of Zhao Yong;

Topic 11: Legal Reform for Water Governance was prepared by the Development Research Center of the State Council and leadership of Chang Jiwen;

Topic 12: China's Water Management Administrative System and Its Reform was prepared by the Development Research Center of the State Council under the leadership of Gao Shiji and Chen Jianpeng;

Topic 13: Technical Innovation and Development of an Information Platform in China was prepared by the Development Research Center of the State Council under the leadership of Zhou Hongchun;

Topic 14: Public Private Partnerships and Water Governance in China was prepared by the Development Research Center of the Ministry of Water Resources under the leadership of Wang Yining;

Topic 15: Summary and Overall Design of China's Water Governance System was prepared by the Development Research Center of the State Council under the leadership of Gu Shuzhong.

These thematic study team reports and recommendations were reviewed by both the Advisory Committee and the Steering Committee. These discussions emphasized key issues for water governance in China, including the need for a stronger legislative foundation for water governance; enhanced basin-scale governance institutions; harmonization of existing policy tools, such as water permits and water rights; better information and data-sharing; and the need to promote ecosystem resilience. Based on these consultations and discussions, a final set of 15 key recommendations have been put forward. These recommendations form the core of the accompanying Synthesis Report. Each priority area is the subject of a separate chapter focusing on the rationale for each of the policy recommendations, drawing on research completed by each study team. In addition, a series of policy notes were prepared by the Development Research Center of the State Council for the Chinese government. These policy notes were submitted by Development Research Center to senior policy makers at the National People's Congress held in March 2018. Several of the key study results from these policy notes (including improvement of the strictest water resources management system, promotion of water right reforms, and establishment of a flood insurance system) were also submitted to senior policy makers of the State Council by Dr. Gu Shuzhong, as a member of the National Committee of Chinese People's Political Consultative Conference (CPPCC).

CHAPTER 1

Overview, Tasks, and Goals of Water Governance in China

Background

The context and institutional environment for water governance can vary substantially. Therefore, water governance may have different meanings and foci in different times and places. Many definitions and studies related to water governance exist both internationally and within China. It is necessary to define the content of water governance scientifically, based on a systematic review of the literature, to provide an analytical framework and decision support for research and implementation of water governance both within China and globally. China's water governance has a long history. Water governance is closely related to national and regional security, governments' ruling concepts, and public concerns. Its effects should be systematically reviewed and its lessons should be summarized as a reference for water governance research and practice.

China is entering a new era. The context for water governance in China is facing substantial and deep changes, and opportunities and challenges exist in parallel. Therefore, objective studies and systematic understandings are needed. To ensure national water security, accelerate building the water governance system, and modernize water governance capacity, it is important to put forward the next-step goals and tasks of China's water governance, adapting to the new contexts and addressing key problems.

Research Objectives

The first research objective is to review and summarize historical lessons of the role of water governance in China's national security, as well as its effects on the government's ruling concepts and public awareness, by scientifically defining its core content. Next, the research should objectively study and systematically understand China's water governance's status, achievements, and problems, as well as the new contexts and new requirements during this transformation period. The third research objective is to put forward the main next-step tasks and goals for China's water governance.

Context and Institutional Environment

Water governance is defined as all water-related stakeholders taking actions, including legal, economic, administrative, and technical means, dialogues, and

This chapter is based on a summary of the Thematic Report prepared by the Institute for Environment and Natural Resources of the Development Research Center of the State Council under the leadership of Li Weiming and Gu Shuzhong.

consultations, to systematically plan water exploitation, utilization, allocation, conservation, and protection in various water-related subsystems, such as resources, environment, ecology, engineering projects, and water supplies, according to natural characteristics of water resources and hydrological cycles, as well as formal institutions (for example, laws, regulations, policies, rules, and standards) and informal institutions (for example, traditions and customs). Besides, the government, diverse actors such as enterprises, organizations, and the public are involved. In addition, water governance has a broader scope than traditional water management. Water governance is defined by the public sphere instead of only government authority. Therefore, legal, economic, administrative, and technical means, dialogues, and consultations should be combined systematically to deal with complicated water issues.

Self-management is particularly encouraged. Besides mandatory national laws, regulations, and standards, the source of power for the institutional foundation of water governance includes nonmandatory contracts, consultation, and cooperation. Power should be realized both horizontally and vertically, and should be bidirectional instead of only top-down, through consultation and cooperation. Water resources, environment, ecology, engineering, supply, and other affairs should be governed holistically. (This study is not concerned with water diplomacy governance because of its sensitivity.)

Historical Lessons of China's Water Governance

Water governance has been an important public issue throughout the history of China. From the perspective of government ruling, eliminating water hazards and developing water conservancy projects have been major issues in China's national administration. Failure or negligence of water governance has resulted in decline and fall of political powers and consequent regime changes. To some extent, Chinese history is a history of water governance. From the perspective of national security, water governance has laid the foundation to improve China's water security and hence underpins ecological, economic, social, and even national security.

There are ten lessons from the history of water governance in China:

(1) Water governance is indispensable to governing a nation. Throughout Chinese history, all successful rulers have prioritized water governance.

(2) Water governance content depends on time and location. Water hazards were often natural events in ancient times, and water governance has focused on responding to flood and drought events, agricultural irrigation, and canal transport. In contrast, contemporary water issues are compounded by both natural and human factors that require innovative approaches to water governance.

(3) Water governance requires strong organizational arrangements. From Water Supervisor and Water Governor in the Qin and Han Dynasties to Water Authority and Water Governor in the West Jin Dynasty, Ministry of Engineering and Ministry of Water Conservancy in the Sui Dynasty, Yellow River Supervisor in the Song Dynasty, General Governor of Rivers in the Ming Dynasty, and General Supervisor of Rivers in the Qing Dynasty, capability and performance on water governance has been an important indicator of an official's performance.

(4) Water governance is the responsibility of the public. Water governance has required joint efforts and cooperation from all societal actors.

(5) Water governance requires clear regulations. Examples include *Water Conservancy Management Regulation* of the Tang Dynasty, *Irrigation and Water Conservancy Law* by Wang Anshi, *Decree on River Water Hazard Prevention* of the Jin Dynasty, and *Water Conservancy Law* during the People's Republic of China, as well as the annual repair and maintenance system, water conservancy official system, budget management system for flood prevention, flood and other disaster reporting systems, and disaster relief and grain storage system.

(6) Water governance requires ensured investment, and its engineering projects should be advanced reasonably. Water governance has been an investment and has required labor-intensive, systematic work that has long durations and involves various social and economic aspects. Therefore, the development scale and rate should be advanced reasonably based on demand forecasting.

(7) Water governance must be facilitated scientifically, with quality as the first priority. Some ancient water engineering projects have functioned into modern times because of their strict quality-assurance mechanisms. For example, the Ming Dynasty enforced a mandatory "quality responsible mechanism"; if accidents happened, responsible people were held accountable, sometimes even facing the death penalty.

(8) Water governance needs to recruit, use, and cultivate talents. According to records, water conservancy talents in China historically have been trusted, respected, recommended, and widely acknowledged. Talents are indispensable to eliminating water hazards from rivers and especially to the development of large- or medium scale water conservancy projects.

(9) Water governance needs to address both symptoms and root causes of problems. Water governance has shifted from addressing the symptoms to addressing the roots, manifested by the transformations along the chain of avoid, block, dredge, guide, sand control to comprehensive water governance.

(10) Water governance requires comprehensive planning and coordination. For example, flood prevention projects not only have to address flood prevention in a river basin but also have to pay attention to water drainage issues in midstream and downstream. Similarly, water conservancy projects need to pay close attention to water storage and sand blocking, siltation mitigation, comprehensive utilization of electricity, irrigation, transport functions, and so forth.

Successes and Problems

Achievements of China's Water Governance

Water security has been regarded as national security. The government has established "Priority on water-saving, spatial equilibrium, systematic governance, and the combined efforts of government and the market" as water governance guidelines in the new era. The government has issued *Opinions of the State Council on Implementing the Strictest Water Resources Management System* (also known as the Three Red Lines policy) and *Action Plan of Water Pollution Prevention and Treatment*.

The most stringent water resource management mechanism has been preliminarily established. The indicators of the three red lines on capping total water use, improving water efficiency, and controlling water pollution have been established at provincial, city, and county levels. Annual evaluations have been conducted. Water use per 10,000 Chinese yuan of industrial value added and gross domestic product (GDP) decreased from 90 and 150 cubic meters, respectively, at the end of the 11th five-year period (2006–10) to 61 and 105 cubic meters in 2015 (at the 2010 price), which further reduced by 7.20 and 7.60 percent by 2016. Farmland irrigation efficiency has increased from 0.50 at the end of the 11th five-year period to 0.54 in 2016.

Progress has been made in terms of water pollution prevention and control. Command and control instruments include discharge standards, total discharge cap, pollution permits, and limited time for treatment. Market-based instruments have also been explored and improved. Technologies and policies have been gradually improved. The accumulative amount of the main water pollutants has stabilized.

Water ecological protection has been strengthened. *Water Function Zoning of Major Rivers and Lakes in China (2011–2030)* has been approved. The pollutant-carrying capacity of major water functional zones has been studied and verified. Safety compliance projects for 175 important drinking water sources have been started. Groundwater overexploitation areas have been identified, and groundwater exploitation restriction plans have been formulated. Ecological restoration and ecological water diversion have been advanced.

Significant effects have been seen in flood prevention and drought control. Flood prevention structure has been established in seven major river basins comprising blocking, drainage, detention, and diversion projects, such as reservoirs, dams, and flood storage areas. Compared with the 11th five-year period, casualty and missing victims, disaster-affected populations, and disaster-stricken areas because of flooding events have decreased by 64, 38, and 28 percent, respectively. The number of casualties and missing individuals has dropped to a record low since 1949.

Construction of water engineering projects has been accelerated. Basin-level and regional water resource distributions have been improved. As mentioned earlier, flood prevention structure in major rivers and lakes has also been improved. Wastewater treatment facilities have been built in large and medium cities. Rural drinking water safety projects have been completed. For irrigation, 50000 square kilometers of effective irrigation area has been newly added from 2011 to 2015, and 80000 square kilometers of high-efficiency water-saving irrigation area has been developed.

Significant progress has been made in terms of water supply capacity. National total capacity was 618 billion cubic meters in 2015, increased by almost five times from when the People's Republic of China was established. Urban water supply coverage has exceeded 97 percent. Water demands for living have been basically met. Rural water supply has reached 76 percent, and the population with a centralized water supply has exceeded 82 percent. In addition, 304 million rural residents and 41.52 million students and faculties in rural schools have access to safe drinking water. Thus, drinking water safety in rural areas has almost been reached.

Positive results have been achieved in key reform areas. Social capitals are encouraged and guided to engage in the construction and operation of important water conservancy projects, water pollution prevention and control, and water ecological restoration projects. Comprehensive reform pilot programs have been facilitated on rural water pricing, water rights registration and trading, and trading of pollution permits. The river chief system has been enhanced. Permission procedures for key water projects have been streamlined. Institutional reform of the management of water engineering projects has been initiated. Project tendering and bidding have entered the market, and a credit system for market players has been launched.

Rule by law has been strengthened in water governance. The *Environmental Protection Law*, *Water Pollution Prevention and Control Law*, and *Water and Soil Conservation Law* have been amended and officially come into effect. *Taihu Lake Basin Management Regulations* and *South-North Water Diversion Project Water Supply and Use Management Regulations* have been promulgated. Proactive steps have been taken in comprehensive law enforcement concerning river-lake boundary determination and delimitation of water conservancy projects. Supervision and law enforcement have also been strengthened for sand excavation along watercourses and administration of rivers and lakes.

Existing Problems Facing China's Water Governance

Acute water supply-demand conflicts exist. China has low water resources per capita, amounting to about 28 percent of the world average. Water efficiency is low; thus, a large amount of water is wasted. Water use per unit of industrial value added is two to three times global advanced levels. Effective irrigation efficiency is 0.52, which is far behind the world advanced levels of 0.70 to 0.80. Some regions are suffering from overexploitation of water resources that has exceeded their reproducible ability. Meanwhile, rapid urbanization and industrialization have exacerbated water supply-demand conflicts, and this trend is expected to continue.

Water environment needs improvement. According to data from the Ministry of Environment and Ecology, China has heavy pollutant loads from industrial, agricultural, and domestic wastewater discharges. In 2015, the total chemical oxygen demand (COD) discharge amounted to 22.24 million tons and ammonia nitrogen discharge was 2.30 million tons, far exceeding the environmental carrying capacity. Among all national surface water controlled sections, nearly one-tenth (8.8 percent) has lost their water utilization functions (poorer than class V); 22.9 percent of key lakes (reservoirs) are in a state of eutrophication. Water in numerous rivers and channels flowing through cities and towns is black and odorous. Pollution of drinking water occurs at times. Among 5,118 groundwater quality monitoring points throughout the country, the "poor" and "very poor" ratings add up to 61.3 percent. Among nine key gulfs in China, water quality of six is rated "poor" or "very poor." In the future, both water use and wastewater discharge are expected to keep increasing, while agricultural and unconventional pollutants are expected to increase rapidly. Water pollution is further shifting from single pollutant to compounded pollution, with more complicated pollutants and increased difficulty for prevention and control.

Water ecological damage is severe. Natural ecological spaces, such as wetlands, coastal zones, lakesides, and riversides, are continuously decreasing, which has resulted in reduced conservation capacity of water sources. According to the *State Council Announcement on Issuing Water Pollution Prevention and Control Action Plan* (Decree No. 17, 2015), the wetland area in the Three River Plain has decreased from 50,000 square kilometers in 1949 to 9,100 square kilometers. The main wetland area in the Haihe River Basin has decreased by 83 percent. The number of lakes directly connected to the Yangtze River along its middle and lower reaches has reduced from more than 100 to only 2, Dongting Lake and Boyang Lake, which are also shrinking. Both the size of coastal wetland and the biodiversity of offshore waters have significantly decreased, with severe degradation of fishing resources. The retention rate of the natural coastline has fallen under 35 percent. Moreover, the area of soil erosion has reached 2.95 million square kilometers, accounting for approximately 30 percent of China's territory. The groundwater overexploitation zone has reached 230,000 square kilometers, causing severe ecological problems, including land subsidence and seawater invasion.

Water project construction and management are lagging. Problems such as flood hazards, wastewater treatment, and lack of engineering projects remain prevalent. Operation and management of water projects are unsatisfactory, with potential negative effects on the project safety. Particularly pronounced challenges include management of medium and small rivers, construction of farmland irrigation projects, insufficient investment in rural drinking water safety projects, inadequate wastewater treatment capacity in urban and rural regions, and high risk rate of small reservoirs, which require increased efforts in addressing these specific issues. Improvement is needed in ecological and geological safety of major water projects. A safety warning system and an accountability system are to be established and strengthened.

Secure water supply capacity is insufficient in both urban and rural regions. First, compared with rapid industrialization and urbanization, centralized water supply capacity is generally lagging behind, with the conflict between water supply and demand being particularly significant in some regions. Second, some small and medium-sized cities do not yet have a fixed, secure ,and reliable water source, and some cities only have one water source, which is extremely vulnerable to potential pollution or damage. Third, the water supply system is overloaded in some cities, which is an especially prevalent and highly challenging issue in megacities. Fourth, because of the relatively low level of water quality, water from the supply system is usually undrinkable unless boiled or purified. Fifth, abnormal events occur frequently in centralized water supply systems, with cases such as 'meat-broth' or 'oil-pollution' incidents happening occasionally.

The water governance system is poorly structured. First, the legal base needs to be strengthened. The legal system is flawed, and practicality is weak. Legal participation is weak, and its function is limited. The environmental litigation system needs to be improved. Law enforcement and capacity are insufficient, and the function of basin organizations needs to be enhanced. A national water inspection system has not yet been established. Second, insufficiency in systematic coordination of water governance has a negative impact on its effectiveness. The transmission processes and spatiotemporal distributions of water and materials are fragmented; therefore, process-based organizational and management arrangements are insufficient to maximize the effectiveness of water governance. Conflicts are likely, because development and utilization functions and protection and supervision functions belong to the same governmental department. Overlapping responsibilities among departments on the same level and poor institutional coordination fail to deliver synergies. Third, the market mechanism should be better used. Water price formation is not reasonable, the water resource tax is relatively low, and the wastewater treatment fee and discharge fee are imperfect. Trading systems for water rights and pollution rights are still being explored. The financing mechanism in the water sector needs to be improved, and a national flood insurance mechanism has yet to be established. Fourth, information-sharing and public participation mechanisms are not established. Technology support should also be enhanced.

New Contexts and Requirements

Water governance in China is facing various new contexts that present not only opportunities but also challenges. To develop new drivers and realize high-quality development, China needs to use the foundation laid by water conservancy projects and the constraining power of water management red lines to develop new growth points, growth poles, and growth belts and to promote national strategies or initiatives, such as new urbanization, one belt and one road, Beijing-Tianjin-Hebei Integration, and the Yangtze River Economic Belt. The supporting capacity of water resources needs to be enhanced, and water allocation and the production-domestic-ecology configuration should be improved. The carrying capacities of water resources, environment, and ecology need to be enhanced in important economic regions and urban agglomerations.

To build a well-off, balanced society, it is necessary to improve the weakest water infrastructures as soon as possible and to move faster toward solutions in terms of water conservancy and water pollution control, which are closely related to people's livelihood. Balanced urban and rural water infrastructures should be facilitated, and equal access to water-related basic public services should be provided. To build an ecological civilization and promote green growth, and to build a beautiful China, it is important to change the methods of governing, developing, and managing water. Holistic governance should be facilitated from 'Mountain to Ocean'. Water resources, environment, ecology, engineering, and supply should be governed in a holistic way. Water resources and ecological environment should be protected with the strictest legal systems. Socioeconomic development should be coordinated with water resource environment and ecological carrying capacity. A responsible nation reputation needs to be established on tackling climate change and protecting biodiversity. National and local climate change mitigation and biodiversity protection could make significant contributions to regional and global climate change mitigation and biodiversity protection. To implement the Internet Plus strategy, it is necessary to construct an information network of water-related monitoring, supervision, and governance and to enhance the capability of water governance.

Conclusions and Suggestions

Tasks in China's Water Governance

The first task for comprehensive water governance is to promulgate or amend water-related laws and regulations and enhance the legal base of water governance. Tasks include amending the water law, enhancing the implementation of the *Water Pollution Prevention and Control Law* and codifying the Public Private Partnership (PPP).

The second task is to enhance the role and effect of basin water governance, to improve the role and responsibility of the national and basin-level water organizations to increase water governance effectiveness according to the principles of nature, and to strengthen their role in ecological protection.

A national water governance coordination mechanism should be established. A clear coordination mechanism should also be established between river or lake chief system and basin organizations. Policy coordination should be clarified among organizations, jurisdictions, and departments.

The third task is to improve economic instruments for water governance and to enhance the application of the market mechanism so that the Three Red Lines policy can be effective. The water withdrawal permitting system and wastewater discharge permitting system should be linked.

The fourth task is to improve climate and environment change adaptability. Green infrastructure should be increasingly used to manage flooding events and increase flood prevention capacity. The ecological flow red line should be established. Nonpoint source pollution control policies should be improved. A pilot program for trading water pollution discharge permits and other financial mechanisms can be used to battle nonpoint source pollution.

The fifth task is to increase information sharing and public engagement. The legal framework for water-related data collection and sharing should be improved. A national water information-sharing platform should be established. Public awareness and engagement should be increased.

The sixth task for comprehensive water governance is to accelerate the establishment of other mechanisms. Priorities include mechanisms of scientific evaluation, technology support, engineering guarantee, experiment and demonstration, evaluation and accountability, and international coordination for water governance.

Water Resource Governance

The first task for water resource governance is to improve the top-level design to advance the construction of a water-saving society. It is crucial to enhance mandatory restrictions on water resources carrying capacity with related indicators and to establish related monitoring mechanisms for warnings and accountability.

The second task is to implement the double-control action plan and constraints placed by water resources. The Plan for the Construction of a Water-Saving Society will be effectively implemented to comprehensively improve the system of water conservation regulations and to push forward the construction of a water-saving society in an integrated and region-specific way, with stronger supervision of water conservation.

The third task is to highlight key areas in which enhanced measures should be taken in water conservation by agriculture, industry, and urban regions.

The fourth task is to optimize water resource allocation and promote reasonable utilization of water resources. It is necessary to enhance river water allocation and distribution, to control the groundwater development and exploitation, and to use unconventional water resources.

The fifth task is to carry out reform in the water sector on a deeper level, allowing the market mechanism to play a role. The key is to deepen the institutional and mechanism reforms in water resource management; to enhance the control of water resource use, starting from clarifying the initial water rights; and to advance water rights registration and trading with pilot projects as breakthrough points.

The sixth task for water resource governance is to enhance capacity building to consolidate the foundation of water resource management, with stronger monitoring capacity, collaboration capacity, and supervision capacity as key priorities.

Water Environment Governance

The first task for water environment governance is to undertake comprehensive control of pollutant discharge. This includes focusing on the prevention and control of industrial pollution, controlling pollutions from agriculture and rural regions, and strengthening pollution control by vessels at the port.

Next, effective measures of water environment management are needed. These include focusing on environment quality target management, continuing with control of total pollutant discharge, implementing stricter measures in environmental risk control, and applying the pollutant discharge permit system on a broader scale.

The third task is safeguarding the security of the water environment. This includes highlighting overall prevention and control of groundwater pollution, pushing comprehensive pollution control in key drainage basins to a deeper level, strengthening environmental protection in river estuaries and offshore areas, strictly controlling environmental hormone contamination, and making extra efforts in treating black and odorous waters in urban regions.

Strengthening support by science and technology is also needed. This includes promoting applicable technologies through demonstration projects, tackling key challenges in research and development of advanced technologies, developing environmental protection industries, and accelerating the growth of environmental protection services.

The fourth task is enabling the market mechanism to play a role. This includes rationalizing pricing and taxation policies, facilitating funding from diversified sources, and creating incentive mechanisms.

Finally stricter environment-related law enforcement and supervision are crucial to water environment governance. Emphasis should be placed on improving the legal and standard system, with more decisive actions in law enforcement and increased capacity of regulation.

Water Ecology Governance

The first task of water ecology governance is to establish an evaluation and monitoring mechanism for water ecology, to determine and maintain the ecological flow of rivers and lakes in a scientific way, and to explore and implement the red line for basin ecological flow. The second task is to strengthen water ecological restoration and governance of key rivers and lakes. The third task is to make more efforts in eco-construction for soil retention. The fourth task is to enhance protection of groundwater and comprehensive governance of overexploited zones. The fifth task of water ecology governance is to secure water ecological safety by all possible means. Priorities include determination of the water ecological red line, management of water functional zones, protection of waters of good quality, preservation of water and wetland ecosystems, promotion of ecofriendly and healthy animal husbandry, and in-depth development of water ecological civilization construction.

Water Engineering Governance

The first water engineering governance task is to improve the comprehensive river flood prevention and disaster reduction system, to strengthen key engineering construction projects on rivers, and to address the poor parts of flood prevention. The second task is to implement water connection projects of rivers, lakes, and reservoirs to increase the environmental supporting capacity of water resources. The third task is to complete major water engineering projects to enhance the water infrastructure system, focusing on large-scale farmland irrigation projects. Priorities include accelerating the construction of key water sources and basin restoration and management, wastewater treatment, water sources for draught resistance, and so on, while implementing a number of key water diversion projects. The fourth task for water engineering governance is to carry out reforms in construction and management of water engineering projects to improve management proficiency. Priorities include reforming the construction management system for water engineering projects, establishing a healthier and diversified investment mechanism, facilitating innovations in management and operation of water engineering projects, and optimizing the scheduling and arrangement of such projects.

Centralized Water Supply Governance

The first task for centralized water supply governance is to improve urban water supply and flood prevention capacity, with the following priorities: optimization of the urban water supply structure, construction of emergency water supplies and backup water sources, and improvement of water drainage and flood prevention capacity of cities. The second task is to consolidate and improve drinking water safety in rural regions, with a centralized water supply rate, tap water coverage, a water supply guarantee, and water quality compliance improved through renovation, supporting facilities, network construction, and upgrading. Source protection and supervision of drinking water are also indispensable. The third centralized governance task is to protect drinking water sources with life-cycle supervision from water source to tap to constantly improve the level of the drinking water safety guarantee.

Major Goals of China's Water Governance

The main goal of water governance in China is to build a modernized water governance system by 2035 that is among world's top systems, has Chinese characteristics, and is suitable for China's market-based economic system and the modernization of China's national governance capacity and systems. The system should also meet the demand of ecological civilization through reforms and development. Within this governance system, the concept of water governance will be a well-understood and relevant issue for all citizens. The system includes (1) diversified, network-connected, and clearly defined governance subjects; (2) diverse, continuous, and systematic governance means; (3) legalization, canonicalization, and standardization achieved as governance methods; (4) strengthened accountability and effectiveness and enhanced efficiency. Eventually, this water governance system will result in significant improvement in the country's guarantee capacity of water security.

Rationalized allocation and efficient use of water resources should be realized. The most stringent water management mechanism should be implemented. A city's population, urbanization, and industrialization should be determined according to its water endowments. A water-saving society should be constructed with improved water-use efficiency and effectiveness. Global advanced levels in terms of water conservation in key areas should be achieved. The arrangement and allocation of water resources and the structure should be optimized. Water resource management capacity should be increased substantially.

Water environment quality and risk should be monitored and controlled effectively. Law enforcement concerning water environment should be stepped up, and a water environment risk control mechanism should be established and improved. All wastewater in urban regions should be properly treated, resulting in a significant drop in the concentration of major pollutants and overall improvement in water environment quality throughout the country. Groundwater pollution should be curbed and tackled effectively, and the environment quality of the offshore zone should remain stable with positive trends. Economic losses because of water environment should be effectively controlled.

Water ecological conservation and restoration should be strengthened comprehensively. Water quantity should be guaranteed for the ecoenvironment of rivers and lakes to guarantee no reductions of river, lake, and wetland areas. Water quality should basically comply with standards in water functional zones, and visible improvement should be seen in the water ecoenvironment, with substantial improvement in the stability and ecological services of the water ecosystem. The retention rate of natural coastline should remain stable, and soil erosion should be curbed, with a well-structured comprehensive governance system for water and soil conservation in place. Overexploitation of groundwater should be strictly controlled, and severely overexploited zones should be eliminated.

Major improvement should be seen in water supply security in both urban and rural regions. Water quality of water supply sources in urban regions should fully comply with the standards. Water supply structure should be optimized, with diversified emergency and backup water sources and significantly strengthened water drainage and flood prevention capacity. Centralized water supply rate, tap water coverage, water quality compliance, and water supply guarantee should see substantial improvement in rural regions, with continuous progress being made in improving the drinking water safety guarantee level.

Water-related engineering support and flood prevention, drought resistance, and the disaster reduction system should be improved. Several key water projects of fundamental significance and long-term impact, aiming to bring development and well-being for the public, should be built, including large-scale farmland irrigation projects, key water source projects, water environment treatment and water ecological restoration projects, major water diversion projects, water source construction projects for drought resistance, and connection projects of rivers, lakes, and reservoirs. The dispatching and command system for flood prevention and drought resistance should be enhanced. Key flood prevention zones on major rivers should comply with flood prevention standards stipulated in river basin planning, while flood prevention and drainage facilities in urban regions should be substantially improved. Economic losses from floods and droughts throughout the country should be effectively controlled.

A comprehensive water governance system should be established and gradually improved. Water governance and management by the law should be strengthened broadly, with the establishment of an environmental carrying capacity assessment and a water resource warning mechanism. The effects of water resources, environment, and ecology on strategic, planning, and project levels should be assessed and verified. Planning should become more science based and compliant with its leading role as highlighted. Markets of water rights and pollutant discharge permits and the corresponding pricing mechanism should be improved gradually. Significant progress should be made in ecological compensation and ecological civilization construction of water projects. The institutional system and mechanism should be more logically organized for science-based construction and healthy operation of water engineering projects. The steady growth mechanism of water governance investment should become more soundly structured, with substantial progress achieved in technological innovation capacity. The principle of equal accountability between the party and the government, as well as government assessment and accountability, should be further implemented. The social atmosphere of public participation and social supervision of water governance should be preliminarily established, and the pace of international communication and cooperation should be accelerated.

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CHAPTER 2

China's Water Security and Existing Problems

Background

The issue of water security has a long history. Modern water security raises concerns mainly because of emerging water supply problems and threats. With the rapid growth of social economies, human overexploitation of resources and the environment has aggravated water-related issues such as water scarcity, water pollution, water ecological degradation, and flooding risks.

Water crises have risen to the top of the agenda for science communities, policy makers, and enterprises. It has become a key research area of regional socioeconomic development and ecological environmental protection. It also generates long-term effects on national security and geopolitics and thus receives growing attention from governmental leaders and nongovernmental organizations.

The outlook on water security in China is not optimistic, because water security faces multiple challenges simultaneously, for example, water scarcity, water pollution, droughts, and floods. Some regional water scarcity and severe water pollution threaten China's crop production and ecological environment and place unprecedented pressure on China's sustainable socioeconomic development. Water security is an important part of national security, and ensuring water security is an important objective of improved water governance.

As a cutting-edge research topic in water sciences, water security encompasses various aspects, such as water supply and demand, water ecological environment, and water hazards prevention and control. It is multi- and interdisciplinary and is related to the central issues in water sciences. Objectively and scientifically evaluating China's water security is an effective way to understand the status of China's water issues.

Research Objectives

This study aims to accurately define water security and its contents, to identify evaluation dimensions based on China's development context, and to construct a scientific and reasonable index framework to evaluate China's water security. In doing so, this study aims to better understand China's water security, diagnose existing problems, and provide decision support for ensuring China's water security and improving China's water governance.

This chapter is based on a summary of the Thematic Report prepared by Shaofeng Jia and Jieming Deng of the Geographic Science and Resources Research Institute under the Chinese Academy of Science.

Evaluation Methods and Analysis

China Water Security Evaluation Framework and Indicator Weight Determinations

Water security contains important connotations of the following: (1) sufficient water quantity and quality to meet reasonable human and ecological demands, (2) sustainability of water supply and water-related ecological system, (3) affordability of water prices and water supply costs, and (4) reliability of flood control and safety. This study defines water security as the ability to provide water of sufficient quantity and quality at an affordable cost and in a sustainable manner and to ensure the security of flood prevention and control. This study uses the analytic hierarchy process (AHP), an effective multitarget decision method combining qualitative analysis with quantitative analysis, to construct a framework encompassing the five following aspects: (1) water quantity, to measure whether the quantity of water resources can meet the needs of human activities such as agriculture, industry, and domestic uses; (2) water quality, to measure whether water quality can meet the requirements of domestic, production, and ecological systems; (3) sustainability, to measure the ability of water resources to ensure their own sustainability, the sustainability of exploitation, and the sustainability of ecological functions; (4) affordability, to measure the water price affordability for all types of users and the water supply costs for the society; and (5) flood security, to measure the occurrence of flood disasters and the corresponding control capacity. Then, the study determines the water security index system according to the interacting relationships between the indicators and the availability of the data.

The AHP is used in combination with expert questionnaires, which gather the collective knowledge of the experts, and is able to pass a consistency test to avoid individual subjective preferences. Individuals are invited to give a matrix of relative importance of the different indicators, and then the consistency test is conducted based on all submitted matrixes. If the test fails, all experts are consulted again until the test passes. Then, mathematical methods are used to determine the matrixes respective weights (Table 2.1). This study conducted two rounds of questionnaires. In the first round, 29 effective questionnaires were returned, and another 25 were returned for the second round. The Kendall W concordance coefficient test of the Multipaired Sample Nonparametric Test method is conducted as the consistency test. The *W* value was .583 for the second round, with a *p* value of .000, passing the consistency test.

Data sources include the most recent available statistic data, planning documents, water resource assessment documents, and so forth. Specific criteria are set for respective indicators. For example, following international standards, water supply is considered affordable when the percentage of domestic water costs based on per capita income is lower than 1 percent in primary cities, whereas it is considered unaffordable if that percentage rises above 5 percent. The values of each indicator are normalized according to their respective criteria. Based on the normalized values and weights of each indicator, an overall score can be calculated. A score of 90 and above indicates extreme security, 80–89.9 is secure, 70–79.9 indicates relative security, 60–69.9 indicates relative insecurity and 60 and below indicates extreme insecurity (table 2.1).

Present and Future Evaluations of Water Security in China

Current Evaluation

China's comprehensive water security score is 83.72, which fits into the security level (80–89.9). Affordability scores 98.18, which places it in the extreme security level (>90). Water quantity and sustainability score 88.12 and 85.66, respectively, fit into the security level. Water quality and flood security score 76.33 and 76.43, respectively, placing them in the relative security level (70–79.9). Each aspect of the framework is evaluated as follows:

- *Water quantity.* The amount of available water resources is greater than the total water demand in China, but there are severe water shortages in some specific areas. The proportion of the rural population with drinking water security has increased in recent years. Drinking water unavailability only exists in some remote rural areas in arid regions. Steady improvement of water supply security has resulted in high coverage of water supplies in urban areas of China. Droughts have been generally light in recent years, mainly concentrated in northern regions. Water resources can meet agricultural demand in normal years.
- *Water quality.* The recent situation of water quality in China is not optimistic in general. Surface water is slightly polluted at present, and nearly a quarter of the river length has been seriously polluted, as well as three-quarters of the lakes. The compliance rate of urban centralized drinking water sources has stabilized around 90 percent, with room to improve. Water supply quality problems are still prominent. Tap water that meets the quality standard is only about 83 percent at water utilities

Table 2.1 Index System (with Weights) of Water Security Evaluation, China

Criteria layer	Sub-criteria layer	Indictor
Sufficient quantity (0.2961)	Level of water demand being met (1)	Percentage of rural population with safe drinking water (0.4034)
		Urban tap water coverage (0.3739)
		3-year average drought-affected areas (0.2227)
Sufficient quality (0.2202)	Natural water quality (0.6216)	Proportion of river lengths that meet class I to III water quality standards (0.3574)
		Proportion of lake areas that meet class I to III water quality standards (0.2224)
		Compliance rate of drinking water source quality of urban water supply (0.4202)
	Water supply quality (0.3784)	Compliance rate of urban tap water quality requirements (1)
Sustainability (0.2074)	Water resource sustainability (0.4377)	Changing rate of local water resources (objective weight)
		Changing rate of external water resources (objective weight)
	Development and utilization sustainability (0.3019)	Development level of surface water (objective weight)
		Level of groundwater overexploitation (objective weight)
	Water ecological sustainability (0.2604)	Ratio of runoff entering ocean (0.4289)
		Changing rate of important lake areas in last 10 years (0.5711)
Affordability (0.0893)	Domestic water price affordability (0.5224)	Percentage of domestic water costs based on per capita income in primary cities (1)
	Production water price affordability (0.2236)	Elasticity of water price to economic growth in primary cities (1)
	Water supply cost affordability (0.2540)	Ratio of marginal water supply costs to per capita income (1)
Flood management guarantee (0.1870)	Safety outcome (0.6641)	3-year average flood-induced mortality (0.6354)
		3-year average proportion of flood-induced economic loss (0.2188)
		3-year average probability of urban waterlogging (0.1458)
	Flood management capacity (0.3359)	Percentage of dikes complying with flood prevention standards (1)

Note: Objective weight is decided by the ratios of local water resources versus external water resources and surface water versus groundwater.

in urban areas and is even lower when the water reaches the users.

- *Sustainability.* The average annual water resources of China remained stable in general, as do external water resources. Development and utilization are not excessive overall, but water resources are highly overexploited in the Hai River Plain and some inland closed basins. The ratio of runoff entering the ocean has improved compared with the multiyear average, which can basically meet the ecological freshwater demand for rivers, estuaries, and oceans. The changing rate of important lakes areas in the last 10 years has improved compared with the most severe period of lake shrinking in 1990s.
- *Affordability.* Domestic water cost is still low in China and is considerably lower than the safety standard of 3 percent of per capita income. The elasticity of economic growth of the water price is lower than 1, and water price is therefore not the main factor affecting the efficiency of enterprises. Water is affordable for enterprises. The water supply costs, such as the South-to-North Water Diversion Project for Beijing, are considerably lower than 3 percent of per capita income and are therefore within the safety range.
- *Flood security.* In recent years, flood disasters have been relatively light in China, and the affected areas have been concentrated in the coastal areas in southwest and southern China. Flood-caused death and economic loss have been halved since 2000. However, the urban waterlogging problem is becoming increasingly prominent and has occurred in about 60 percent of cities. The percentage of dikes complying with flood prevention standards is still low, below 70 percent, and therefore can be improved.

Future Evaluation

The comprehensive score of water security of future China (2030) is 93.32, which places it in the extreme security level. The separate categories score, from high to low, 98.80 (affordability), 94.11 (water quantity), 93.61 (sustainability), 93.51 (water quality), and 88.93 (flood security). Except for flood security, the rest fit into the extreme security level. Each aspect of the framework is evaluated as follows:

- *Water quantity.* Applying environmental Kuznets curve to water use, water demand is expected to be less than the available water resources of 810 billion cubic meters. Water supply-demand conflicts in the north will be eased with the completion of interregional water diversion projects. Water quality compliance rate and water supply guarantee will be enhanced, with drinking water security for the rural population in China being guaranteed. Drought effects are expected to decline slightly by 2030.
- *Water quality.* According to the State Council, water quality of water function zones in major rivers and lakes should basically meet the standards. Good-quality water should occupy more than 75 percent in the seven major river basins. Water quality of all drinking water sources of the urban water supply will meet the corresponding standards. According to environmental Kuznets curve, China's water pollution is ceasing to degrade, and water environment can be expected to improve to good conditions by 2030.
- *Sustainability.* The sustainability of water will be improved. Precipitation and available water resources are expected to vary within limited ranges and are therefore sustainable. Surface water and groundwater overexploitation and water ecological degradation are expected to be alleviated through more reasonable water allocation, diversion, and unconventional water resource utilization. However, some water ecological issues cannot be overlooked, such as the drying up of rivers in the north.
- *Affordability.* Water supply costs can be maintained within the affordable range. The main reasons are because China's water use is close to its peak, few new water supply projects are expected, and the cost of unconventional water sources is declining. Even if water price increases by 100 percent and water use per capita increases by 50 percent, water cost will still be less than 3 percent of the per capita income.
- *Flood security.* Flood prevention and control will still face severe challenges in the future. Basin-level flooding and regional heavy precipitation may still happen at times. Flooding effects are expected to decline slightly. By 2030, 80 percent of urban areas should meet the sponge city standard, and urban waterlogging will be eased. According to a target set by the Ministry of Water Resources, dikes should all meet flood-prevention standards in the future.

Provincial and Basin-Level Water Security Evaluations

Water Quantity

At the provincial level, water is abundant in the southern regions, especially the coastal areas. Urban and rural drinking water security and socioeconomic development's water demands can be met. Water is also relatively abundant in central China and the northeast. Provinces in the North China Plain, such as Beijing, Tianjin, and Hebei, face potential water supply-demand imbalances, which are expected to be addressed with interregional water diversion projects. Water-scarce provinces, such as Inner Mongolia, Tibet, and Gansu, have relatively low urban tap water coverage due in part to droughts in recent years. In 2030, rural drinking water security will be basically met with increasing water supply coverage and improvement of water engineering projects and interregional water diversion projects. Water demands by crop productions can be met. Relatively severe droughts in the northern regions will be effectively relieved. Overall, water demand in the eastern coastal regions will be satisfactorily met, and water scarcity in the water-scarce regions will be eased.

At the basin level, water resources of basins in the south, such as the Pearl, Yangtze, Southeast, and Southwest River Basins, are extremely rich. Domestic and production water demands can be met. But water supply infrastructure in the Southwest River Basin is relatively poor, and irrigation water supply needs to be improved. In the northeast, water resources are relatively rich in the Songliao River Basin. Water resources in the Huang-Huai-Hai River Basins are the scarcest, but this is expected to be eased by interregional water transfers. Water is scarce and unevenly distributed in the Northwest River Basin. With the increase of socioeconomic water uses, water supply-demand conflicts are increasingly acute. In 2030, water resources are expected to be abundant in the Pearl, Yangtze, Southeast, and Songliao River Basins, with adequate water supply infrastructure. Water demand can be satisfactorily met. Water demands in the Hai and Huai River Basins can be met by interregional water diversion projects being completed. Rural drinking water security and water demands for crop production can be assured in the Southwest, Northwest, and Yellow River Basins with increasing water supply infrastructure.

Water Quality

On a provincial level, rivers and lakes are more polluted in Beijing, Tianjin, Hebei, Shandong, and Shanxi. Water pollution in provinces in the northwest and northeast have been improved. Among southern provinces, Yunnan, Guangdong, and Shanghai have relatively poor water quality, mainly in the lakes. Water supply quality is good overall and meets water demand requirements. Urban water supply quality could be improved. In 2030, according to the environmental Kuznets curve, China will have reached a tipping point. In economically relatively developed provinces in particular, economic development and environment protection will be better coordinated. Water quality will continue to be good in southern and western provinces. Water quality in Shanghai and Guangdong will be significantly improved. Water pollution in the north, especially the Beijing, Tianjin, and Hebei regions, will be effectively controlled. Urban water quality will meet the standard, with water source protection and water supply and wastewater treatment infrastructure being improved.

At the river basin level, water pollution, of both surface water and groundwater, in the Huang-Huai-Hai River Basin in the north is the most serious. Water pollution in the Liao River Basin is relatively severe, while the Southwest River Basin is fine. In the southern rivers, lakes in the Yangtze, Pearl, and Southwest River Basins have poor water quality, while water quality in the Southeast River Basin is relatively good. By 2030, according to basin environmental management planning and the development trend, water quality in China's seven major river basins, as well as water sources, will be significantly improved.

Sustainability

At the provincial level, poor water sustainability is seen in the North China Plain, including provinces such as Beijing, Tianjin, and Hebei. Multiyear average water resources have reduced significantly. Problems include high water demand, groundwater overexploitation, and ecological flows being depleted. In provinces in China's arid and semiarid northwest, such as Ningxia, Gansu, and Xinjiang, water resources are extremely scarce, evaporation is large, and rivers and lakes are losing substantial amounts of water. With their socioeconomic development, water resources carrying capacity has been exceeded and ecological flows have been used. Water resources in China's south are abundant, and multiyear average water resources have remained stable. Water development and utilization are low, and the water ecological problem is not severe. By 2030, provincial water resources will remain similar. Through more reasonable water allocation, water diversion project implementation, and unconventional water resource utilization, water sustainability will be improved in provinces facing surface water and groundwater overexploitation and water ecological deterioration. Overall, water sustainability in the Beijing-Tianjin-Hebei region will be hugely improved, while because of natural constraints, the northwestern provinces will still face high risks.

At the basin level, water sustainability is poorer in the north than in the south. In these areas, the Hai River Basin has the worst sustainability; its water resources have decreased for years and are being overdeveloped. The existing situation is not sustainable. Water ecological sustainability in the Yellow River Basin also faces acute problems. Water resources in the Songliao River Basin have largely decreased, and ecological flows have been used. By 2030, water resources will become more sustainable. By developing new water sources, water overexploitation in the Hai River Basin will be relieved. Water sustainability in the Northwest and Yellow River Basins will still face threats because of natural conditions, such as scarce water resources and large evaporation, along with increased water demands.

Affordability

At the provincial level, household water costs and marginal water costs in all provinces are both lower than the international safety standard: 3 percent of per capita income. However, in some less economically developed areas, some projects have problems being used after completion because of the high costs of high-lift and long-distance water transfer projects. Examples include the Wanjiazhai Water Transfer Project in Shanxi and the high-lift Yellow River projects in Ningxia and Gansu. The ratio of water price elasticity to economic growth is lower than 1 in all provinces. Therefore, water price increase is within a reasonable range, and production water prices are affordable. By 2030, production and domestic water prices, as well as water supply costs, will still be affordable. On one hand, because of the cost reduction of unconventional sources and water source quality improvement, water supply costs will be further reduced. On the other hand, along with economic growth, people will be able to afford increasing water prices. Except a few poor regions, water prices and water supply costs in all provinces will be stabilized within affordable ranges. Water supply costs will be even lower in provinces without water transfer projects.

At the basin level, household water costs and marginal water costs in all basins are both lower than the international safety standard: 3 percent of per capita income. Some water supply projects in the Yellow River Basin have lost money because of the high costs compared with low water prices. The water supply cost of the South-to-North Water Diversion Project is so high that only higher-value-added industries with good economic performance can afford to operate in the Hai River Basin. By 2030, production and domestic water prices, as well as water supply costs, will still be affordable. However, water supply costs in western regions using transferred water need controlling to be within the economic bearing capacity in the poor areas.

Flood Security

At the provincial level, severe flood disasters are mainly concentrated in the southern provinces, such as Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Guizhou, and Yunnan, with heavy rainfall. Flood-induced death and economic loss occupy higher proportions in their gross domestic product. Urban waterlogging has become an increasing problem. More than 50 percent of cities in almost all provinces are experiencing increasing waterlogging. The dike compliance rate with flood prevention standards is higher in the west than in the east. By 2030, with the improvement of flood prevention projects, flood-affected areas and severity will be reduced. But damages are difficult to estimate. Southern provinces with more frequent heavy rainfall and western provinces with steep terrain will experience more severe flooding than eastern and northern provinces. With the construction of sponge cities, China's urban waterlogging problem will be effectively relieved.

At the basin level, flood disasters are more prominent in southern basins, such as the Yangtze, Pearl, and Southwest River Basin, where there are often landslides and mudslides. Northwest and Yellow River Basins in the north also have had relatively high numbers of flood-caused deaths and economic losses and therefore face relatively high risks. Moreover, dike compliance rates in the Yangtze, Pearl, and Songliao River Basins are relatively low and could be improved. By 2030, China will start to focus on flood prevention and control in small basins. Urban flood management, flood prevention, and control capacity at all basins will be improved. However, basin-level floods, regional heavy rainfall, and typhoon-caused torrential floods and urban waterlogging still occur, especially in several basins in the west and south.

Comprehensive Water Security Evaluation of China

At the provincial level, China's water security level is higher in the north than in the south (map 2.1). All provinces in the south score "relatively well" or better, while all provinces in the north score "relatively good" or worse. Beijing, Tianjin, Hebei, Shanxi, and Shandong in the North China Plain score the lowest and showed regional concentration. By 2030, water security in the north will still be worse than in the south. Provinces in the northwest, such as Ningxia, Gansu, and Inner Mongolia, score relatively low. The Yellow, Huai, and Hai River Basins in the north score relatively low.

Conclusions and Suggestions

Overall, China's water security is satisfactory with some regional problems. Several suggestions are detailed here.

Water Demands and Overexploitation

Although the overall available water resources in China can meet the demand for socioeconomic development, water shortages are still serious in some regional areas, such as the Hai, Yellow, and Huai River Basins. Drought is relatively severe in the north, and rural water demand in the northwest is poorly met. Overexploitation are acute in some regions; for example, groundwater overexploitation in the Hai River Plain poses unsustainable risks. To relieve such regional water supply-demand conflicts and to reduce their negative effects on crop production, urban water supply, and ecological environments, additional water demands should be met through water allocation optimization and water efficiency improvement. New water sources, including unconventional sources, should be used to meet water demands in water-scarce regions. Costs and technologies of desalination and recycling should keep improving. Water overexploitation should be eliminated through urban flood management, rainwater utilization, water source retention, and ecological development.

Water Pollution and Water Supply Quality

The water quality problem is the primary threat for water security in China, with different degrees of pollution in rivers, lakes, groundwater, offshore water fields, and so on. Water supply quality is also of concern, with the water quality standard compliance rate lower than 90 percent. After going through the pipe networks, water quality may deteriorate further before reaching the final users. To control water pollution, water environmental management should be prioritized to build an ecological civilization and control pollution sources. The total pollutant amount should be capped within the assimilation capacity. Meanwhile, water source protection should be strengthened. Water supply quality supervision should be enhanced, with comprehensive water supply information becoming transparent.

Map 2.1 Spatial Distribution of China's Water Security, by Province and Basin, 2018 and 2030

a. 2018 (by province)

b. 2018 (by basin)

c. 2030 (by province)

d. 2030 (by basin)

Although water ecological deterioration has been eased, water ecological function damage is still severe in some regions. Although lake shrinkage is reversing and water ecological sustainability is enhanced, they have not reached ideal conditions. Because of human interventions such as dam blocking and water storage, it is common for rivers to dry up in the north. Ecological flows are not ensured, which can cause detrimental effects on river sustainability. Ecological flows and river ecological protection should be taken into consideration in water resource allocation and water engineering project operation to ensure water ecological sustainability.

Water Supply Project Operation and Maintenance

The high costs of inter-basin water transfer and high-lift water supply projects in some areas may temporarily exceed the levels of local economic capabilities, which may cause difficulties in attaining their engineering benefits. Taking water supply costs into account, water-scarce regions should use water transfer projects to avoid the situation of water overexploitation coexist with some projects being left idle.

Flood Prevention and Control

The overall level of damage has been reduced compared with historical situations. However, the seriousness of urban waterlogging and insufficient flood control capacity of medium and small rivers show that weaknesses still exist in the flood control and disaster mitigation systems.

Future Challenges and Opportunities

The Chinese economy is rapidly improving, China's population will continue to grow, and urbanization and living standards are expected to improve. The formation of an increasing number of big cities and the uncertainty of climate change together pose various challenges for China's water security issues, such as water supply and flood prevention and control. However, based on environmental Kuznets curve, China's pollution discharge and water use have started to decrease. Under strict management and substantial investment, with the flood prevention system being improved in major rivers and flood prevention projects being implemented in medium and small rivers, water pollution prevention and control have risen to a national strategy for building an ecological civilization. Water use has peaked and started to decrease. Therefore, China's water security is set to improve.

Acknowledgments

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CHAPTER 3

Advancing Water Quality Markets in China

Background

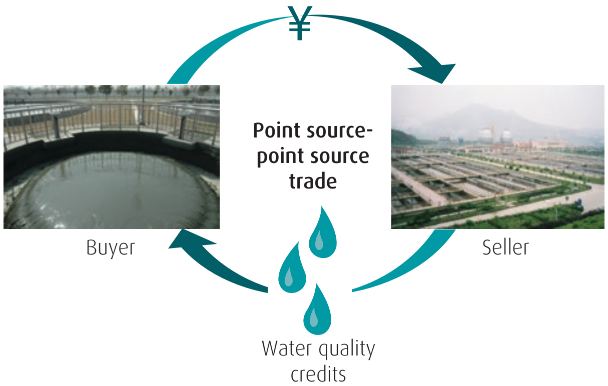
Deteriorating water quality poses a growing challenge to health, sustainability, and development that undermines the security of the water supply as countries industrialize and urbanize and populations grow. Despite having 20 percent of the world's population, China's water resources represent only 6 percent of global freshwater resources, and these face major stress from economic growth pressures, climate change impacts, and institutional and regulatory gaps in management. Official reports find that one-third of China's surface water is unfit for human contact, while more than 80 percent of groundwater used by farms, factories, and communities is too polluted for safe drinking or bathing (Reuters 2015; Xia 2016). In the absence of adequate measures to manage water, the economic costs are conservatively estimated at 2.3 percent of China's gross domestic product (Xie et al. 2009).

Acknowledging these challenges, the Chinese government has made significant investments and introduced several important regulatory initiatives concerning water. Investments in industrial and municipal wastewater treatment have generated major benefits relative to costs and achieved important reductions in pollution discharges affecting chemical oxygen demand and ammonia concentrations. Several agricultural initiatives have been developed to reduce excess fertilizer and pesticide runoff. The government has been promoting greater innovation in environmental policy under the 13th Five-Year Plan, calling for a shift to a more sustainable economic development paradigm under the goal of achieving an ecological civilization (State Council 2016). New policies, regulations, and standards for various aspects of water management have been issued, and ambitious pollution reduction targets have been established. These include the adoption of market-based mechanisms and policies to address water pollution.

Water quality markets (also called emission trading, tradable allowances, water quality trading, and other names) can improve water quality faster and at lower cost than traditional approaches, and with multiple benefits for communities and business (Figure 3.1). Internationally, water quality markets have improved access to information on pollution sources and reduction goals; strengthened cooperation among government, businesses, and farms; supported adaptability in water management; and improved monitoring and centralized collection of water quality

This chapter is based on a summary of the Thematic Report prepared by the Willamette Partnership and the World Resources Institute under the leadership of by Bobby Cochran.

Figure 3.1 Water Quality Credit Trades



Source: Water Quality Markets in China's Rapidly Evolving Policy Landscape: Challenges and Opportunities (2007). Policy brief prepared by the Willamette Partnership and the World Resources Institute.

data. Water quality markets work because they provide flexibility for how pollution reduction goals are met, allowing sources with higher reduction costs (also called abatement costs) to buy pollution reductions—often called credits—from sources with lower costs that are able to reduce pollution discharges below a required, or baseline, level (Selman et al. 2009). A credit is a measured or estimated unit of pollution reduction per unit of time (for example, in kilograms per year) at a specified location that can be sold or traded as part of a market (USEPA 2007).

Water quality markets were first mentioned in economics literature in the 1970s, and they have been in use in China and the United States since the 1980s. However, market development has faced several challenges related to inconsistent policies and market guidelines, missing information, and monitoring. In contrast to air pollution markets, water quality markets are often localized, creating fewer potential buyers and sellers with lower volumes of transactions. People care deeply about clean water, so negotiating stakeholder interests can be challenging. Despite the challenges facing water quality markets, there have been some success stories, and it is estimated that US$31.8 million was transacted globally in water quality markets outside of China in 2016, an increase from US$20.8 million in 2013 (Bennett and Ruef 2016).

The potential benefits a water quality market include (1) reduced costs and increased speed of meeting water quality improvements, (2) added flexibility in how regulatory requirements are met, (3) the creation of new sources of revenue for entities that reduce pollution more than required, (4) the creation of multiple environmental benefits beyond the targeted pollutant being reduced, (5) increased accountability and provision of new tools for tracking water quality improvements, and (6) the creation of new relationships among businesses, farms, and other communities (adapted from Willamette Partnership et al. 2012).

International best practices often frame water quality markets as an approach that can only be developed pending certain regulatory, institutional, and technical prerequisites. However, many initiatives have been developed in the absence of one or several prerequisites and have served as important entry points to a pathway leading to better management. Within the complex and rapidly evolving landscape in China, the requisite institutional, regulatory, and technical reforms are being established, and water quality markets could be a valuable approach to both catalyze a shift toward improved water resource management and provide a more flexible mechanism to help achieve water quality targets at lower cost.

Research Objectives

The objectives of this study are to provide background on international best practices in water quality markets, reflect on the Chinese experience, and propose recommendations on how to advance water quality markets in China as part of the overall efforts to improve water management. It is based on *Water Quality Markets in China's Rapidly Evolving Policy Landscape: Challenges and Opportunities* and the accompanying *Advancing Water Quality Markets in China: A Guide for Government and Business*.

Analysis and Summary

Water quality markets require a set of intentional decisions about desired water quality goals, who is responsible for reducing pollution, and how progress will be monitored and tracked. Based on international experience and best practices, there are several important prerequisites to a successful water quality market (Stavins 2006; World Resources Institute 2013), including the following: (1) a designated authority to enforce pollution reductions exists, (2) pollution sources are identified, (3) the types of pollution that mix do not create localized impacts, (4) a range of abatement costs exists across pollution sources, and (5) the market's geographic boundary is defined. Common elements and process steps are needed to build effective markets. These common elements include shared principles to guide market design and operations, a standard set of market design steps, and recommendations for how to advance water quality markets.

Successful water quality markets can be defined as having achieved transparency, real pollutant reductions, accountable tracking, sound science, and clear lines of responsibility. If some prerequisites are not in place, water quality markets may experience several challenges (adapted from Willamette Partnership et al. 2012, Part 1, p. 13), including (1) uncertainty about whether pollution reduction is achieved if monitoring is limited, (2) the creation of localized pollution hot spots (for example, areas of elevated eutrophication or concentration of toxics), (3) the perception that some polluters are not doing their share to reduce pollution, (4) concerns over the balance between privacy and transparency for market participants, and (5) difficulties in achieving equity for new or expanded businesses if some entities have to reduce pollution more than others.

International experience also suggests that even in absence of these prerequisites, the process of developing water quality markets can serve as a catalyst for improvements in water management. Potential improvements from the process of developing a water quality market can include the following: (1) more effective platforms and protocols for communication, engagement, cooperation, and joint decision making among the range of government agencies, economic actors, and communities involved in water use and management, including joint clarification of goals, rights, roles, and responsibilities; (2) strengthened water quality monitoring, better identification of key polluters, and the development of a clearer picture of the status of water resources within the relevant geographic unit; (3) improved understanding of the range of abatement costs among identified polluters; and (4) greater flexibility and adaptability built into management frameworks. Moreover, these improvements in the development of water quality markets can facilitate a more integrated and effective framework for process-based problem solving and management and introduce greater economic rationality into water resource management and planning. This can, in turn, feed back into and strengthen the development of water quality markets by creating demand.

Clear, complete, and enforceable goals that can be monitored to verify that pollution reductions are real are two of the most critical elements to a water quality trading market. The government has established a clear red line that requires 95 percent of major water function zones to comply with water quality standards and all sources of drinking water to meet rural and urban standards by 2030. Goals ensure that markets are producing desired effects and provide information used to best design and operate markets. Where goals are established in regulation or policy mechanisms, the implications for the level of restriction on market activity (demand) need to be carefully considered. If pollutant limits or caps are set too stringently or the timeline to meet those is too short, the cost of trading as an approach to meet regulatory requirements may be higher than alternative compliance measures. If these limits or caps are too lax, no market demand will occur (Corrales et al. 2013). For China, before credit demand occurs, a system needs to be in place to allocate pollution permits and trade allowances. The total number of allowances needs to be scarce enough to create demand for additional allowances but not so scarce that costs for trading become too high and limit market activity (Zhang et al. 2013). Clarity of water quality goals also often depends on sound scientific understanding of pollutant damage.

Stipulating percentage reduction targets for particular pollutants from particular sectors is an important first step to begin generating water quality market demand. However, key economic actors and water users will likely raise questions at some point regarding what levels of pollution reduction are needed to support current and future water use needs, such as for clean drinking water, industrial processes, agriculture, fisheries, and recreation. To anticipate and address these questions, the following actions are recommended. First, existing water quality standards and watershed pollution budgets should consider the use of water quality markets and extend some of these goals into other priority water bodies. Second, guidelines should be provided on how to measure and report pollution reductions. Next, databases and reporting structures for pollution discharges should be centralized, and these databases should be able to track pollution reductions and market transactions. In addition, tools should be provided to local governments to predict and measure pollution reductions in a low-cost, standardized way (for example, a standardized nutrient reduction model for farms). Finally, a standardized verification template should be provided to monitor performance and compliance for credit sellers.

Limited demand for credits is a common factor undermining the success of water quality markets. Demand is often driven by stricter, enforceable pollution reduction requirements (Willamette Partnership et al. 2012, Part 1, p. 17), and few water quality markets rely on voluntary reductions to create demand for credits. Conflicting policies and regulatory constraints will also serve as barriers (Corrales et al. 2013), and water quality markets in China need to fit within several policy frameworks, such as Five-Year Plan goals, environmental impact assessments, pollution discharge levies, and local requirements (Zhang et al. 2012). Sometimes, these policies can limit who participates in a water quality market, how transactions occur, and who is responsible for monitoring and tracking pollution reductions. It is also important to manage risk and uncertainty, which can increase transaction costs associated with generating water quality credits and moving them between buyers and sellers. High transaction costs reduce the economic efficiency of markets, and if they are too high, they can be a barrier to transactions occurring (Alston et al. 2013).

Transaction costs include (1) start-up costs to build and launch a market; (2) finding and matching buyers and sellers; (3) negotiating the price and terms of a transaction; and (4) monitoring, verification, and enforcement costs. Risk is also generated from uncertainties around the source and effect of pollution, weather events, changing market rules, and how market participants will behave, each of which can be mitigated by appropriate market design elements (Willamette Partnership et al. 2015, p. 90). However, mitigating each risk is often tied to accessing more information, which has been a significant problem challenging various water quality markets. Filling information gaps takes time and resources, and there is a need to consider trade-offs between known risks and the costs of managing those risks.

China has been building the foundations for trading both water and air pollution emission rights for more than three decades, and pollution emission trading markets have been largely driven by government policy and have required significant government intervention. Most buyers purchasing credits are either new sources or existing sources offsetting new growth in pollution discharge. An emission rights trading platform has been piloted by the Ministry of Environmental Protection and the Ministry of Finance in the Tai Lake Watershed (Wang et al. 2008), as well as across several other provinces, including Chongqing, Jiangsu, Zhejiang, Inner Mongolia, Hubei, Qinghai, Guangdong, Fujian, Henan, Hunan, Xinjiang, Shaanxi, Hebei, and Shanxi. Although the emission trading in China's air pollution permit trading pilot programs have been heavily influenced by institutional and political considerations, more than 3.9 billion yuan was transacted through air and water quality markets (1.9 billion yuan) and pollution discharge levies (2 billion yuan) through 2013. For water quality markets, this included trades in 176,000 tons of chemical oxygen demand credits and 0.2 million tons in ammonia nitrogen. Most air and market transactions (86.2 percent) have concentrated in Zhejiang, Shanxi, Shaanxi, and Jiangsu provinces. Pollution discharge levies were used mainly to build government capacity to regulate and reduce pollution (Liu 2014) and most of these trades have been conducted in combination with new, expansion, and technical innovation projects arranged by local environmental protection bureaus (Morgenstern et al. 2004).

To achieve the full benefits of water quality markets, a wider range of economic actors and sectors will eventually need to be included in trading. Internationally, several water quality markets allow for trades between point sources (such as industry) and nonpoint sources (such as agriculture) of pollution. For China, agricultural nonpoint-source pollution has surpassed industrial point-source pollution as the country's main source of water pollution (Xu and Berck 2014). As such, inclusion of agriculture in water quality markets will be necessary. However, the specific characteristics of China's agricultural sector makes this challenging in the near term: around 200 million small farmers contribute most of the national crop production in China, with an average farm size of 0.60 hectares per household in 2010 (Huang, Wang, and Qiu 2012). This suggests that transaction costs could easily become prohibitive without innovative approaches. Market programs involving point-source discharge sectors as buyers and agriculture sectors as sellers, or with agriculture sectors as both buyer and seller have been developed in New Zealand, Canada, and the United States, including with small farmers that grow specialty crops (Duhan et al. 2015; O'Grady 2008; Selman et al. 2009). Larger professionally operated, corporate-owned, or state farms could be could be included in water quality markets as a first step while exploring the opportunities, transaction costs, and risks associated with mechanisms to include smaller units, such as contracting villages as single entities in water quality market trades.

Social relationships among participants are important for facilitating information exchange, trust, and reciprocity for transactions (Corrales et al. 2013). Trust can also help reduce transaction costs (Mariola 2012). Globally, active stakeholder participation has been essential to ensuring access to environmental markets for community participants (Hejnowicz et al. 2014). In China, the mix of important stakeholders may be different, but it is still likely important to involve the key buyers, sellers, and market administrators early, as the market is being designed (Han and Hu 2011). Aspects of water quality markets have to be built locally, but diverse stakeholders often identify a common set of guiding principles that water quality markets should achieve. The following guiding principles were established in the United States by business, government, farmer, environmental activist, and other stakeholders part of a National Network for Water Quality Trading (Willamette Partnership et al. 2015): (1) effectively accomplish regulatory and environmental goals; (2) be based on sound science; (3) provide sufficient accountability, transparency, accessibility, and public participation to ensure that promised water quality improvements are delivered; (4) produce no localized water quality problems; (5) be consistent with the water pollution prevention and control regulatory framework; and (6) include appropriate compliance and enforcement provisions to ensure long-term success.

Conclusions and Suggestions

Policymakers are increasingly looking to market-based mechanisms to provide several important water quality benefits. First, markets can be extremely effective mechanisms for price discovery. Water quality markets can thus be used to identify what the real cost of water quality allowances should be in specific contexts. Second, price helps signal relative resource values and can help identify hot spots where resource bottlenecks are severe. Third, markets help stimulate better supply and demand management via price, which includes catalyzing technical innovation to overcome constraints. Thus, well-functioning water quality markets in China can help encourage enterprises to adopt best management practices in mitigating the water pollution they generate. Finally, markets are dynamic and allow for flexibility and adaptation via the price signal. This is especially important in the face of ongoing climate change impacts, which will have important and unforeseen effects on water systems.

The development of water quality markets has the potential to address water quality challenges. However, particular actions will be needed to overcome the challenges faced in China. Markets are not magic, and although the government's promotion of market-based approaches to water management is encouraging, water quality markets are no substitute for the fundamental reforms needed to achieve effective water management. This is evident from past experiments with these approaches. Effective water resource management will only be achieved via a comprehensive and effective water quality monitoring system, a clear and detailed legal and regulatory framework governing water resources, strong enforcement of current and future regulations and contracts, and sufficient technical capacity on the part of water agencies at central and local levels.

Several common questions have to be answered to build any water quality market, and markets have to follow a common set of design steps. Using standard design steps, such as those shown in figure 3.2, can reduce start-up costs, increase consistency to enable scaling of markets, and improve the likelihood of market success. These standard elements and design steps are meant to help incorporate global best practices and the prerequisites to market success into market policy and practices.

Based on international experience, the national government can do much to encourage provincial and subprovincial experimentation with and development of water quality market approaches. This includes both the standard role of market referee—monitoring and verifying water quality and enforcing water regulations and contracts—and the role of market enabler (Scherr and Bennett 2011). The central government has demonstrated a clear political will and financial commitment to addressing the remaining management gaps, meaning that water quality market development can play a role in both building flexibility and adaptability into evolving management frameworks and engendering greater economic rationality and planning in the use of and investment in water resources. Enabling the role of the market can be enhanced through the following recommendations:

- *Raise awareness of water quality markets as a tool.* Although water quality markets are not new, many government and business stakeholders are not aware of their potential or have limited expertise in designing and using such approaches to achieve water quality goals. As such, there is often a need for active education and awareness about where markets can be useful, where they are not, and how to begin. China can increase awareness of and interest in markets by providing communication tools and messages about the applicability of markets, training local governments on the resources available to design markets, and creating incentives for businesses and local governments to consider water quality markets early in their pollution reduction planning processes.
- *Provide technical support and guidance.* Many locales across China lack the capacity to develop water quality markets by themselves. The central government can thus provide assistance to locales interested in experimenting with these approaches. This includes creating and providing standardized methodologies and guidelines, assisting in the development of pollution reduction benchmarks and baselines, assisting in monitoring and assessing ongoing market performance, and planning for adaptive management by revisiting national and local market policies regularly (although not too frequently) based on ongoing market performance. All of these functions could be supported by the creation of a specific national office for facilitating water quality market development.

Figure 3.2 Common Design Steps

Building a water quality market	1. Feasibility and convening	2. Design	3. Pilot test and approval	4. Operations	5. Program improvement

- *Conduct feasibility studies.* It is important to identify locales where water quality market pilot programs are most likely to succeed. Markets do not work if there is no demand. Demand is most often created when there is a clear obligation to reduce pollution and individual dischargers can translate that obligation into their own planning. Potential buyers also need to know how to participate in markets, how much a credit will cost, and how to understand potential risks. Clear market rules answer these questions. China can expand on its existing pilot programs by looking across the country for watersheds where clear demand and clear rules intersect or are close to emerging. Implementing pilot programs solely based on stakeholder interest has not generated the hoped-for market activity in the United States. A good feasibility study can help identify the conditions necessary for market success. The national government could fund and support feasibility studies in watersheds that have clear pollution reduction goals, stakeholder support for markets, and enough potential buyers and sellers to make a market viable.
- *Increase consistency across market policies and implementation.* The national government can improve local uptake by creating a more consistent policy environment for water quality markets. Some actions could include incorporating clear authorization and/or preference for the use of water quality markets in national policy; issuing a set of common guiding principles and minimum market sideboards to provide a starting point for market development locally; generating local policy templates that local governments can use to create consistent market rules and requirements; providing technical assistance to local governments as they build, operate, and adaptively manage their water quality markets; and providing tools to dischargers to incorporate consideration of a market option as they plan for treatment plant upgrades, business growth, and so on.

CHAPTER 4

Macroeconomic Effects of Water Scarcity and Red Lines in China: Results from an Integrated Regional CGE Water Model

Background

The allocation of water resources typically involves many economic agents and sectors with complex interactions and often-competing demands. As populations increase, societies develop, and as hydroclimatic conditions become increasingly uncertain, the analysis of the economic implications associated with the allocation of water becomes increasingly important to support the political decision-making process. This is particularly important to China's economy, which is challenged by limited water resources, increasing industrialization and urbanization, regional heterogeneity, and a changing climate. Forward-looking and agile policy instruments are required to respond to changes in demand and increasing competition from different economic sectors to ensure water security for sustained and sustainable development.

Recognizing these challenges, the Chinese government has adopted a comprehensive set of policies and legislative measures over the last several decades aimed at improving water management. These include measures to address water pollution, control water-related disasters, and promote water conservation. The No. 1 Central Document of 2011 highlighted water resource development and established water conservancy as a priority investment area to accelerate economic development. In 2012, *Opinions of the State Council on Implementing the Strictest Water Resources Management System* established three red lines that set targets for water use, water use efficiency, and water quality, including at the provincial levels. The first red line aims to cap national annual water use at 700 billion cubic meters by 2030. The second red line sets specific targets on industrial water use efficiency (reduce water use to 40 cubic meters per US$1,600 industrial added value) and agricultural water use efficiency (irrigation efficiency must exceed 60 percent). The third red line requires 95 percent of major water function zones to comply with water quality standards by 2030 and all sources of drinking water to meet rural and urban standards by 2030.

Managing water use within the three red lines is thought to require the annual increase in the demand for water to be limited to less than 1 percent. While it is projected that there will be gaps between supply and demand across the country, there have been limited analyses on the quantitative effect of water scarcity and these specific policies on the national and regional economies in China. Computable general equilibrium (CGE) models offer a comprehensive way of modeling the overall effect of policy changes on the economy. The model simulates the interrelationship among production activities, factors of production, households, and government and can capture both direct and indirect effects of policy change. Moreover, coupled with water resource models developed

This chapter is based on a summary of the Thematic Report prepared by the International Food Policy Research Institute in Beijing under the leadership of Kevin Chen.

to optimize water allocation under various hydrological scenarios, an integrated modeling framework can improve understanding of the links between water scarcity and economic growth and ways in which to effectively cope with these challenges.

Interactions between water and economy are incredibly complex, and although CGE models have been widely used in China since the 1980s, few have been applied to analysis of water-related policy issues. As economies become more developed and sophisticated, so do the multiple demands for water resources. Water can have multiple uses, and unlike other intermediate inputs or final consumption goods, water can be used for consumptive and non-consumptive purposes. These uses are often integrated or interrelated. In addition, the value attributed to water needs to consider a range of attributes associated with the resource, including the quantity and timing of flows and the quality of the water. Historically, all uses of water were confined within the watershed. However, infrastructure development and the virtual trade of water further increase the complexity in estimating the value of water and its contribution to the economy. Special techniques are required to tackle the difficulties and build the links of water and the CGE model. First, water is as a factor in the production function; both aggregated water supply and water coefficient by crop are fixed, but water is freely mobile across sectors. Second, water is incorporated as a factor input in sectoral constant elasticity of substitution production functions. Third, water is an input to one or more industrial sectors in the production function. Fourth, water models are integrated with CGE models, which strengthen the component economic and water models.

Research Objective

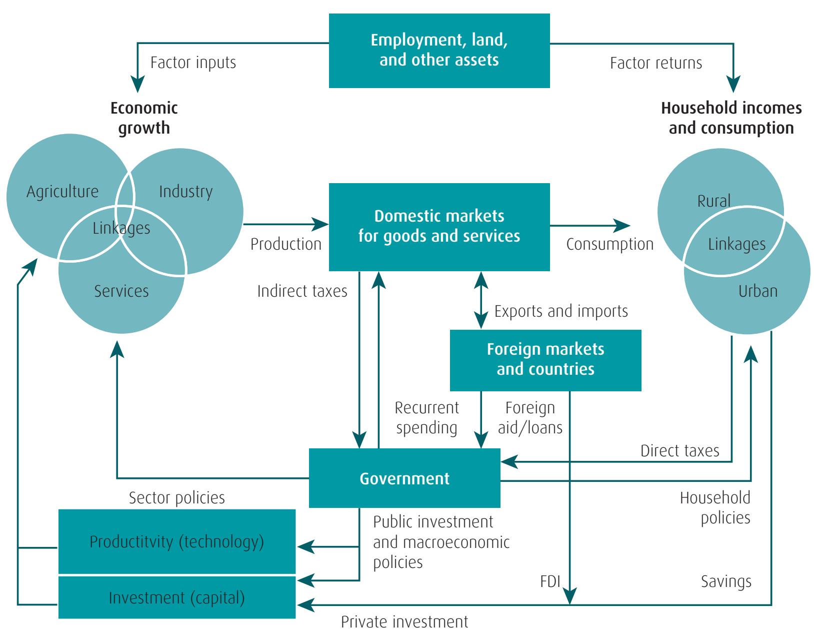
The objective of this chapter is to examine the economic impacts of China's Three Red Lines policy. This is done through the development of a coupled multiregional dynamic CGE model and water resource management model at the river basin-provincial levels.

Issue Analysis and Summary

An integrated multiregional dynamic CGE and water resource management model was developed for China. This integrated model approach draws on the strengths of the two models to consider the characteristics of both the water resource system and the economic system. As such, it can be used to simulate river basin water accounting and the allocation of water across sectors, as well as to evaluate the effects of water shortage on the regional economy and the effects of water resource management policies on the macroeconomy.

The multiregional dynamic CGE model simulates the operation of a market economy, which include all relevant agents, such as producer, household, and government, and their interaction across the markets (figure 4.1). In the figure, the arrows represent payment flows. This is based on the CGE model developed by the International Food Policy Research Institute (Lofgren, Harris, and Robinson 2001) and extended to the regional level (Diao et al. 2012; Zhang 2009). The recursive dynamic version of the CGE model incorporates a series of dynamic factors. Similar to other single-country

Figure 4.1 Dynamic Computable General Equilibrium Model



Note: FDI = foreign direct investment.

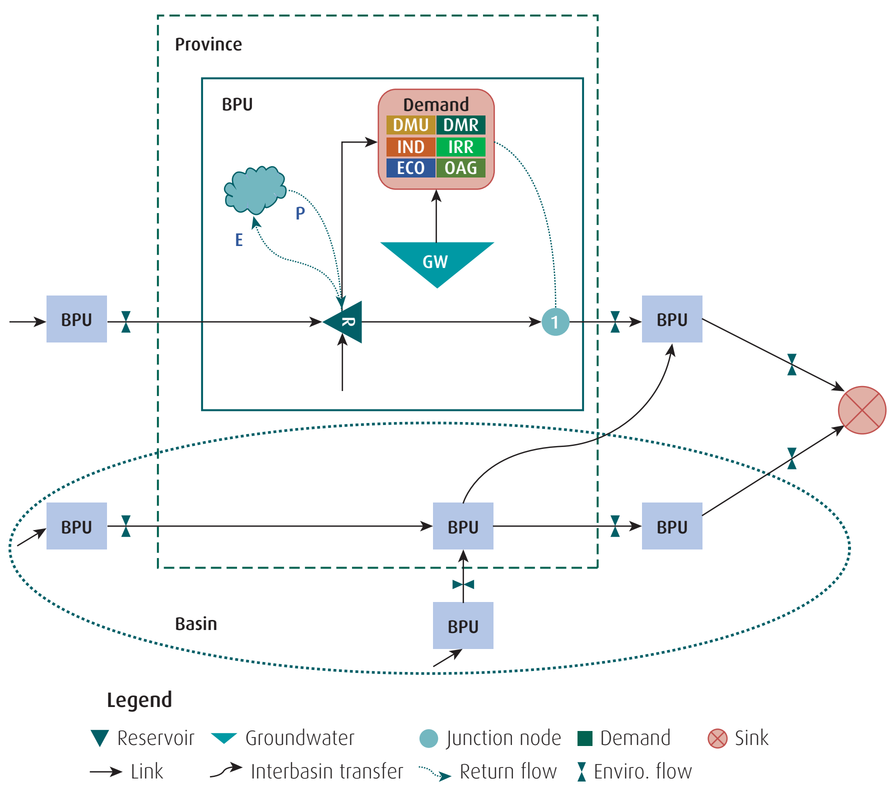
CGE models, China is assumed to have a small, open economy in that the international price for each tradable good is exogenous. Following the general equilibrium theory, both consumers (households) and producers are individual economic agents.

The dynamic CGE model is a multisectoral general equilibrium model that captures economic activities on both supply and demand sides. The model captures production and consumption behavior through nonlinear, first-order optimality conditions of profit and utility maximization. The equations include a set of system constraints that define macroeconomic equilibria (balances for savings investment, the government, and the current account of the rest of the world) and equilibrium in markets for factors and commodities. The base year was updated to 2014 using the latest available macroeconomic data and 2012 national and provincial input-output tables. Both aggregate and disaggregate social accounting matrixes were constructed for the Chinese economy in 2014. Recursive dynamics are applied in the model, occurring only between two periods, and neither consumption smoothing along the growth path nor multisectoral investment and saving decisions are taken into account. Instead, private investment (and hence capital accumulation) is determined by a Solow type of saving decision, in which savings are proportional to income. The model can be used to simulate the effect of various policies or external shocks, with each model solution providing a range of economic indicators. Outputs include national and regional gross domestic product (GDP), sectoral production, trade volumes, commodity prices, and household income.

Production activities and production factors were divided into six regions (north, northeast, east, south central, southwest, and northwest) to reflect the production characteristics and differences among the regions. Taking into account the integration of the market, production is linked to a unified national market at the same price, and interregional trade is not explicitly counted. Each region coproduces a class of products, and products can be replaced with one another. Factor mobility is allowed between crop production within regions and labor migration from regional crop production to non-crop and nonagricultural activities at the national level. The model is regionally disaggregated, with several agricultural sectors to capture the effects of water stress on crops, because agriculture is the largest water user, with 11 crops in 62 sectors.

The water resource model has four components: (1) water demand projections for domestic, industrial, irrigation, and other sectors; (2) water supply optimization; (3) water allocation across sectors; and (4) cropwise water allocation and simulation of crop yield reductions under water stress, wherever it occurs. The basic structure is illustrated in figure 4.2.

Figure 4.2 Schematic Illustrating Basic Structure of the CWRM Based on the BPU Concept



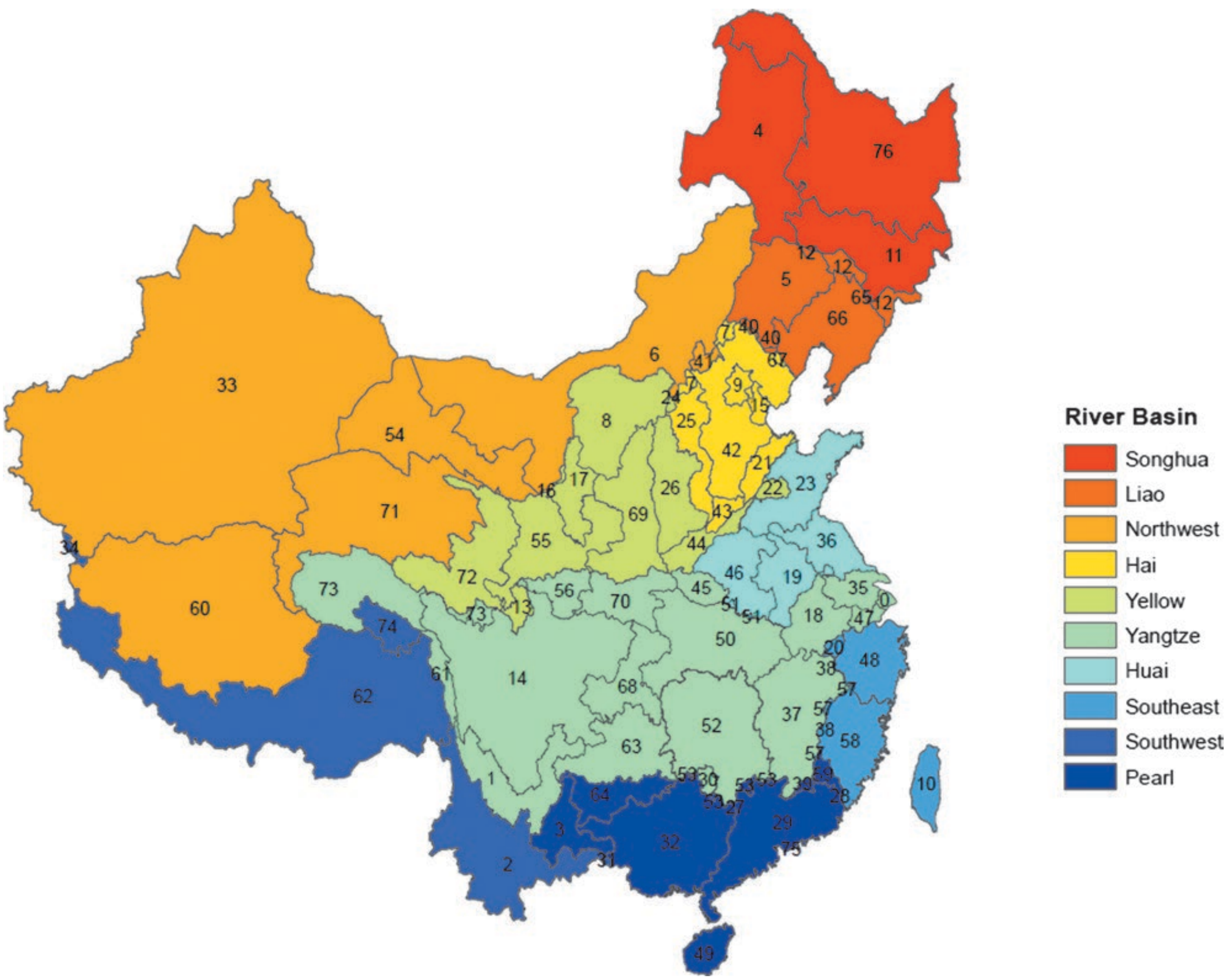
Source: Authors analysis.
Note: BPU = basin-province unit; CWRM = China Water Resource Model GW = groundwater R = reservoir.

A minimum environmental flow requirement is applied to constrain release from the last basin-province unit (BPU) in a basin. Minimum flow requirements are also applied to upstream BPUs to reflect water allocation regulations among provinces within the same river basin. The model can simulate water use impacts of technological and socioeconomic changes, as well as climate change.

Water resources are integrated in the CGE model as intermediate goods for production and to incorporate their effects on land productivity. Water use is separated into two types, industrial water use and household water use, to identify the different water constraints. Both industrial water use and household water use are disaggregated into each region, and water demand and water supply are balanced at the regional level, assuming no water trade among the regions. In that way, the water stress in one region only affects the regional water price, the water prices in other regions would not change. Water quantity by sector is incorporated into the model to assess the effects of water shortage on industrial water use.

Policy-oriented water resource modeling in a country as large and hydrologically diverse as China requires disaggregation to capture these spatial heterogeneities in the endowment of water and land resources, differences in socioeconomic development, structure of water-using sectors, water infrastructure, and water-using technologies. The 10 first-order river basins delineated by the Ministry of Water Resources were intersected with the 34 provincial-level administrative units to create 76 BPUs (map 4.1). In addition to capturing spatial variations in spatial units smaller than basins or provinces, the BPUs allow aggregation of input data and output results from BPUs to river basins, provinces, and regions.

Map 4.1 Map of Basin-Province Units (BPUs) with BPU Identifiers in the 10 First-Order River Basins in China



Source: Authors analysis.
Note: BPU = basin-province unit. Gray lines represent provincial boundaries.

Table 4.1 Policy Scenarios for Assessing Economic Effects of Water Scarcity and Red Lines

Identity	Background	Scenario specifications	Remarks
Business as usual (BAU)	Average per capita water resources in China is about 2,039 m^3. During the normal years, China is short of water by more than 50 billion m^3 (The World Bank 2017). Moreover, The percent of water that was not qualified for portable use was 11.7% in 2015.	BAU scenario assumes modest increase of water use efficiencies (annual growth rates at 50% of that for meeting red lines) and length of river reaches seriously polluted (i.e. worse than class V) remains unchanged throughout 2030.	There will be an increasing trend of water shortage challenge facing China from now to 2030. The pollutants disperse and contaminate other freshwater resources and further contribute to water scarcity.
Total water use cap (REDTWUC)	In 2015, the total water use is 610 billion m^3 in China. The red line caps the total water use at a maximum of 700 billion m^3. The total water use red line is allocated to the province and prefecture.	All other factors same as BAU, except the national and provincial "total water use red line" is applied.	The national and regional impact of imposing red line will be simulated.
Industrial water use intensity red line (REDIWUI)	The water use per 10,000 yuan industrial GDP at the national level decreased from 283 m^3 in 2000 to 75 m^3 in 2015 with the annual decreasing rate of 8.5%.	All other factors same as BAU, except the red line target of 40 m^3 per 10,000 yuan industrial GDP in 2030 is applied.	The regional impact of imposing the red line for industrial water use intensity will be simulated.
Increased irrigation efficiency red line (REDIE)	In 2015 about 63% of water use in China is for irrigation, irrigation water use efficiency is 0.53 in 2015.	All other factors same as BAU, except the "red line on irrigation water use efficiency" increase to 0.6 in 2030 is applied.	The national and regional impact of imposing the irrigation efficiency red line will be simulated.
Surface water pollution red line (REDSWP)	The red line requires that more than 95% of the water function zones meet water quality targets by 2030.	All other factors same as BAU, except 100% of water qualified for domestic uses and other productive uses.	There are a number of criteria for meeting the red lines on water quality. By 2030, 75% of water from seven major river basins is required to qualify for type I-III 100% of water qualified for portable use in Jing-Jin-Ji corridor, Yangtze River Delta, and Pearl River Delta.
All red lines (REDALL)	Combined scenarios as described above.	All the "red lines" above are applied in the model.	This "Combined red lines" scenario forms a counterfactual condition of the BAU.

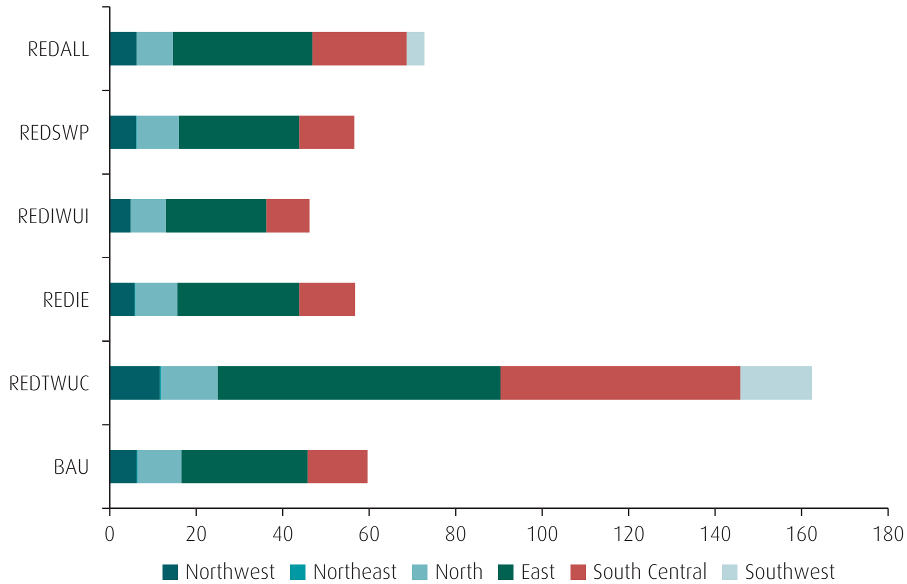
Source: Authors analysis.

Six policy scenarios were designed to assess the effects of water scarcity and red lines on the economy (table 4.1). The business-as-usual scenario is simulated to 2030 from the base year 2014 using a 45-year historical climate data series. Using long-term data is important to capture the stochastic realizations of weather and river flows. The baseline considers exogenous drivers, such as population growth, urbanization, and technology change. The total population is estimated to reach 1.41 billion by 2030, with an urbanization rate close to 68 percent. The total productivity growth rate is set with reference to the historical GDP growth by sector. In the business-as-usual scenario, the irrigation efficiency and water use intensity are conservatively increased at annual growth rates that are half of those needed to meet the three red line targets. The percentage of polluted water remains unchanged to 2030. Thus, the drivers of water demand are population and economic growth, in addition to moderate increases in water use efficiencies. More details of the six scenarios are given in table 4.1.

Conclusions and Suggestions

The model highlights the challenges of physical water scarcity and the gap between demand and supply. At the national level, under the business-as-usual scenario, a gap of 59 billion cubic meters is estimated by 2030. If only the total water use cap red line is implemented, this gap increases to 162 BCM. As expected, these gaps are projected to be severe in the dry north and northwest regions. However, the relatively wetter east and south central regions also face future scarcity challenges as demands (largely industrial demands) are increasingly in excess of available supplies (figure 4.3). While industrial water abstraction has remained relatively constant, because of increasing

Figure 4.3 Estimated Regional Water Shortages, in Cubic Kilometers, 2030



Source: Authors analysis.
Note: REDALL = all red lines; REDSWP = surface water pollution red line; REDIWUI = industrial water use intensity red line; REDIE = increased irrigation efficiency red line; REDTWUC = total water use cap; BAU = business as usual.

efficiency, domestic water use, driven primarily by rapid urbanization, is estimated to be increasing around 2.5 percent per year.

Water use efficiency improvements are central to offsetting the implementation of the total water use cap. To minimize water shortage and the associated economic cost, water withdrawal regulation needs to go hand in hand with water use efficiency improvements and pollution reduction, which have the indirect effect of increasing supplies. The results of both improvements in industrial water use efficiency and irrigation efficiency show that the water shortage situation is improved significantly compared with the business-as-usual scenario. Comparatively, the economic effects of improving industrial water use efficiency will be larger than those of irrigation efficiency. In the absence of incentives to encourage continued improvements in water efficiency, the total water use cap will result in significant negative effects on both national and regional economies. In particular, water shortages in the east, south central, and southwestern parts of China will increase dramatically, with the cumulative negative effects on the regional GDP estimated to be almost 5 percent in the east region and between 0.5 and 0.8 percent in the southwest and south central regions, respectively.

Caps on total water use control could be traded at provincial and lower administrative levels (much like in a traditional cap and trade emission programs), facilitating market-based water reallocation. Linking these to improvements in water pollution trading mechanisms can also help to narrow the gap between supply and demand in key areas, particularly in the east and south central regions. While the positive economic impacts of water pollution control are small and the effects of improved water quality are largely localized, several intangible benefits through ecological improvements would need to be considered. Water transfers and other measures can be used to augment water supplies, although they will increasingly require innovative institutional and governance arrangements to facilitate transboundary considerations and administration of economic policies.

Overall, the implementation of the Three Red Lines policy appears to be an effective water management policy that will not substantially reduce national economic growth. The limited impacts of the Three Red Lines policy on the national economy largely result from localized effects of water shortages. However, there are several important assumptions in the CGE model. For example, the model allows for factor mobility between crop production within regions and labor migration from regional crop production to reallocation and nonagricultural activities at the national level. In reality, these factors cannot move freely among regions, thus underestimating the national macroeconomic impacts of the Three Red Lines policy would be higher. Future work will need to examine the effects of these assumptions on the model results.

The relative impacts of the national measures of the Three Red Lines water policy on the regional economy are more significant. Thus, future policy measures will need to be tailored to the regional and/or provincial context for maximum effect. Differential effects of the policy measures on different sectors are also observed. The model predicts significant policy-related effects on irrigation water and crop yields in the northwest, and imposing the total water use cap will lead to dramatic increases in water shortages and large economic losses in the east, south central, and southwest regions, where urbanization and industrialization are driving demand. Industrial sectors with higher water use intensity, such as machinery and equipment, metals, chemicals, and non-metal products, are the most affected. Additional research, along with model development and sector disaggregation, are required to improve the confidence of these scenario outputs and to better refine the policy interventions. Nonetheless, the results provide insights into the economic implications of water resource-related policy measures stipulated under the Three Red Lines policy that can be used to inform the political decision-making process around development trajectories in China.

CHAPTER 5

Re-Examination of the Strictest Water Resources Management System and Basin Water Allocation in a New Era

Background

To solve increasingly complicated water-related problems and attain high-efficiency utilization and effective protection of water resources in China, based on a systematic summary of empirical experiences of water management in China, both the 2011 *Decision of the CPC Central Committee and the State Council on Accelerating Water Conservancy Reform and Development* (No. 1 Central Document) of the Central Committee of the Communist Party of China (CCCPC) in 2011 and the Central Government Water Conservancy Conference have required implementation of the Strictest Water Resources Management System (SWRMS) and set up the Three Red Lines policy in *Opinions of the State Council on Implementing the Strictest Water Resources Management System*. The three red lines set targets on water development and utilization, water use efficiency, and water pollution control and aim to facilitate coordination between socioeconomic development and water resources carrying capacity using an institutional approach. In accordance with the water management strategy of the central government, the State Council issued opinions on implementing the SWRMS that lay out corresponding implementation plans and specific arrangements, marking the official establishment of the SWRMS in China.

From the implementation experiences of the last few years, it is clear that problems still exist in matching top-level institutional designs with on-the-ground implementations. There are technical problems such as total water use cap adjustment under different water availabilities, institutional problems such as coordination between water quotas of river basins and provinces, and implementation problems such as monitoring capacity building. These problems are reflected in the rationale, implementability, and effectiveness of the Three Red Lines policy and river basin water allocation. Therefore, this chapter reexamines China's Three Red Lines policy from regional and socioeconomic perspectives to offer suggestions for improving China's water resource management.

Research Objectives

This chapter discusses problems in implementing the SWRMS from various perspectives and offers corresponding solutions for decision makers. The main research objectives are to (1) review the status of the three red lines and water resource allocation; (2) evaluate the rationale, implementability, and

This chapter is based on a summary of the Thematic Report prepared by Jianhua Wang and Fan He of the Institute of Water and Hydropower Research under the Ministry of Water Resources.

effectiveness of the three red lines and water resource allocation; and (3) offer suggestions to improve the three red lines and water resource allocation.

Analysis and Summary

Overall Development Progress of the SWRMS

China has established the SWRMS at various levels with the Three Red Lines policy and four sets of regulations, namely, the regulation on total water use, the regulation on water efficiency improvement, the regulation on restriction of pollutants in water function zones, and the regulation on water resources management responsibilities and performance monitoring. Progress has been made in several areas. First, the institutional system is continuously being improved. The period targets of the evaluation indictors of the three red lines have been allocated to all provinces, cities, and counties. More than 100 implementation documents have been issued by local governments. Various mechanisms have been established, such as double control on water use and efficiency, the national water-saving campaign, and a water resources carrying capacity monitoring and warning system. Evaluations have been conducted, and inter-department coordination has been facilitated. Mechanisms that hold the main government officials accountable have been established. Most provinces have included water-related evaluations into the overall performance evaluations of governmental and party officials.

Second, resource management targets have been fulfilled. In 2016, the total water use of 31 provinces was 604.02 billion cubic meters and water use per 1,000 Chinese yuan of industrial value added has decreased from 9 cubic meters in 2010 to 7.23 cubic meters in 2016 (2000 price). Farmland irrigation efficiency has increased from 0.5 to 0.542 in the same period. The water quality compliance rate in important lakes and rivers reached 73.4 percent.

Third, provincial and local governments have developed water management mechanisms that suit their circumstances. For example, Shandong has set yellow, orange, and red warning lines and is using them for warning purposes to assure sufficient urban and rural water supplies and water ecological security. Hebei province has changed its water resource fee to a tax and included both surface water and groundwater in its tax collections.

Overall, China has established the Three Red Lines policy and four sets of regulations. The SWRMS has been effectively implemented. However, China's water resource management mechanisms face challenges in two respects. The first is the weak foundation of monitoring and measuring capacity. In addition, the indicators of the three red lines are strict in some regions but less so in others. Second, China's water resource management is facing new requirements and contexts, such as the new water governing strategy and the river chief system. In particular, the 19th National Congress of the Communist Party of China (CPC) pointed to new directions for building an ecological civilization and required China's water management mechanisms to be continuously improved and promoted.

Overall Progress of River Basin Water Allocation

Since the 1980s, China has completed the water allocation plans for the Yellow, Heihe, Luan, Zhang, Yongding, and Daling Rivers, where water resources are scarce and water supply-demand conflicts are stark. Those actions have played an important role in regulating water development and utilization, enhancing water management, and advancing water protection. However, interprovincial water allocation in China is lagged and cannot meet the requirements of water management in the new era. Based on the *Water Law of the People's Republic of China* and the "*Decision of the CCCPC and the State Council on Accelerating the Reform and Development of Water Conservancy*" (Decree No. 1, 2011), the Ministry of Water Resources started the allocation of water resources in more interprovincial river basins in 2011.

In August 2014, a technical review of the first batch of 25 river basin water allocation plans was completed. In March 2015, the Ministry of Water Resources consulted provincial and municipal governments on the river basin water allocation programs in the Nen, Huai, Han, and 17 other rivers. In October 2016, with the approval of the State Council, the Ministry of Water Resources officially approved the first batch of water allocation plans for interprovincial river basins (Han, Jialing, Min, Tuo, and Chishui Rivers), which marks a new stage of basin water allocation work in China.

Suggestions on the SWRMS

To meet the requirement of standardization, refinement, and normalization, several suggestions can further develop the SWRMS.

SWRMS and the River Chief System

The goals of the river chief system and the SWRMS are consistent. While the river chief system emphasizes overall organizational structure, the SWRMS emphasizes concrete targets and tasks. Two mechanisms have their own organizational arrangements, management methods, and implementation means. How to better coordinate these two mechanisms to create synergies should be further explored. The following suggestions are offered: first, local party and governments should include the SWRMS in their river chief system implementation, especially taking water efficiency red lines into consideration. Second, indicators of the SWRMS, such as total water use, water use per unit of industrial value added, water quality compliance rate of water function zones, and total pollutant caps in major water function zones, should be allocated to river chiefs at different levels. Third, consistent evaluation indicators and mechanisms should be established. Implementations of the river chief system and the SWRMS should be evaluated together.

Water Sector Legislation

China's water resource management faces new requirements and contexts. In particular, water conservation and protection lack sufficient legislative foundations. The existing legal system in the water sector needs to be reviewed systematically and corresponding legislation or amendments should be arranged. First, several important laws and regulations on implementing the SWRMS, constructing a water-saving society, reviewing groundwater management, and regulating geothermal development should be promulgated. These include 'Water Resources Management Regulations', 'Water Saving Regulations', 'Groundwater Management Regulations' and 'Geothermal Resources Management Regulations'. Second, the water law needs to be improved by adding content on water quality protection. The legal status of the water law should be elevated to develop a comprehensive water law. Implementation details and supplementary regulations should be issued. Third, the *Basin Water Resources Protection Law* should be promulgated, laying out principles and regulations for basin water resource development and utilization, as well as protection. Specific legislations should also be facilitated. For example, water use control and water and soil conservation should be prioritized in the Yellow River Basin, while water pollution prevention and control, as well as ecological protection, should be prioritized in the Yangtze River Basin. Fourth, criminal responsibility legislation on water resource protection should be advanced. Based on international experience, means of criminal law could be adopted to deter behaviors that seriously violate water resource protections. Water-related crimes, such as illegal water withdrawal, polluting the water environment, and damaging water conservancy infrastructures, can be set up, in addition to crimes related to damaging resources.

Water Ecological Red Line

China's SWRMS has been implemented but can be improved. It is necessary to add a water ecological protection red line, in addition to the existing three red lines. Because of the complexity and diversity of water ecological systems, and considering the feasibility of local implementation, one indicator should be added for the water ecological protection red line based on ecological flows and biodiversity that are included in the river and lake health indictors. Governments of all levels above counties should start listing rivers and lakes for health evaluations. In the early stage, the list can be based on the national important river and lake water function zones, supplemented by other important rivers and lakes in the same region. Then, health evaluations on important rivers and lakes can be advanced step by step. The number of rivers and lakes for evaluation and the targets of health indicators should be decided each year. The average values should be used as control targets.

To implement the water ecological red line to protect river and lake health, the first step is to work out river and lake health evaluation guidelines based on the existing health evaluation indicators, standards, and methods for rivers and lakes, respectively, to develop standardized and normalized evaluation procedures and technical methods. The second step includes enhancing monitoring capacity on aquatic biodiversity, facilitating staff skill training, and developing a relatively comprehensive water ecological monitoring network in China. The third step is to raise awareness of water ecological protections. The roles of public supervision and evaluation should be fully used, and the value of harmony between water and people should be promoted. The fourth step is to enhance support for river and lake health evaluations in terms of institutional design and funding.

Basin Organizations' Role

The river basin is the basic unit of land surface hydrological cycles. Water resources in the same basin form a system in which upstream and downstream resources are closely related. Therefore, river basin water management can attain comprehensive benefits from water resources. With the completion of comprehensive planning of water resources in various basins and advancement of water allocation in interprovincial river basins, the technological foundation for comprehensive river basin management has gradually been formed. Unclear responsibilities exist between basin management and administrative regional management in terms of water resource management, leading to insufficient implementation.

To address these issues, the first step is to enhance and improve the existing water management system and confirm basin organizations as representatives, planners, and coordinators of the basin. In particular, the supervision function of basin organizations should be enhanced with clearly defined supervision content. Targets on total water use cap, water function zones, water quality compliance rate, and reduction of total water pollution in important water function zones can be allocated to each basin (river chiefs at different levels should be responsible). A basin water management evaluation system should be established to be the basis for the SWRMS. The second step is to establish a new multidepartment basin organization to coordinate various departments and regions on water-related management issues, such as planning and formulating standards and policies. Meanwhile, each basin could explore water resource and environmental management systems that suit their local context, as well as interdepartment and interregional coordination mechanisms. For example, river basin water resource protection and water environment protection committees can be formed, consisting of relevant central government departments and government officials from provinces within the basin. Water pollution prevention and control joint meetings can also be initiated. In doing so, coordination between water resource protection and water pollution prevention and control can be enhanced. Information sharing can be an entry point for the establishment of the coordination mechanisms. The third step is to improve laws and regulations and advance basin legislation. Duty, responsibility, and power should be made consistent between basin organizations and corresponding provincial and local water departments. A special basin water court can be established to deal with various torts, negligence, and other water disputes. A basin management law enforcement team should be established to enhance basin law enforcement.

Differentiated Water Management and Evaluation System by Region

China is vast, with substantial spatial differences in terms of water resource natural endowments, water development and utilization, water conservancy project construction, economic structure, city scale and type, and socioeconomic development stage. These characteristics indicate that China's water resource management should differ depending on regional natural conditions and socioeconomic characteristics. A guidance on the implementation of the SWRMS by region should be issued.

The first step is to establish a differentiated evaluation framework, design indicators, and weights in different regions. For example, evaluations in water-scarce northern regions should focus on saving water. Weights of indictors on water use, water efficiency, and groundwater management should be increased. Ecological flow should be added as an indicator. Total water use control can even be changed to mandatory, while a certain level of flexibility could be given to water-abundant southern regions. The second step is to implement differentiated financing policies. For example, in grain-producing regions, more financial help should be given to water-saving irrigation, while in regions that produce high-value-added crops, fewer financial subsidies should be given to water-saving irrigation.

Refined Water Resource Management Supporting Systems

Implementation of any mechanism requires strong supporting systems, especially for mechanisms with innovative top-level designs such as the SWRMS. Since 2012, the Ministry of Water Resources has implemented national water resource monitoring capacity building projects (phases 1 and 2) and has preliminarily completed monitoring and statistical analytic systems on water use by main water users and water quality of main water function zones. Comprehensive management platforms have been established at central, provincial, and city levels. To enhance water resource management-supporting capacities, the tradition concept that only dams and canals are water conservancy projects needs to be changed. Water monitoring system development and water information capacity building should be included and even prioritized.

The first step is to develop three monitoring systems for water users, water sections (provincial boundary sections and control sections), and water function zones. Water metering and monitoring capacity should be improved. Water quality and quantity at water sections at provincial boundaries should be improved, and monitoring points and systems should be established. Remote real-time monitoring of discharge at water sections should be gradually accomplished. The second step is to improve the grassroot water management capacity. Grassroot water management standardization should be facilitated. Organizational responsibilities, personnel, funding, technologies, and equipment should be clarified. Grassroot water management training should be facilitated, and grassroot professionals' skills should be improved. The third step is to advance technological innovations in the water sector. Focus should be placed on fundamental questions, key technologies, and equipment to develop a science-technology supporting system that suits the contexts of China's water sector and national development.

Suggestions on Water Allocation

Postallocation Evaluation and Adjustment Mechanism

Whether water allocation organizations are effective and the allocation targets can be met can only be verified by implementation. For river basins like the Yellow River, where water resources, water supply conditions, and socioeconomic development are going through substantial changes, water allocation plans should be adjusted over time. To summarize lessons already learned and to improve water resource management, postallocation evaluations are recommended based on water dispatch practices. This study suggests the construction of an evaluation index framework based on the three following aspects: implementation targets, implementation effects, and institutional development. Such a framework can be used to evaluate scientifically the effectiveness of water allocation and to identify problems. Suggestions on water supply calculation, water allocation coordination mechanisms, and implementation can be offered. The procedures for water allocation adjustment should be clarified. Water allocation plans should be adjusted and improved based on evaluations.

Implementation through Water Dispatch

Water dispatch is an important means to implement water allocation plans. First, water dispatch joint meetings should be initiated; basin organizations and water department officials should attend, and important issues and problems should be addressed in terms of river basin dispatch. Second, water dispatch plans, water dispatch methods, and water allocation plans should be made, as well as plans for water dispatch during drought emergencies. A hierarchical management and responsible mechanism should be used in making water dispatch plans. The total water use cap and discharge control in important water sections should be implemented. According to the principle of dynamic adjustment, annual water allocation plans should be made based on medium and long-term projections. Third, hydrological modeling and forecasting work should be enhanced. Scientific forecasts of annual water availability can provide technical support for water dispatch plans. Fourth, the existing legal framework for water dispatch should be improved. Sectoral regulations should be improved to provide references for daily dispatch work. Water dispatch organizations in charge of daily water dispatch work should be established within the administrative system.

Water Allocation in the Water Use Red Line

Water allocation should be included in the water withdrawal caps. The total water allocated in a basin cannot exceed the total water available in that basin. Water allocated in a certain administrative region, i.e. province, city, or county, cannot exceed the water quotas allocated by their respective basin organizations or superior governments. Water withdrawal permitting departments should give water withdrawal permits to water users based on water allocation plans and water resource availability to secure reasonable water use and suppress excessive use. Monitoring management and performance evaluation should be enhanced. Provincial governments should include water use quotas, water allocation, and water transfer plans in their SWRMS and implement river and lake chief systems.

Trading Mechanism

To use the effects of market mechanisms and attain efficient utilization of water resources, an allocated water trading mechanism should be explored, in combination with the pilot mechanism for water rights allocation. Local governments should be allowed to trade the allocated water resources that they do not use. Agreements can be made before every annual water allocation plan and should be approved by the respective basin organizations. After water is allocated each year, the tradable amount can be determined based on actual water use. Only usage rights, not proprietary rights, can be traded.

Conclusions and Suggestions

As an innovation of China's water resource management mechanisms, the SWRMS has been implemented at different levels and its targets have been met. Corresponding institutions keep being developed. At the same time, the water resource management mechanisms are facing multiple challenges. Basin-level coordinated management should be improved, regional differences are not yet well accommodated, and monitoring and measuring capacity is rather weak. To improve China's SWRMS, the system should be advanced with the river chief system. The legal framework should be developed or amended. A water ecological red line should be added. Basin organizations' supervision over water resources, environment, and ecology should be enhanced. Regional differences should be better accommodated in the water management and evaluation system to enhance the supporting capacity of water resources. Finally, evaluation and adjustment mechanisms should be developed after water is allocated to continuously improve allocation.

Acknowledgments

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CHAPTER 6

Water Rights Allocation and Trading

Background

Water resource management is an integral part of China's water governance. China's total water resources amount to 2.8 trillion cubic meters, ranking it 6th in the world. However, its water resources per capita only amount to one-fourth of the global average, ranking China 100th in the world and among the countries with the fewest water resources per capita. Meanwhile, the spatiotemporal distributions of China's water resources are uneven, and its economic productivity levels are mismatched. Because of rapid socioeconomic development, population growth, improving living standards, and the need for environmental and ecologically friendly policies, water supply-demand conflicts have become a bottleneck for socioeconomic development. Through market mechanisms, a water rights system is an effective way to optimize water allocation, conserve and protect water resources, and increase water use efficiency and benefit. Accelerating the establishment of a water rights market has become an important and urgent task for sustainable socioeconomic development and construction of an ecological civilization. Establishing a water rights market involves institutional reforms in China's water resource management system and promotes the improvement of China's water governance mechanisms.

In the 2000s, China began conducting a series of water rights theoretical studies and practical explorations that have generated many research outcomes and lessons. Much progress has been made in water rights content, allocation, trading, supervision, and institutional development. Overall, water-stressed regions are more enthusiastic about exploring water rights trading systems than water-abundant regions. However, the foundations of water rights allocation, measuring, and monitoring are incomplete. Consensus has not been made in terms of many key concepts and theories. The legal foundation is weak, and China's water rights trading system is still being explored.

In deepening China's reforms, the national government places great importance on establishing water rights trading systems and has laid out plans several times. In 2011, the *Decision of the CPC Central Committee and the State Council on Accelerating Water Conservancy Reform and Development*, also known as the No. 1 Central Document of the Central Committee of the Communist Party of China (CCCPC), required China to "Establish and improve the national water rights system

This chapter is based on a summary of the Thematic Report prepared by the Development Research Center under Ministry of Water Resources and leadership of Li Jing.

to optimize allocation of water resources using the market mechanisms." In 2012, the report of the 18th National People's Congress encouraged to start pilot programs for trading water rights. In 2013, the *Decision of the CCCPC on Some Major Issues Concerning Comprehensively Deepening the Reform*, issued at the Third Plenary Session of the CCCPC, required the promotion of water rights trading mechanisms. In 2014, President Xi Jinping encouraged use of water rights and prices to optimize water resource allocation and let both visible and invisible hands, that is, the government and the market, play their roles. He urged China to 'establish water rights mechanisms, to clarify water rights ownership, and to develop a water rights trading market while preventing agricultural, industrial, and domestic water uses from being overrun.' In October 2015, recommendations for the *13th Five-Year Plan for Economic and Social Development of the People's Republic of China (2016–2020)*, passed at the Fifth Plenary Session of the CCCPC, required the establishment of a preliminary water rights allocation system. After the *Overall Plan of Ecological Civilization Institutional Reforms* proposed to explore a water rights system, many places started to explore water rights market mechanisms again. In 2015, the Ministry of Water Resources initiated seven pilot programs on water rights. The national agricultural water price reform has set up 80 pilot counties and stated that setting up agriculture water rights is the foundation and prerequisite for water price reforms. Some places in Hebei, Shanxi, Xinjiang, and Zhejiang have started water rights pilot programs. The China Water Exchange (CWE) began operating June 28, 2016. Thus, China's exploration of water rights has entered a new stage. Furthering the research on water rights allocation and trading is important for accelerating the establishment of China's water rights system, deepening water resource management institutional reforms, and improving water governance capacity.

Research Objectives

This study aims to analyze the needs for water rights allocation and trading in China, to summarize experiences and lessons from water rights allocation and trading pilot programs, and to estimate the development of trading water rights in China. It aims to offer policy recommendations on water rights allocation and trading and provides decision support for China's water rights market development.

Analysis and Summary

Needs

Social Economy

Ensuring industrial and agricultural water use requires water rights allocation and trading. First, water rights need to be assigned in water-scarce regions to ensure agricultural irrigation water uses. Ensuring both water supply for registered legal farmlands and agricultural water price reforms requires water rights allocation. Second, industrial water uses require water rights transfers in water-scarce regions. In many water-scarce regions, it is difficult for industries to develop without water rights transfers. Third, water rights stocks should be revitalized for new water users in water-abundant regions. With the implementation of China's Strictest Water Resources Management System (SWRMS), some regions are forced to satisfy their new water users through water rights trading.

Ecology

Building an ecological civilization requires ensured ecological water rights. The first step is to clarify ecological water rights to ensure ecological water uses. The minimal flows in rivers and the quantity and quality of river flows used to maintain ecological environment for an aquatic biodiversity should be clarified. Supervision and responsible departments should also be clarified. Ecological protection requires a water rights buyback system. In addition, an ecocompensation mechanism requires clear regional ecological water rights.

Governance

Improving water governance requires an end-user water rights market. The market must be allowed to decide on appropriate water allocation among users, which further improves water allocation efficiency and benefits. Focus should be placed on uses other than domestic and agricultural water uses, such as industrial and service sectors, when introducing the water market. If nondomestic and nonagricultural water uses were determined by the government, administrative efficiency would be significantly decreased and opportunities for rent seeking and corruption could be created.

Public

Water rights provide incentives for saving water. Water rights allocation and trading can bring economic benefits to water rights holders and provide internal drivers for reasonable development, efficient utilization, conservation, and protection of water resources.

Conditions and Difficulties

Water rights allocation requires preconditions in five aspects, as listed in table 6.1.

In terms of difficulties for water rights allocation, the legal framework for water rights is not complete. The existing legal framework is not clear on related responsibilities and subjects. In terms of the

Table 6.1 Preconditions for Water Rights Allocation

No.	Aspect	Preconditions
1	Legislation	Legal definitions of water rights, obligations, objects, subjects, and procedures
2	Administration	Water resource allocation, water administrative management, and risk prevention and control
3	Technology	Metering and monitoring facilities
4	Economy	Costs for water rights allocation and operational costs for monitoring and measuring facilities
5	Social	Public awareness and participation

Table 6.2 Preconditions for Water Rights Trading

No.	Aspect	Preconditions
1	Legislation	Water rights allocation and tradable water rights
2	Administration	Institutions and supervision
3	Technology	Platform and intermediary services, metering, and monitoring
4	Economy	Purchasing demands, water rights mechanisms, and a reasonable price formation mechanism
5	Social	Public awareness, participation, and supervision

administrative framework, water allocation is incomplete for many rivers and between sectors. It is debatable whether the existing water withdrawal permits can be used as the basis for water rights allocation. Difficulties exist in linking the water rights system and the water withdrawal permit system. Administrative measures are used to allocate nondomestic and nonagricultural water uses. Technically, measuring and monitoring facilities are not in place. Moreover, water rights allocation is costly, and local governments have limited funding. Measuring and monitoring facilities require a large amount of operational and maintenance expense. Public awareness and participation in water rights are insufficient.

Water rights trading also requires preconditions in five aspects, as listed in table 6.2.

Water rights allocation preconditions differ from those for water rights trading. The legal foundation is limited in terms of interregional water trading. There are differences between transferable water rights and tradable water rights. Tradable water rights in irrigation areas are controversial, and there is a lack of legal foundation for water rights trading between irrigation water users and other water users. Second, the coexistence of the water withdrawal permit system and the water rights system affects the public's willingness to purchase water rights. The institutional arrangement is also incomplete. Third, the water measuring and monitoring capacity is insufficient, and it is hard to know whether water saving has occurred or the environment has been negatively affected by water rights trading. Fourth, water rights trading platforms are scattered, and intermediary services and public participation need to be improved.

Methods and Lessons in China's Pilot Programs

Water Rights Allocation Methods

In 2014, the Ministry of Water Resources approved pilot plans for water rights trading by provincial governments and established seven pilot programs for water rights trading. Ningxia, Gansu, and Jiangxi provinces and Yidu City in Hubei province have explored water rights allocation. These pilot programs for water rights allocation have generally gone through three phases: preparation, water rights registration, and institutional establishment. In 2014, the Ministry of Water Resources, Ministry of Finance, National Development and Reform Commission, and Ministry of Agriculture selected 80 counties throughout the country to test comprehensive agricultural water price reforms. Project acceptance and evaluation work started in 2015. Initial agricultural water rights are allocated through water rights certificates or other official documents. Establishing water rights is the precondition for water price reforms. So far, 39 counties have allocated agricultural water rights to irrigation users and 41 counties have allocated irrigation water rights to water user associations. Other places, such as Hebei and Shandong provinces, the Dongshao River Basin in Zhejiang province, and Qingxu county in Shanxi province have also explored water rights allocation. Basic means include total water use control, water quota management, water user allocation, and institutional development.

Water Rights Trading Methods

All water rights pilot programs have attached great importance to water rights trading. Inner Mongolia has enabled intercity and intersector water trading. The main methods include setting up a water rights transfer center and financing irrigation water-saving projects to generate unused water allowances. Intercity water trading is then facilitated by listing on the CWE and formulating water rights trading management methods. The Henan province has conducted water rights trading along the middle route of the South-to-North Water Diversion Project. The main methods start with defining initial water rights and then calculating tradable water amounts. Interregional water trading can then be facilitated. A dynamic adjustment mechanism for water rights should be established. Water trading price and time should be reasonably set.

Guangdong province has enabled water trading between upstream and downstream areas of the Dong River. First, regional water allocation was made. Water withdrawal permits were given, and a water rights information system and water rights trading rules were established. Three types of water trading were facilitated. The first type sells unused agriculture water allowances to domestic users. The second type sells water saved by irrigators to electric power companies. The third type purchases water allowances reserved by the government to meet water demands the Pearl River Delta.

The Jiangxi province has conducted interbasin water trading from the Shankouyan reservoir. The Luxi county government transfers 62.05 million cubic meters of water every year from the Shankouyan reservoir to economic-technological development districts in Anyuan District and Ping county. Usage rights of 25 years were traded at 2.55 million yuan. The Shandong province has enabled agricultural water rights trading by issuing regulating documents, allocating initial water rights, setting up a water rights trading management agency, and implementing a policy of “one card, two prices, and one platform.” The Changji prefecture in the Xinjiang province also enabled unused agricultural water quota trading. Agricultural users were given initial water rights certifications. The water trading is specified on unused agricultural water allowances. According to clear criteria and regulated procedures, unused agricultural water allowances were bought back at higher prices. The roles and responsibilities of supervision agencies at all levels still have to be clarified.

Lessons

Several lessons have been learned through China’s water rights pilot programs. (1) A legal basis is the fundamental guarantee for lasting water rights allocation and trading. An incomplete rights system may create potential problems. (2) Water rights allocation and trading require both hard and soft conditions. Soft conditions include water rights allocation implementation methods, usage regulations, and rights protection mechanisms. Hard conditions include water supply and drainage infrastructure, metering and monitoring facilities, and information management systems. (3) Water rights allocation and trading have to be linked to relevant regulations, such as the SWRMS, the water withdrawal permit system, and the water allocation system. (4) Agricultural water allowances should be decided based on land rights and should be linked with water prices. (5) Water rights allocation requires a large amount of preparatory work, including the status of existing water use, water quotas at different levels, water quota determination, and irrigation area determination (6) Clarifying initial water rights contributes to further water rights trading. (7) Agricultural water saving is the main source for tradable water. A water rights reservation system is an effective way to expand water rights supply, and governmental buyback is an important means to incentivize agricultural water saving.

Reasons for Success

Increasing socioeconomic water demands and benefits from water trading are the main drivers for successful water rights allocation and trading. The SWRMS has created an enabling environment by capping total water use. From the implementation perspective, the success of pilot programs should be attributed to high-level government facilitation, policy guidance, and solid preparation.

Outlook on Water Rights Trading Pilot Programs

Overview of the China Water Trading Platform

The CWE was established jointly by the Ministry of Water Resources and the Beijing government on June 28, 2016, after approval by the State Council. The CWE is a stock corporation with registered capital of 0.6 billion yuan and 12 sponsors. Its main business is to organize eligible water users to conduct water rights trading that is approved by the water departments. It also provides service consulting, technology evaluation, information disclosure, intermediary services, and other public services. China’s existing provincial water trading platforms are limited. Inner Mongolia, Henan, Gansu, Guangdong, and Shandong provinces have done some positive exploration into options of trading water rights. The first option is to establish a provincial water trading platform in cooperation with the CWE. The most typical one is the Inner Mongolia Water Right Reservation Exchange Company. The second option is to use provincial trading platforms for other public goods, which is the method used in Guangdong province. The third option is to use a local water rights trading center established by the CWE. For example, Gansu province plans to open an online water rights trading center for the Shule River Basin on the website of the CWE. The fourth option includes planned provincial water rights trading agencies that will be members of the CWE. For example, the Shandong province has established a water rights trading company as a member of the CWE. Many water trading platforms have been established at the county level and below. For example, seven counties in the Xinjiang province’s Changji prefecture have established water rights trading centers and 30 water rights reservation trading platforms.

Table 6.3 Outlook of the CWE

Period	Development conditions	Outlook
Short term	Water rights trading is mainly driven by policies and pilot programs.	Relatively stable
Mid- to long term	The national government requires all water rights trading to be conducted at the CWE	Optimistic
	The national government requires all natural resources, including water, to be traded on the same platform. Therefore, the CWE may be merged or may exist as a branch of the national natural resource trading platform.	Relatively good
	The national government does not issue clear regulations and maintains the status quo. Policy-driven trading will be reduced, while more market-driven trading can be expected.	Challenging

Note: CWE = China Water Exchange.

Outlook of the CWE

The development of the CWE is affected by many factors, including trends in water use, trends in water rights trading, technology development, policy directions, legal foundation, institutional reform, and operational capacity. Taking all these factors into account, it is expected that the CWE will have overall stable development in the short term and far more midterm changes with both opportunities and challenges. The outlook of the CWE is summarized in table 6.3.

Conclusions and Suggestions

Conclusions

China's water rights system has made significant progress. But it is still in the exploration stage and has room for development. There are actual demands for water rights allocation and trading. Water rights allocation is not only a precondition for water rights trading but also a precondition for ensuring agricultural water supply and setting water prices in water-scarce regions. The implementation of China's SWRMS indicates that water rights trading is needed not only in water-scarce regions but also in water-abundant regions to revitalize water rights stocks. Meanwhile, water rights allocation and trading contribute to ensuring ecological water use, improving governmental water governance, and incentivizing public water saving.

Water allocation and trading require preconditions in legal, administrative, economic, technological, and social aspects. Those preconditions include clear definitions of water rights and the existence of tradable allocated water rights, metering and monitoring capacity, and public awareness and participation.

China's water allocation and trading have encountered difficulties. The first problem is insufficient top-level design. The water rights system is not yet complete. A relevant legal framework is lacking. Problems exist in linking the water allocation system and the water withdrawal permit system. The second difficulty is insufficient preparation work. River water allocation is incomplete. Metering and monitoring facilities are insufficient. Water rights trading platforms are scattered and poorly regulated. Intermediary services and public participation need to be improved. Operational costs exceed the financial capabilities of local governments.

Rich experiences have been learned from various pilot programs. Water rights allocation and trading require both hard and soft conditions. Links with other relevant mechanisms also need to be addressed. Water rights allocation requires a large amount of preparation work. Agricultural water rights must follow land ownership. Clarifying initial water rights contributes to further water rights trading. Agricultural water saving is the main source for tradable water. Water rights reservations constitute an effective way to expand the water rights supply, and governmental buyback is an important means to incentivize agricultural water saving. The integration and coordination of different water rights trading platforms needs further exploration.

The CWE will stably develop in the short term and encounter both challenges and opportunities in the mid- to long term. China's water rights market is a quasimarket and is undergoing development. The next 3–5 years form the key period for China to deepen its reform based on the many existing pilot programs. In this period, water rights trading is expected to be mostly policy driven. Trading conditions are good. By 2020, China's comprehensive reform should have achievements in key areas. According to this timeline and considering the transition period after the reform period, in 5–10 years (that is, 2022–27), China's market mechanism will be further improved. The future development of the CWE will depend on national decisions on natural resource trading. There are both opportunities and challenges.

Suggestions

Laying foundations for water rights allocation and trading starts by completing regional water allocation, including total water use control and river water allocation. Improvements can then be made to sectoral water allocation, with emphasis on ecological water use; water conservancy projects; river and lake management; and water resource metering and monitoring facilities.

To accelerate water-related legislation on the national level, water-related regulations and laws should be amended, including the *Water Law of the People's Republic of China* and Decree No. 460: *Regulations on Administration of Water Abstraction Licensing and Collection of Water Resources Charges*. On the local level, water-related regulation amendments should be encouraged.

Water rights reform is essentially the reform of the water resource management system. It is advisable to reform the existing mechanisms that are not suitable for developing water rights trading, such as the water withdrawal permit system.

To innovate water allocation means, the roles of the government and the market should be further differentiated. The way of working needs to be changed. The government's micro-allocation to end users should be substantially reduced.

Improving water rights allocation and trading-related mechanisms includes water allocation coordination mechanism, water rights protection mechanism, water use control mechanism, water market supervision mechanism, intermediary service mechanism, and public supervision and participation mechanisms.

To deepen research into water rights theory, water rights allocation and trading development patterns, as well as related theories, should be reviewed and analyzed.

To raise public awareness, the water rights system should be introduced to all societal actors and consensus should be made. Public participation should be encouraged.

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CHAPTER 7

Best Practices in Cost-Benefit Analysis for Water Investments

Background

China has made significant and high-impact investments in water management and infrastructure. Over the last 50 years, government has recognized the potential for water scarcity to impose potential constraints on economic growth and development. Almost 300,000 kilometers of river dikes and more than 87,000 reservoirs accounting for more than 700 billion cubic meters in storage have been constructed. By 2000, China had built an estimated 85,000 dams, with 22,000 considered large dams, almost half of all large dams globally (Fuggle et al. 2000). While these dams provide benefits to different communities, it is unknown whether they optimized public utility. More than 93 percent of China's rural residents enjoy access to an improved water source. Hydropower capacity is more than 170,000 megawatts, and significant development in irrigation infrastructure enables China to support 21 percent of the world's population with only 9 percent of the world's cultivated land and 6 percent of the world's water resources.

Significant investments have been made in flood protection and management to increase the protection of people and economic assets and to sustain environmental functions. Flood control structures have been built in all major river basins and provide protection for more than 500 million people and about 47 million hectares of land area. These investments have contributed to a reduction in the average annual number of deaths because of flooding, from about 9,000 deaths in the 1950s to 1,500 deaths by the early 2000s. This has been achieved through an increase in overall investments in flood control infrastructure by more than four times from the 1990s to the early 2000s. Much of this progress has been achieved through integration of investments within a comprehensive flood control system that includes infrastructure, early warning systems, and a closely coordinated flood response structure that involves disaster response headquarters at central, river basin, provincial, municipal, and county levels.

These achievements have been made possible through significant public investment, including more than US$200 billion spent between 1991 and 2010.[1] China's central government continues to commit significant financial resources to water management. In 2011 alone, the government allocated 380 billion yuan to improve wastewater treatment and improve water-quality monitoring. Despite these significant achievements, China is facing acute challenges with respect to both water quantity and water quality.

This chapter is based on a summary of the Thematic Report prepared by Mark Radin of the University of North Carolina Chapel Hill.

As investment decisions become more complex, they require a set of tools to facilitate the decision-making process. As development progresses, project planning and project economies are increasingly affected by various aspects of sustainability, including those of a financial, environmental, economic, social, and political nature. Issues of equitability, participation, and governance require considerations of environmental trade-offs. This complexity implies that there is a need for deeper analysis and evidence to substantiate each step in the project's causal chain. These require multicriteria considerations. Key to these considerations is the application of economic analysis to facilitate the analysis of these additional issues while maintaining the basic functions of economic viability. In many countries, legislative initiatives have required cost-benefit analysis (CBA) to ensure that large-scale investments meet specific criteria, often related to efficiency.

CBA is one of a range of analytical tools available to appraise investment decisions that assess the attributable welfare changes and, in so doing, the contribution to specific policy objectives. CBA is an objective method to facilitate a systematic evaluation of the effects of specific projects or policies on society. Each alternative is evaluated by aggregating its positive and negative effects on the goods valued by society, not just the immediate or direct effects, financial effects, or effects on one group. These alternatives are then compared, valuing the gains and losses in monetary terms. This approach is derived from the theory of welfare economics. When countries borrow, and repay, funds for specific projects in which costs exceed benefits, the standard of living of the country declines.

Many governments have adopted CBA as an integral part of the planning and decision-making process for water-related investments with the purpose of facilitating more efficient allocation of resources and demonstrating the convenience for society of a particular intervention over possible alternatives. The goal of a CBA is to provide the final decision maker with as much information about an investment proposal as is relevant to inform the decision. It provides an objective framework for weighing different effects occurring in different periods. This objectivity is supported by converting all effects into present-value U.S. dollar terms. Even when full quantification of the effects is not possible, CBA can still be useful in providing a clear decision-making framework.

Research Objective

The objective of this study is to provide background on international best practices and guidance to policy makers on the use of CBA for policy proposals. The principles are meant to provide guidance in the selection of alternatives, project criteria, project beneficiaries, and decision criteria.

Analysis and Summary

A CBA monetizes all major benefits and all costs associated with a project so that they can be directly compared with one another, as well as to reasonable alternatives to the proposed project. A water investment analysis should start by identifying the challenge or challenges it attempts to address.[2] A baseline set of conditions must be documented, as well as a forecast on future conditions. This is essential for comparing project alternatives to a baseline without intervention. This is often complicated when a receiving environment is already degraded from a legacy of discharges. In these scenarios, the baseline degradation may continue to extract environmental costs if no remedy is applied.

CBA is generally considered the most comprehensive approach to economic analysis, and it requires the following steps: (1) define the problem, (2) select alternatives, (3) determine standing, (4) identify costs and benefits, (5) quantify the value of the benefits and costs over time, (6) calculate the net present value, (7) compare the benefits with the costs, (8) conduct a sensitivity test for uncertainty, and (9) consider equity issues and intangibles. Each of these steps is often subjected to external influences or significant unknowns. Possible mechanisms to influence a CBA include limiting benefit or cost criteria or the set of alternatives assessed within the CBA. However, these issues can be addressed by establishing a well-defined and inclusive planning process and a set of overarching principles for CBAs. CBAs are most trusted and most useful when they involve multiple stakeholders in a transparent process.

A CBA requires data on the project life or number of years to include in the analysis, the values of project benefits and costs expressed in monetary terms for each year included in the analysis, and the discount rate. The period used to define the analysis should to be long enough to capture all potential costs and benefits, and it should not be assumed that the net benefits for one year will be repeated every year. Despite the uncertainty involved in forecasting costs and benefits over long periods, many environmental issues can benefit from long time horizons. Explicitly considering and justifying assumptions underlying the forecasts improves implementation planning and identifies where more effort should be made to improve the analysis.

It is important to identify those parties with standing, that is, whose benefits and costs should be analyzed. Once costs and benefits have been identified and quantified, they should be valued according to common criteria. This allows them to be aggregated and compared. The analysis should account for the inherent risk in calculating the costs and benefits in the project or program. Finally, the benefits and costs should be aggregated across the parties with standing and, through a discount factor, into a common period to determine whether the investment would improve social welfare. These processes are complicated and can influence the outcome of an analysis.

Because the aim of a CBA is to measure social welfare, the notion of total economic value should guide analysts in calculating the costs and benefits of the changes under analysis. This is particularly important for analyzing projects or policies that affect the environment. CBAs take an anthropocentric view and rely on human valuations to calculate costs and benefits. A typology described in the *Millennium Ecosystem Assessment* in 2005 is helpful for identifying the environmental goods and services that humans value. The typology identifies four main types of ecosystem services:

- Provisioning services directly provide physical resources for consumptive or productive uses and include water for drinking, irrigation, hydropower, food, or other items such as medicine.
- Regulating services maintain global and local conditions, such as the filtration of water, the sequestration of carbon, and natural protection from floods, which support environments for human habitation.
- Cultural services are related to experiential activities and include benefits from tourism, cultural practices, learning, recreation, and other psychological or emotional demands.
- Supporting services are the ecological processes and functions necessary for sustaining the cycles and processes that ensure continued survival of an ecosystem.

When analysts use this approach to evaluate an affected ecosystem, they can more easily identify those goods and services that are affected by a proposed alternative. For water investments, the following services are of particular interest: (1) water quality, (2) nutrient regulation, (3) mitigation of floods and droughts, (4) water supply, (5) aquatic and riparian habitat, (6) maintenance of biodiversity, (7) carbon storage, (8) food and agricultural products, (9) raw materials, (10) transportation, (11) public safety, (12) power generation, (13) recreation, (14) aesthetics, and (15) educational and cultural values. Although some of these goods and services have easily monetized or quantified values, others do not. A CBA should include values for all goods and services, regardless of use or nonuse, and transparently identify criteria with unquantifiable values.

Many goods and services from water-related investments are not traded in a market and are difficult to value. Three main approaches are used to value these goods and services: (1) revealed preference methods that rely on existing market data to determine how people value nonmarket goods, (2) stated preference methods that use surveys to measure how specific populations value nonmarket goods and services, and (3) benefit-transfer methods that use existing data on valuations in one population to assume the valuation in another. For projects that decrease extreme events, such as flooding, cost-based estimates or avoided-cost approaches may be informative. However, the nonuse benefits often require revealed or state preference methods for quantifying society's valuation of these goods. Water projects can often involve both use and nonuse goods and services, which complicates a CBA.

The three valuation methods produce uncertain estimates. Valuation studies of environmental projects also suffer, because not enough is understood about how complex ecological systems cope with pollution or other damage, which makes quantifying the benefits difficult. Another important critique is that these methods can only be applied to ecosystem services that people experience or understand and that influence their choices in related markets, such as where to purchase property or spend recreation time (Börger et al. 2014). This limitation is increasingly problematic as technology improves, and infrastructure projects can interfere with ecosystems that are poorly understood, like the deep sea. Many remote aquatic ecosystems may provide significant but unseen services. Previous attempts to measure the value of marine ecosystems focused on the values of wildlife, such as dolphins or turtles (Börger et al. 2014).

CBA involves aggregating costs and benefits across individuals without explicit regard to the equity or otherwise of the distribution of those costs and benefits among individuals. However, decision makers would normally wish to consider the identity of gainers and losers resulting from a project (and the magnitude of the gains and losses) in making a decision to proceed or not. In most cases, this need is best met by including a distributional incidence matrix, which sets out the identities of groups or communities that gain or lose from the project or program and the expected size of those gains and losses. In exceptional circumstances, in which it can be justified by clear reference to established government policy, analysts may be justified in attaching differential weights to costs and benefits that accrue to particular groups. Such weights and the basis for them should be stated explicitly. However, a full unweighted analysis should always be presented.

The rate that converts future values into present values is known as the discount rate. Discount rates are used to convert benefits and costs into values in one period. Standard economic analysis links social discount rates to the long-term growth prospects of the country in which the project takes place. This is because future benefits and costs should be valued at their marginal contribution to welfare, which will be lower with the higher growth and richer future project beneficiaries. However, this can be difficult for water investments, because environmental effects often occur over long periods that can extend beyond the expected life of infrastructure projects. A discount rate represents a complex relationship between the value of consumption today and the value of consumption in the future. Higher or lower growth prospects would normally imply a higher or lower discount rate, respectively, for a particular country. A discount rate for environmental goods and services is an estimate of how the current population values those services for the future generation. In addition, some argue that a constant discount rate does not adequately reflect how people value benefits over time. They argue for declining rates, which give a greater weight to long-term benefit. Regardless of the social discount rate chosen, it is good practice to provide a sensitivity analysis that calculates the net present value of the project for a range of discount rates.

An objective method for applying the results of a CBA is essential for informing decision making. The concept of Pareto efficiency is that only those projects or policies that can make at least one person better off without harming any other person should be adopted. However, a more common approach for interpreting CBA results is the Kaldor-Hicks approach, which accepts projects when the economic benefits are greater than the economic costs. This approach is based on the hypothetical scenario that if those who gained from a project fully compensated those who lost, those who gained would still be better off.

Conclusions and Suggestions

Continued demand for water for sustained growth, coupled with scarcity, growing uncertainty, greater extremes, and the challenges of fragmentation, requires increasingly complex investments in infrastructure, along with institutional strengthening and improved information management. To deal with these interlinked challenges, countries need to continuously improve the management of water resources and associated services to strengthen water security.

Given the complexities and shifting societal values, it may not be possible to arrive at a comprehensive monetary value of benefits, or it may be prohibitively costly to do so. As a result, decisions around water resource management and development are increasingly be guided by multiple objectives measured in different units. Multiple criteria analysis (MCA) allows decision makers to include a full range of social, environmental, technical, economic, and financial criteria. MCA is particularly helpful when a single-criterion approach (such as CBA) is inadequate, especially when significant environmental and social effects cannot be assigned monetary values.

CBA is an important analytical tool that can provide economic criteria to help inform investment decisions by assessing the attributable welfare changes and, in so doing, the contribution to specific objectives. A CBA monetizes all major benefits and all costs associated with a project so that they can be directly compared with one another, as well as to reasonable alternatives to the proposed project. The following recommendations are based on international best practices and intended to guide measures to strengthen the multicriteria framework for decision making around future investments in water resource projects and programs.

The first recommendation is for China to establish a set of water investment priorities to help guide investment decisions and CBAs. These principles can include both quantifiable and nonquantifiable priorities such as equity, specific environmental standards or goals, or project approaches.

The second recommendation is to include a CBA or a requirement for assessing costs and benefits into legislation or a regulatory framework and provide guidance on adhering to this requirement. This would help ensure that planners incorporate costs and benefits into their planning and that society's benefits are considered, rather than just specific populations' benefits.

The third recommendation is to standardize the project planning and assessment process to help ensure transparency and to encourage collaboration efforts for the cost-benefit assessment. Aligning the environmental assessment with the CBA allows the environmental costs and benefits of alternatives to be captured as part of the feasibility studies.

The fourth recommendation is to support additional academic research into both the environmental effects of water infrastructure projects and the local valuations of ecosystem services. These efforts could improve the planning processes and decrease the costs of CBAs.

The last recommendation is to incorporate qualitative efforts in defining project beneficiaries and selecting alternatives to analyze. This can help improve support for the results of the analysis. In addition, using qualitative measures can help analysts define the parties with standing for a CBA.

Box 7.1 Example of CBA with Ecosystem Service Valuation in China

An ecosystem valuation approach to a cost-benefit analysis (CBA) was used by Lei et al. (2011) to measure the utility change associated with rehabilitation of land along Nansi Lake, in Shangdong province, aimed at improving water quality as part of the South-to-North Water Diversion Project. This approach helped identify which farmland should "be converted to wetland in the watershed-scale wetland rehabilitation in Nansi Lake ... to choose priority in restoring farmland areas and determining the amount of payments for ecosystem services" (Lei et al. 2011, 788).

To rehabilitate the wetland, the government was paying farmers to convert their farmland into wetland to reduce pollution and restore the ecosystem. Once a farmer enrolled, the project compensated farmers 100 percent of the previous year's income from the farmland for the first year and 60 percent of that same amount during the second year. Starting in the third year, farmers would no longer be compensated.

The Shandong Environmental Protection Bureau collected data on potential farmland to rehabilitate and collected plot-specific data, including information on the crops grown, the pesticides used, and the economic return, of different parcels of land. These data helped the analysts divide the farms into low-productive, normal-productive, and vegetable farms to estimate the financial returns for different farmers.

Nansi Lake provides recreation and tourism benefits, and the study used data from the Weishan statistical bureau, to estimate a tourism value for restored wetland. In addition, the analysts included the value of the wetland's ability to improve water quality.

The analysts found that the project had a significant economic return; however, the farmers on the normal-productive and vegetable farms were less well off after land conversion because they only received compensation for 2 years.

The analysis shows that society would be better off if the government continued to pay these farmers to remain enrolled in the program and restore the wetlands. This provides significant benefits:

> For the upstream area, after wetland rehabilitation, the opportunity cost will be 1.88×10^8 Chinese yuan each year, including reduction of biomass value and increase of tourist income. And for the downstream area, the wetland rehabilitation will reduce the cost of water purification at a value of 1.14×10^9 RMB, 6 times the upstream opportunity cost.... In addition, after wetland rehabilitation, each hectare of wetland will potentially increase the local tourist income at a value of about 4,877 RMB each year in the long-run. (Lei et al. 2011, 795)

Box 7.2 Who Should Perform the Cost-Benefit Analysis

Deciding who should perform cost-benefit analysis (CBA) for a new project presents a dilemma because two desirable attributes, familiarity and objectivity, are unlikely to be found in the same group. Those who are most familiar with the project are usually those who are promoting it; they may not be sufficiently objective to conduct an unbiased assessment of costs and benefits.

Some propose that borrowing countries should carry out the cost-benefit analyses for their projects. Objectivity would still be critical because project promotion exists both in client countries and in the World Bank. One variant of this proposal would be to entrust the CBA to an independent agency within the borrowing country, if such an agency exists and functions effectively. Consultants hired by project promoters are not necessarily the answer, as they may have an interest in securing the next consulting contract.

One question is whether objectivity can ever be ensured if the analysis is entrusted to a single group. The analogy with legal systems may be helpful. The task of eliciting an objective verdict does not rest on the assumption that either the prosecution or the defense will be objective. The truth is expected to emerge in the debate between the two.

The accountability system in development agencies is typically built around the assumption that those close to the project will provide objective information. Some agencies are overseen by independent groups, such as the World Bank, but these groups usually do not assess and rate projects until after they have closed. An independent voice to check the CBA and the quality of monitoring and evaluation plans before a decision is made to proceed with the project could strengthen accountability.

Notes

1. This does not include investments made in water supply networks and sewage systems at the provincial level or through the Ministry of Housing and Urban-Rural Development.
2. Although this chapter focuses on the planning process and *ex ante* CBAs, other types of CBAs are possible. A midterm analysis or *ex post* analysis can help policy makers stop or expand a project, as well as assess whether previous projects had the intended impacts and should have been built, which can help improve future CBAs. A complexity in *ex post* analysis is the difficulty of comparing the project or policy to a counterfactual world in which the project or policy never occurred.

CHAPTER 8

Policies on Water Prices, Taxes, and Fees and Their Implementations

Background

China is facing multiple water challenges, including water scarcity, water pollution, and water ecological deterioration, generating substantial effects on water security and an ecological civilization. As an economic instrument for better water development and utilization, water price has played an important role in promoting resource saving and environmental protection. Governments at all levels in China have set their water prices, and relevant departments are in charge of water fee, water resource fee, and wastewater discharge fee collection. Fee usage is also regulated. However, the water price formation and water governance market mechanisms are not yet complete.

First, a reasonable water price formation mechanism has yet to be established. Water prices are still relatively low, and the water price structure is not reasonable. The water resource fee occupies a too small proportion and, in some places, the wastewater treatment fee is not included in water supply prices. The role of water prices in providing cost recovery for water suppliers, compensating environmental costs, and incentivizing water users to save water is not effective. Second, the water price management system and mechanism are not yet complete. Water management organization is fragmented; water user engagement in setting up and adjusting water prices is insufficient; water fee measurement and collection are not scientific; the water price supervision mechanism needs to be improved; and water price collection, usage, and management are not well regulated. In particular, institutional flaws exist in collecting and using water resource, wastewater treatment, and wastewater discharge fees. Third, the water supply pricing system is not complete. The distributions and differences of various prices are not reasonable, and fees and taxes for water suppliers are not scientifically applied.

This project aims to study the policies on water prices, taxes, and fees in China and their implementations and to offer corresponding suggestions on reforming and developing the water security market mechanism with Chinese characteristics to provide decision support for the formulations of related laws, regulations, and other institutions.

Research Objectives

Guided by the scientific development concept, this study aims to offer policy suggestions on

This chapter is based on a summary of the Thematic Report prepared by Yuxiu Zhong, Jian Fu, and Peilei Li from the Development Research Center of the Ministry of Water Resources.

China's water prices, taxes, and fees and their implementations within the framework of water security governance. It addresses the economic attributes of water resources and highlights water supply's basic functions as a common good. It aims to provide suggestions for establishing reasonable water price formation and water governance market mechanisms with Chinese characteristics to determine the pricing mechanisms' role in prioritizing water allocation, promoting resource conservation, and providing environmental protection.

Analysis and Summary

Breakdown of Water-Related Value Forms

Water, involving both quantity and quality, is an irreplaceable natural and environmental resource that is required for production and human survival. In certain economic and technological conditions, it can serve as fresh water that is directly used or reserved for future use in the society, taking part in natural water cycles and affecting economies. Analyses on the values of water resources have been mainly based on the western utility theory, Marx's labor value theory, ecological value theory, and the like. The new value system, which combines the utility value theory and the labor value theory, is being developed and gradually recognized by the public.

The Chinese constitution and the *Water Law of the People's Republic of China* stipulate that water resources are state owned. The realization of ownership is the inevitable result of a market economy. As a commodity, water resources have economic attributes, which are noticeable in absolute rent, differential rent, convertible water assets, water prices, and water value flows.

China's major economic instruments are pricing, taxation, administrative fees, and other profit-making charges. In terms of the management of water resource utilization, the main economic means include water prices, water fees, and water taxes. China's water prices are classified as the water supply price from water conservancy projects and the urban water price. Water fees include administrative fees and other profit-making charges. The administrative fees include the water resource fee, the wastewater treatment fee, and the water fees for nonresidential water use beyond water quotas, while the profit-making charges are categorized into agricultural water fees, tap water fees, and other fees paid on the basis of the water price. The water tax is not a real tax. Instead, it is a general name of all taxes in the field of water governance, including the water resource tax.

In China, the most common water-related value forms include the water price, the water resource fee, the wastewater treatment fee, wastewater discharge fee, and the water resource tax.

Development of Water-Related Value Forms in China

Water Prices

The water supply price from water conservancy projects has experienced changes from nonprofit water into commodity water. Ratification, collection, and management of the water price have been legalized. A reasonable water price–setting system has been initiated and gradually developed. The water pricing and cost supervision systems for water conservancy projects have been established, and the water pricing system has become increasingly scientific. The urban water pricing system has shifted from a single pricing system to block or progressive pricing systems. Categorical pricing has been gradually developed in a scientific way. The water pricing system has been gradually established in an increasingly scientific manner. In addition, the water price supervision and evaluation system has been established to replace cost and price surveys, as well as price approval systems.

Water Fees and Water Taxes

The water resource fee has been established with a gradually improved collection management system and increasingly strict collection management measures. In the future, the water resource fee may be changed into a water resource tax. The wastewater treatment fee has been growing rapidly since it was established, but it is still at a lower level than the global average. The wastewater discharge fee has been collected for a long time with mature management measures and will be transformed into an environmental tax. China's water resource tax is still under exploration. A water resource tax reform pilot program has been set up in the Hebei province.

Status and Future Trends of the Water Price in China

Policies

At the central government level, there are several relevant laws and regulations, such as the water law, price law, and *Regulations on Farmland Water Conservancy*; various management measures, such as "Management Methods of Water Suppliers in Water Conservancy Projects" and "Management Methods of the Water Price in Cities"; and many documents, including "Circulars of the State Council General Office on Promoting Water Price Reforms to Boost Water Saving and Water Protection," "Circulars of the National Development and Reform Commission and the Ministry of Construction on Relevant Matters of Water Price Management in Cities," and *Opinions of the State*

Council General Office on Pushing General Reform of the Agricultural Water Price. At the local government level, many corresponding documents have been released to clarify management systems, pricing principles, water price structures, water fee collection, and utilization and management of the hydroproject water price, urban water price, agricultural water price, reclaimed water price, and so forth.

Status

The water supply prices for water conservancy projects include the agricultural water price and nonagricultural water price. In practice, the water supply price for an agricultural water conservancy project refers to the water price for a lateral canal without considering the water price for the canal at the last stage. In some areas, water prices vary when water is used for different food crops, economic crops, husbandry, and so forth.

Urban water uses are divided into urban residential water use, nonresidential water use, and special water uses. The special water use price is higher than that of nonresidential water use, while both higher than the residential water price. In most cities, a tiered pricing system has been adopted for residential water. In a few cities, a progressive pricing system for excessive nonresidential water use has been implemented.

The agricultural water price is the final water price for users, including the water supply price for water conservancy projects (lateral canal or above) and the water price of the canal water system at the last stage. In 2009, as assessed by the Development and Reform Commission and the Price Bureau of the Ningxia Autonomous Region, the water price of the Yanghuang Main Canal for the Yanhuanding area was approved to be 0.157 yuan per cubic meter, and the water price for final users was set at 0.174 yuan per cubic meter. In some areas in Sichuan, Guangdong, and Zhejiang provinces, the agricultural water price is exempted, while the tiered water pricing system is used in some areas in Ningxia province.

As of 2010, 37 cities and counties in 18 provinces (autonomous regions and municipalities), Beijing and Tianjin included, have set a reclaimed water price and have collected reclaimed water fees of 249 million yuan in total.

Future Trends

The water supply price for water conservancy projects is expected to be determined categorically. Different projects will be subject to different water price management. The policy of "industries subsidize agriculture" may be implemented, raising the industry water price to cover partial costs of agricultural water uses.

The urban water price is also expected to be determined categorically. The tiered water pricing system for urban residents is expected to be expanded. The system of progressive pricing for excessive nonresidential water use will be promoted extensively. Finally, the water price adjustment procedure will be implemented strictly.

In contrast, the agricultural water price will be directly collected from villages or households. A discounted price for water use within the water quota and a progressive price for excessive use will be implemented. A categorical water price will be implemented for different types of crops. Precise agricultural water subsidies will be released. Finally, water-saving incentive mechanisms will be set up.

The reclaimed water price will be set in accordance with a few principles: cost recovery, reasonable profit, high price for high quality, fair burden, and use orientation. It will also be adjusted according to the cost and to market supply and demand. The reclaimed water price should be lower than the tap water price. The government should subsidize enterprises using reclaimed water. The price of reclaimed water is expected to be determined categorically. The relationship between reclaimed water and tap water should be determined reasonably. Finally, the price linkage mechanism between reclaimed water and tap water will be established step by step.

Status and Future Trends of the Water Resource Fee and the Water Resource Tax in China

Status of the Water Resource Fee

The *Water Law of the People's Republic of China* has laid the legal foundation for the water resource fee. *Regulations on Management of Water Abstraction Permission and Water Fee Collection* and "Circulars on Relevant Issues of Standards of Water Fee Collection" also provide references for the management of water resource fees. Many local governments have launched programs for water resource fee collections. As in 2018, the water resource fee is collected in 31 provinces (autonomous regions and municipalities) in China.

Status of the Water Resource Tax

The implementation of a water resource tax is in the pilot period. Since the official start of the pilot period on July 1, 2016, the Hebei provincial government has collected a water resource tax to an accumulated amount of 716 million yuan, a 100 percent increase compared with the water resource fees collected in the same period in 2015.[1]

Future Trends of the Water Resource Fee

Several changes are anticipated for the water resource fee. The pricing mechanism will be more scientific and reasonable, and the water resource fee standards will be raised. The tiered pricing system or the progressive pricing system will be promoted, as will the fee-to-tax reform that is in the pilot phase.

Status and Future Trends of Wastewater Treatment and Discharge Fees in China

Status of the Wastewater Treatment Fee

Regulations on Urban Drainage and Wastewater Treatment stipulates that discharging units and individuals should pay the wastewater treatment fee in accordance with the relevant regulations of the state. "Circulars on Relevant Matters of Formulating and Adjusting Wastewater Treatment Fee Standards and Other Issues" and "Measures of Management of Collection and Use of the Wastewater Treatment Fee" provide details on the standard, collection, use, and management of the wastewater treatment fee. So far, 36 large and medium-size cities have started to levy the wastewater treatment fee, which is generally less than 2 yuan per cubic meter. At the end of 2012, the average residential wastewater treatment fee of these cities was 0.81 yuan per cubic meter, accounting for 29.5 percent of their water price. The average urban nonresidential wastewater treatment fee was 1.13 yuan per cubic meter, accounting for 27.8 percent of their total water costs.

Status of the Wastewater Discharge Fee

Regulations on Management of Collection and Use of the Wastewater Discharge Fee and "Measures of Management of the Collecting Standard of the Wastewater Discharge Fee" stipulate that enterprises and individually owned businesses that directly discharge pollutants into the environment (hereafter called polluters) should pay wastewater discharge fees in accordance with the provisions.

Future Trends

Among future trends, a comprehensive wastewater treatment fee collection system is expected to be established, and the collection rate is expected to be increased. In addition, the wastewater discharge fee will be replaced by an environmental tax.

Effects, Problems, and Deficiencies of the Water Price

Regulating Role and Effects

In terms of water prices, awareness of commodity water has been developed widely to provide effective economic leverage for water saving. Water efficiency has been improved, and optimal allocation of water resources has been promoted. In addition, people's livelihood and basic water use have been guaranteed. The price of reclaimed water is lower than that of tap water to improve the economic efficiency of enterprises. The water supply price for water conservancy projects provides project operators with an important source of maintenance funding, ensuring the sound operation of managers in irrigation areas. The reform of the agricultural final water price has solved the challenges for maintaining canals at the last stage.

Problems

The water price for water conservancy projects is still much lower than the water supply costs. The water supply price for agricultural water conservancy projects is generally low. The pricing method for the water price is too simple; charging by the acre is still the main charging method in most irrigation areas, and charging by a measured amount is not popularly used. In only a few small irrigation areas, tiered or progressive pricing systems are implemented for the agricultural water supply as pilot projects.

The overall level of the urban water price is still low. The comparison between water prices for different uses is not reasonable enough. The price formation mechanism is not perfect. Metering and monitoring facilities need to be improved.

The overall level of the agricultural irrigation water price is also low. The agricultural irrigation water price is lower than the cost. The actual agricultural collection rate is also low.

There is no reasonable price difference between reclaimed water and tap water. There is no pricing policy for reclaimed water. There is no clear pricing basis, and there are no clear pricing procedures. Reclaimed water prices on water supplies of different qualities have not been established.

Deficiencies in Meeting the Objectives and Requirements of Water Governance

Meeting the objectives and requirements of water governance means facing several issues. First, the water price for water conservancy projects is low. Water conservancy project maintenance and repair lack funding, and engineering facilities are aging badly. Second, the ratio of groundwater price to surface water price is unreasonable, and the cost of groundwater use is too low to curb the overexploitation of groundwater. Third, there is not a reasonable price difference between the unconventional water price and the conventional water price. The substituting role of reclaimed water is not fully effective. Fourth, the agricultural water price is low, and irrigation water is measured by irrigated area instead of water use. Thus, farmers do not have high enthusiasm for water conservation, which results in both water shortages and water waste.

Effects, Problems, and Deficiencies of the Water Resource Fee

Regulating Role and Effects

Through the water resource fee, paid use of water resources is arranged preliminarily, and water conservation is promoted. The fee provides funds for the development, use, and protection of water resources.

Problems

Several problems must be addressed in relation to the water resource fee. The overall collection standard is low and lacks a unified calculation method. In addition, the collection rate of the water resource fee is relatively low. Water resource management is not in place, and there is no progressive pricing system for the water resource fee in most regions. Water resource tax reform has just started.

Deficiencies in Meeting the Objectives and Requirements of Water Governance

The water resource fee cannot reflect the scarcity of water resources effectively. The regulating role for water saving is limited. In addition, funding for water resource development, use, and protection is inadequate.

Effects, Problems, and Deficiencies of Wastewater Treatment and Discharge Fees

Regulating Role and Effects

By implementing wastewater fees, pollutant discharges have been reduced. At the same time, water recycling has increased.

Problems

A key problem related to the wastewater treatment fees is that standards are not unified and are relatively low. There are no mature price differences among treatment of wastewater of different pollutants and loads. In addition, neither a collection mechanism nor a management system for wastewater treatment fee is in place.

Deficiencies in Meeting the Objectives and Requirements of Water Governance

In terms of water governance, wastewater fees cannot reflect the principle that polluters should pay. Their role in reducing pollution discharge and in promoting water resource utilization is weak. Wastewater fees also cannot meet the funding demands for expanding wastewater treatment facilities and promoting pollution prevention and control.

Conclusions and Suggestions

Reform of the Water Price, Water Resource Fee, Wastewater Treatment Fee, and the Water Resource Tax

The agricultural water price formation mechanism should be reformed comprehensively. The cost of the agricultural water supply should be assessed in a scientific way. A mechanism of water price allocation between the government and farmers needs to be set up. Financial subsidization should be promoted to cover expenses related to the operation and maintenance of irrigation and discharging projects. Discounted water prices for uses within the water quota and progressive prices for excessive water use should be promoted. Enhanced support should be given to promote agricultural water supply metering facilities and the agricultural water fee collection system, promoting water supply metering and door-to-door allocation, charging, and billing".

The nonagricultural water price should be actively reformed, and efforts to adjust the nonagricultural water price for water conservancy projects should be enhanced to reach cost recovery and reasonable profitability as soon as possible.

Deepening water price reform in cities starts by facilitating comprehensive urban water reform. Urban water use should be categorized as urban residential water use, nonresidential water use, and specific water use. Commercial water prices should be the same as industrial water prices. Conditions for water price reform must be created in all cities and allow room for water price rises. It is necessary to design a better tiered water pricing system and reduce the effects on low-income households. Accelerated improvement of the progressive pricing system for excessive nonresidential water use will lead to better results.

The paid-use system for water resources and the collection and the management system for water resource and wastewater treatment fees need to be improved. Water resource fee and wastewater treatment fee standards should be raised. The water resource fee for self-prepared water sources should also be raised gradually. The usage of collected water resource fees should be well regulated and dedicated to specified issues. In addition, the water resource fee should be exempted for reclaimed water to promote its utilization and replace conventional water sources. Wastewater treatment fee standards should be raised to cover the cost with minor profitability.

To promote water resource tax reform, lessons from the Hebei pilot experiences should be reflected and the pilot program should be expanded. A national water resource tax reform should be planned.

To improve the tax and fee system for water suppliers, tax and fees should be exempted for reclaimed water. For example, an enterprise value-added tax can be exempted or income tax can be halved for reclaimed water suppliers or enterprises to promote reclaimed water utilization.

Policy Suggestions for the Construction of a Water Governance Market Mechanism with Chinese Characteristics

To deepen the water price reform and to improve the water pricing mechanism and system, the first step is to establish a reasonable water price formation that is able to reflect changes in water demands and supplies. The water supply price should reflect the water values and demands in different regions of different sources for different users. The second step is to establish a water pricing system that encourages reclaimed water to replace conventional water resources. Therefore, reclaimed water should be cheaper than tap water, and governments should subsidize reclaimed water. Third, seasonable water prices should be adopted according to different cities' characteristics to ease the seasonal water conflicts. Fourth, the groundwater price should be increased to promote groundwater protection. Finally, a water pricing system should be established that contributes to water conservation and pollution reduction.

To strengthen cost constraints and improve water use efficiency, dynamic water price formation and evaluation mechanisms should be established. Supervision and evaluation of enterprises' operational costs and other related costs should be enhanced to calculate water supply and treatment costs. In addition, a water supply price monitoring mechanism should be improved by calculating the average societal costs of regional water supply engineering projects. Management regulations on water supply cost assessment should be amended. Statistic and assessment mechanisms should be established in terms of the average costs of the water supply sector, with a market mechanism introduced to facilitate the reduction of water supply costs.

Coordinating water price reform with other reforms involves regulating the use of collected water fees and encouraging water users to supervise the water suppliers' use of collected water fees. Enterprises need reasonable investment returns and profitability. Institutional reform of the management of water engineering projects must be deepened.

To strengthen relevant legal system construction, the "Management Methods of Water Price for Water Conservancy Projects" should be amended as soon as possible to improve the water pricing system. Experiences from agricultural water price reform should be incorporated. Discounted water prices should be applied to water uses within the water quotas, while progressive water prices should be applied to excessive water uses. Progressive water prices for nonagricultural water uses should be explored. The water pricing mechanism in which industries subsidize agriculture and urban subsidizes rural should be established. The "City Water Supply Price Management Methods" should be amended to "Urban Water Price Management Methods" to legalize water supply price management in counties. "Rural Water Supply Price Management Methods" should be formulated to regulate rural water supply water prices. "Water Engineering Projects Maintenance Fund Use Management Methods" should be promulgated to regulate the use of the funding for maintenance.

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Note

1. The resource fee was collected by the water department based on water use data that are difficult to obtain without sufficient monitoring capacities and are often underreported by water users. The water resource tax is collected by the tax department based on production data and related water quotas. Therefore, changing the water resource fee to a tax enhances the implementation of the value charging and collection system.

CHAPTER 9

Flood Risk Management and Flood Insurance

Background

Because of the effects of monsoon climate and three tiers of topography, the spatiotemporal distributions of China's precipitation are highly uneven. Moreover, socioeconomic development is highly concentrated in flood-prone areas, making flooding the severest natural disaster in China. From ancient times, floods have posed serious dangers to the Chinese nation. China started and has been benefiting from flood control.

Since 1949, through long-term river basin management in the Yangtze, Yellow, Huai, and Hai River Basins, flood damage has been effectively controlled. Flood prevention and control structures in China's major rivers have been able to deal with the most serious floods since 1949, ensuring steady and continuous growth of China's economy. In the twenty-first century, the characteristics of China's flood risks have changed significantly because of the compounded effects of global climate change and rapid urbanization. Requirements for flood prevention and control keep increasing along with socioeconomic development; difficulties related to flood prevention and control have also increased.

Therefore, it is necessary to review the overall status of China's flood risks, to analyze the existing problems and challenges in flood risk management, to establish flood risk management mechanisms, to operationalize such mechanisms, and to develop a more complete flood risk management system. The roles of flood insurance and land management in flood-prone areas, as well as flood risk sharing and flood recovery capacity improvement, should be highlighted to fully implement flood insurance management in China and support the sustainable development of social economies.

Research Objectives

This study analyzes China's flood characteristics and the weaknesses of China's flood prevention and disaster reduction. It then analyzes the causes and evaluates the overall status and context of China's flood disasters. Flooding effects on China's water security and socioeconomic development are examined, and improvements to the flood management system and flood insurance are proposed.

The research includes tasks from five aspects. The first aspect is flooding effects on social, economic, and environmental aspects. The second aspect is on context and challenges of China's flood prevention and control, as well China's flood prevention and control capacity. The third aspect is flood disaster evaluation,

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including overall evaluation, evaluation of typical areas, and flood causes. The fourth aspect is flood insurance research, including the status of and problems related to flood insurance in China. The final section focuses on institutional improvement, including the flood risk management system, land use management system, flood prevention structure, emergency response mechanism, and flood insurance mechanisms.

Analysis and Summary

China's Flood Prevention Structure

Flood Disasters in China

Through its location next to the Pacific Ocean, China is affected by land-ocean circulation, monsoons, and tropical cyclones. Its precipitation decreases gradually from southeast to northwest. The largest storms in the east are close to world records. The middle and lower reaches of seven major rivers and coastal areas have abundant rainfall, 60–80 percent of which is concentrated during 4 months. Meanwhile, 67 percent of the national population, 35 percent of farmland, 90 percent of large and medium cities, and 80 percent of agricultural and industrial added value are located in China's flood-prone areas. Flood disasters significantly affect societal safety and socioeconomic development. China is one of the countries that suffer from the severest flood disasters.

From ancient times, flood disasters have been the evil of Chinese civilization. Flood control has played a vital role in maintaining social security and power change. Failure in flood control has resulted in social turbulence and regime change. Flood disasters have had severe effects on human lives and social development. For example, in the 1915 Pearl River flood, Guangzhou City was submerged for 7 days and casualties exceeded 0.10 million people. In the 1931 Yangtze River flood, the flood-caused death rate reached 0.15 million people. Total casualties exceeded 0.40 million people because of the subsequent plague and famine. After the People's Republic of China was established, with the construction of flood control infrastructure and increased flood control capacity, the number of deaths caused by floods has constantly decreased. In 2000–16, the flood-caused death rate was around 1,248 deaths per year. Among these, 909 deaths were because of small river floods and torrential floods. With rapid economic development, flood-induced economic loss has been enlarged. In the 1950s, flood-induced economic loss was 219,000 yuan per square kilometer, but it rose to 1,373,000 per square kilometer by the 1990s, an increase of more than five times. The structure of the damage has also changed: agricultural damage has decreased, while damage in industrial, transport, electric, and telecommunication sectors has grown significantly. Since the start of the twenty-first century, flood damage occupies around 1.41 percent of the national gross domestic product every year. In years with large floods, the rate can go up to 4 percent.

Flood Control System

Flood prevention structure has been established, comprising blocking, drainage, and detention and diversion projects, such as reservoirs, dams, and flood detention areas. Major rivers are equipped with relatively high flood-defense levels. For example, the upstream and main tributaries of the Yangtze River can defend against floods with a 20-year return period, while the downstream areas can cope with floods on the scale of those that occurred on the river in 1954. The downstream areas of the Yellow River are equipped with a flood-defense level with a 1,000-year return period, while a 40-year return period is found in the middle reach. Over half of the flood-prone cities in China have reached the national standard of flood prevention. Coastal cities, such as Shanghai, are equipped with flood-defense levels against a 100- to 200-year return period. Flood prevention sections in other important cities also have a 50- to 100-year return period, while most other regions are equipped with flood-defense levels lower than a 20-year return period.

In addition to improving engineering infrastructure, nonstructural solutions should be facilitated to improve overall flood prevention and control capacity. A series of laws, such as the water law and flood prevention and control law, were issued. A flood management system has been constructed, with flood-focused emergency response agencies at all levels and a specialized emergency response team. A flood forecasting and warning system has been established, and a flood emergency plan covering all levels of government and flood situations has been formulated. A scientific flood management system has been established, comprising blocking, drainage, and detention and diversion measures.

Flood Control Context and Challenges

Global Climate Change

Against the backdrop of global climate change, the average temperature of Earth has increased 0.7°C–1°C, which increases evapotranspiration and atmosphere humidity and leads to increases in the frequency and severity of extreme precipitation, uncertainties in large river floods, damage from small and medium river floods and torrential floods, and urban flooding events. Moreover, the increase in the average global temperature leads to polar ice cap melting and sea-level rise, decreasing the capacity of coastal cities to defend against storms and so forth.

Modern Urbanization and Industrialization

The expansion of urban areas; concentration of industries; heat emission from factories, vehicles, and domestic energy uses; and effects from architectural structures have increased the heat island effect and rain island effect, and the amount and intensity of rainfall have increased significantly. Impermeable areas are growing because of the construction of urban houses, roads, and squares. Infiltration of precipitation decreases, while surface runoff increases. Flash floods often appear with increased peak discharge.

Meanwhile, information- and technology-driven industrialization has increased cities' dependence on the information system unprecedentedly. Affected areas are larger than flooded areas. Indirect losses could be a few or even ten times greater than direct losses. Population concentration, urban expansion, industrial concentration, and lifestyle transformation have all posed new requirements on flood control and drainage. Green infrastructure must be added to build resilient cities and explore intensive, smart, green, and low-carbon flood control measures.

Poverty Alleviation and Societal Development

Poor areas in China are mainly located in the middle and western regions, especially mountainous areas. These areas have frequent sudden rainfall. Watercourses are steep, with rapid flow rates and damaging power, and therefore warning and prevention difficulties, in some sections, negatively affecting poverty alleviation in poor mountainous regions. Achievements in poverty alleviation can be wiped out by serious floods. Flood-induced poverty is common. The national poverty alleviation strategy has posed higher requirements on flood prevention and control. Weaknesses in flood control and drainage infrastructure must be addressed to reduced flood effects and ensure poverty alleviation achievements, to promote the construction of a well-off society in all aspects.

Main Problems Related to Flood Prevention and Control

Infrastructure

Some flood prevention infrastructure has not been constructed according to the requirements. Flood-defense infrastructure against torrential floods and floods in small and medium rivers is insufficient. Many rivers have no defense infrastructure. Some cities' flood-defense levels do not meet the requirements. The existing drainage systems are insufficient. Existing projects still face maintenance issues such as negligence in maintenance. The lack of routine monitoring and safety evaluations leads to hidden problems that remain unseen for a long time. A long-term maintenance mechanism needs to be established.

Legal Foundation

Flood risk management is almost nonexistent in the existing legal system. Because of a lack of legislation and supervision, project development often neglects flood risks and occupies flood-prone areas, which may lead to severe flood damage and human casualties. Flood risk zoning, flood-prone land use, and flood risk disclosure, as well as education, need to be advanced.

Land Use Planning and Management

Land use planning is not strictly implemented in flood-prone areas. Flood management planning, land use planning, and other relevant planning sectors do not match. Land is not properly developed in some regions according to relevant laws and regulations. Improper occupation of rivers and lakes prevails, which leads to a decrease in regional flood detention capacity and to blockage of flood drainage. Sponge city construction is at the starting stage, while sponge city infrastructure is insufficient. Some river occupation by urban construction still exists.

Flood Emergency Management

In terms of flood emergency management, coordination of governments of different levels and across departments is insufficient. The planning systems in some areas are incomplete or infeasible. The accuracy of monitoring, forecasting, and warning should be improved. Emergency response at the basic level is insufficient. Relevant technologies are still weak. Society participation in flood disaster reduction is insufficient. Education methods are simple and singular, and education coverage is insufficient. Public knowledge and awareness of and capacity for flood disaster reduction should be enhanced.

Flood Insurance

China has not yet established national insurance for flood damage. Since the 1980s, China has promoted a few pilot programs on types of flood insurance. However, because of lack of knowledge by local governments and the public, the pilot programs were not advanced and faced difficulties in collecting insurance fees, along with other issues. The existing flood-related insurance types include commercial property insurance and policy agricultural insurance. In such insurance policies, flooding is included as one of the natural disasters. However, because the insurance rate is not correlated to the actual flood risks, insurance areas are mainly in flood-prone regions. Once a flood happens, insurance companies face substantial payment requirements and therefore have low interest in offering such policies.

Suggestions for a Flood Risk Management and Insurance Mechanism

Establish a Flood Risk Management System

Based on in-depth understanding of flood risk characteristics and changing patterns, a flood management system that suits China's characteristics should be incorporated into the existing legal system. Legal documents such as the flood prevention law should be amended to advance the implementation of flood risk management measures. The roles and responsibilities of different departments should be clarified in the legal framework and the coordination mechanism. Institutional reform should be facilitated to enhance interdepartmental coordination and capacity building. In the law's implementation, law violation and poor enforcement should be eliminated to establish stable financial assurance, strengthen research and technical support of flood risk management, and raise public awareness. In terms of securing people's lives, a flood risk management system should be established to mitigate the risks to a mild level and maximize the benefits of land utilization and even flood resource utilization in flood-prone regions as well as to attain comprehensive, coordinated, and sustainable development.

Enhance Land Use Management

Land use in flood-prone areas should be limited to ensure enough flood detention and drainage space. Development in any form should be prohibited in the river. Limited development can be allowed in some delta areas for flood detention, on the condition that this does not affect flood detention capacity. New dikes cannot be built for land development without a flood assessment.

Land in flood detention areas should be reasonably used to ensure flood detention capacity. Land utilization and construction in these areas must abide by the flood prevention requirements. Different land use policies should be implemented comprehensively in these areas, considering risk distribution, use frequency, topography, the status of land use, and socioeconomic development requirements.

Green-gray combined land development should be promoted to lower flood risks in flood prevention areas. The main green-gray infrastructure solution in flood protection areas include the following. (1) Impermeable surfaces should be reduced in urban construction. (2) Urban construction should not occupy natural environments such as rivers and lakes. Development should be limited in flood-prone areas, and construction in low land should be avoided. (3) For large urban development and construction, planning should be appropriate for the developed areas, with construction of water systems to ensure sufficient flood detention and drainage capacity and good water ecology.

In flood-prone rural areas, green-gray infrastructure measures mainly include the following. (1) Land overexploitation should be limited to avoid severe soil erosion and water loss and to protect forest and grassland from severe damage. (2) Rivers and lakes should not be occupied to ensure flood detention spaces and capacity.

Improve the Flood Control and Drainage Infrastructure System

Flood protection planning should be scientific, considering flood patterns and socioeconomic requirements both upstream and downstream. Coordination among planning sectors is particularly important. Flood protection planning should concur with other plans in the respective region and basin, as well as other comprehensive land resource planning. Regional flood protection planning should concur with the respective river basin flood protection planning.

The flood prevention system in all river basins should be accelerated to meet the corresponding requirements to reach the target of no severe casualties in large floods. Urban flood prevention and drainage construction should be enhanced. Dikes in medium and small rivers, as well as in important mountainous regions, should be strengthened. Different preparation and scheduling plans should be improved to advance the scientific scheduling of flood prevention infrastructure.

The maintenance of flood prevention and drainage infrastructure should be enhanced. Skilled workers and funding channels should be established. Technology innovations should be facilitated to establish flood prevention infrastructure operation and a management platform and to enhance infrastructure monitoring so that problems are discovered in time for maintenance to be undertaken and thus ensure normal functioning of flood prevention and drainage infrastructure.

Enhance Flood Disaster Emergency Management

The disaster monitoring system comprising the sky, rivers, and land should be enhanced by including more monitoring categories and improving monitoring content and data-acquiring levels. Satellites should be used to monitor flood disasters, acquire disaster locations information. Helicopters or drones should be used to acquire real-time information in flood-affected areas. Electronic water-level metering and video monitoring facilities should be installed in flood-prone areas. Specialized teams should be developed through methods such as special training and market services.

The flood disaster forecasting information system should be enhanced to increase accuracy and time effectiveness. A weather forecasting application system should be established at small and medium spatial scales. In terms of the temporal scale, short-term forecasting should be improved, while mid- and long-term forecasting should be developed to meet the demands of urban and mountainous areas. The comprehensive construction system at all flood prevention decision, forecasting, and warning levels should be enhanced. A long-term information-sharing mechanism should be established among different levels and departments.

Flood prevention organization, including prevention at the basic level, should be enhanced, as should emergency response capacity. A standing body should be set up at the basic level. For example, a flood emergency response team should be formed at the village level or the community level. Flood prevention planning should be improved at and below the county level to increase its feasibility and practicality. The skills of workers in key positions should be enhanced through training and drills. Flood disaster prevention and control education and training should be enhanced to facilitate 'public prevention, self-protection, and community safeguarding' by raising public awareness on water-related risks, including wide public participation to promote societal disaster reduction.

Establish a National Flood Insurance Program

The Chinese government has actively explored the possibility of establishing a national flood insurance program for years. The relatively complete flood prevention and control structure has enhanced the insurability of flood risks. Based on China's existing circumstances, flood insurance work should be advanced from two aspects: establishing a national flood insurance program and improving existing commercial insurance.

Backed by national financial power, a mandatory national insurance program enforced by the government is an important measure and option for flood risk management. National flood insurance regulations should be formulated to clarify compulsory insurance regulations. A reasonable flood insurance mechanism that suits China's societal and flood characteristics should be established. Flood insurance plans should be made through legislation, which should list plans for different phases and scientifically determine insurance rates. Regions and populations for flood insurance should be determined based on China's flood risk map. A flood risk zoning plan should be facilitated to calculate reasonable rates.

Before establishing a national flood insurance program, existing flood-related insurance should be improved. Coverage and payment of the existing insurance options should be improved, and the insurance types should be diversified. Payment efficiency should be enhanced. The role of insurance in disaster recovery should be fully used. Technical support from flood risk research should be enhanced. Different types of disaster information and achievements should be shared. Contact between insurance companies and research departments, meteorological and hydrological departments, and flood emergency response departments should be facilitated. The support of commercial insurance companies for flood-related policies should be protected with related regulations and incentives to create a positive institutional environment. Public insurance awareness should be raised through publicity and public education programs.

Conclusions and Suggestions

Frequent flooding events have heavily affected China's socioeconomic development. After the People's Republic of China was established, China constructed a large amount of flood prevention infrastructure in its major rivers, different areas, and cities and implemented nonstructural disaster reduction measures, resulting in significant achievements. However, the flood prevention and control capacity in some regions is still insufficient, as manifested in various aspects, such as major infrastructure construction, medium and small river management, urban flood prevention and drainage, land use development and utilization, flood risk management, flood emergency response, and societal flood disaster reduction.

With global climate change and rapid urbanization and social ecological development in China, future flood prevention and control in China is going to be more challenging. A few suggestions are offered on managing China's flood risk and establishing an insurance mechanism after taking into account China's flood risk causes, changing patterns, and existing problems:

- A flood management system that suits China's characteristics should be incorporated into the existing legal system. Institutional reform is necessary to clarify roles and responsibilities of different departments and to enhance interdepartmental coordination. Capacity building should be enhanced. Stable financial assurance should be formed, and public awareness should be raised.

- Land use management should be enhanced. Land development in flood-prone areas should be limited to ensure effective flood space. Flood detention areas should be reasonably developed and used to ensure flood detention capacity. Green-gray combined land development should be implemented to reduce flood disaster risks.
- Continued improvement of the flood control and drainage infrastructure system should target weaknesses in flood prevention structures and accelerate cities' compliance rates with flood prevention requirements, particularly related to dikes and drainage pipelines. Flood prevention system maintenance should be enhanced.
- Flood disaster emergency management, should be enhanced, including the disaster monitoring system, with more monitoring categories and improved monitoring content and data-acquiring levels; the flood disaster forecasting information system, with increased accuracy and time effectiveness; flood prevention organization, including prevention at the basic level; and emergency response capacity.
- A national flood insurance program should be established, and existing relevant insurance should be improved. This involves formulating national flood insurance regulations to clarify which are compulsory, establishing a reasonable flood insurance mechanism that suits China's societal and flood characteristics should be established. Flood insurance plans should, scientifically determine insurance rates, with enhanced technical support from flood risk research. Improvement of existing insurance options should focus on coverage, payment efficiency, and protection for commercial insurance companies. Publicity and public education programs can raise public awareness about existing and developing flood insurance options.

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CHAPTER 10

China's Water Ecological Compensation and Governance

Background

China has the highest degree of water resource stress among the world's major economies. With a large population but less water than many countries, the water resources are unevenly distributed in time and space and do not match the distributions of cultivated land, energy, and mineral reserves. With the rapid development of economy and society, as well as the long-term, large-scale, and high-intensity development and utilization of water resources, the new and old problems of water ecological and environmental security in China are intertwined. Against the backdrop of increasing effects from global climate change and the acceleration of industrialization and urbanization, the problem of water pollution is becoming increasingly prominent, causing various ecological problems, such as drying up of rivers, lake and wetland shrinkage, groundwater overexploitation, sea (salty) water intrusion, water function declines, and serious soil erosion.

To ensure the security of water ecology, the Chinese government has actively explored various countermeasures, striving to control economic and social water use through implementing the Strictest Water Resources Management System (SWRMS) and to restore the water ecological system through various measures, such as the construction of a water-based ecological civilization a water ecological compensation mechanism, integrated river basin management, water pollution prevention, and groundwater exploitation control. In 2013, the Chinese government initiated the construction of a water-based ecological civilization, with 105 cities and counties identified as pilot programs that have local government support; good basic conditions; representativeness; and typicality, including Jinan in Shandong province, Suzhou in Jiangsu province, and Xuchang in Henan province. The pilot work in constructing a water-based ecological civilization was carried out to explore experiences and models at different development levels, with different water resource conditions, and in areas with different water ecological statuses. The main construction focuses include implementing the SWRMS, optimizing water resource allocation, strengthening water conservation management, providing stringent water resource protection, promoting water ecosystem protection and restoration, strengthening ecological protection in water conservancy project construction, improving the ability for guarantee and support, and carrying out extensive

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publicity and education. The *Water Pollution Prevention Action Plan* issued in 2015 stated that "all efforts should be made to ensure the safety of water ecological environment." In 2016, the *Report on the Work of the Government* also required efforts to "advance the protection and development in parallel, and continuously promote the construction of ecological civilization."

In terms of policy mechanisms, the establishment of an ecological compensation mechanism has become a key policy option. In 2007, the report of the 17th National Congress of the Communist Party of China (CPC) required "the implementation of a fiscal and taxation system conducive to scientific development, and the establishment and improvement of the system of paid use of resources and the mechanism of ecological environment compensation." In 2012, the report of the 18th National Congress of the CPC called for "deepening the reform of resource-based products' prices and taxes, establishing the paid use of resources and an ecological compensation system which reflects market supply and demand, resource scarcity, ecological values and inter-generational compensation." In 2013, The Third Plenary Session of the 18th CPC Central Committee pointed out that "the ecological compensation mechanism for key ecological functional zones should be improved, as well as the establishment of an inter-regional ecological compensation system, based on the principle of 'who benefits should compensate.'"

Research Objectives

The research objectives of this study are to scientifically understand the concept, connotation, and significance of water ecological security and water ecological compensation; to analyze the water ecological security situation in China; to evaluate the progress and effectiveness of constructing a water-based ecological civilization in pilot cities; to analyze and understand the relationship between ecological compensation and water security; to summarize the history and status of China's water ecological compensation; and to offer countermeasures and suggestions for strengthening water ecological security governance in China.

Analysis and Summary

Problems

The first problem is water pollution. Water pollution in China is serious. Along with increasing point-source pollution, nonpoint source pollution is becoming increasingly prominent. Some water bodies have lost their ability to function. Water pollution problems are increasingly complicated and acute, showing a compounded, watershed, and long-term nature, and have developed into the most serious water issue in China. In 2015, the water quality of 235,000 kilometers of river in China was evaluated. Among them, 8.1 percent of the total river length was classified as class I, 44.3 percent was class II, 21.8 percent was class III, 9.9 percent was class IV, 4.2 percent was class V, and 11.7 percent was inferior class V. The water quality of 116 major lakes in the whole year was evaluated. Among them, there were 29 lakes classified as class I–III, 60 lakes classified as class IV–V, and 27 lakes classified as inferior class V, accounting for 25.0, 51.7, and 23.3 percent of the total number, respectively.

The second problem is the degradation of water ecology. With the overexploitation of water resources, aggravation of water pollution, and poor management of water conservancy facilities, water ecological problems have become increasingly prominent, manifested by situations like drying up of rivers, lake shrinkage, wetland reduction, land subsidence, seawater intrusion, and increasing threats to aquatic species. The situation of "partial improvement, overall degradation" of the freshwater ecosystem function has not changed. The exploitation and utilization rate of water resources in the Yellow River, Huai River, Hai River, and Liao River in northern China has reached 40–72 percent, and the water entering the sea has decreased from 152.16 billion cubic meters in the 1950s to 85.32 billion cubic meters in the early twenty-first century. According to a survey of 514 rivers in the northern region, 49 rivers have experienced drying up, and the total dried-up length reached 7,428 kilometers, accounting for 35 percent of the total river length. Compared with the 1950s, the total area of lakes larger than 1 square kilometer has decreased by 14,850 square kilometers, accounting for 15 percent of the lake area in the 1950s. In addition, 231 lakes that are larger than 10 square kilometers had various degrees of shrinkage, including 89 dry lakes, and the dry lake area reached 4,289 square kilometers.

The third problem is groundwater overexploitation. Because of the shortage or pollution of surface water resources, some areas in China have to rely on overexploited groundwater to maintain economic and social development. In the past 30 years in particular, the phenomenon of groundwater overexploitation has become serious, causing a series of ecological, environmental, and geological problems, such as land subsidence, ground collapse, ground fissures, and sea (salty) water intrusion. According to the *Guidelines for the Evaluation of Groundwater Overexploitation Zones* (SL286-2003), China has classified 413 groundwater overexploitation areas. Among them, there are 295 shallow groundwater overexploitation areas and 118 deep confined water overexploitation areas. By analyzing the exploited amount and exploitable amount of shallow groundwater in overexploitation areas in the base year and the exploited amount of deep confined water in the base year, it was found that the overexploitation amount of groundwater in plain areas in China is 17.1 billion cubic meters, making up 16 percent of the total groundwater exploitation amount in the base year.

The fourth problem is severe soil erosion. China is one of the countries with the most serious soil erosion problem in the world. Soil erosion is happening in many areas. The total area of soil erosion in China is 2.949 million square kilometers, accounting for 30.7 percent of the total land area, which includes 1.293 million square kilometers of hydraulic erosion and 1.656 million square kilometers of wind erosion. The annual average amount of water and soil erosion is 4.52 billion tons, accounting for about 20 percent of the total global soil erosion. The annual average soil erosion in the main river basins is 3,400 tons per square kilometer. The water and soil types are complex. Water erosion, wind erosion, freeze-thaw erosion, and gravity erosion such as landslide and debris flow are interlaced.

Achievements

The key projects for the construction of a water-based ecological civilization vary for different regions. Focusing on the six regions of northeast China, Huang-Huai-Hai, the middle and lower reaches of the Yangtze River, the south China coast, southwest China, and northwest China, this study investigates and analyzes the characteristics of representative urban projects for the construction of a water-based ecological civlization from each region. The first batch of pilot areas includes 46 cities, which are also the focus of this study. The survey found that all pilot cities have made great efforts to promote the construction of key projects during the pilot period and achieved initial results in the construction of water-based ecological civilization cities.

First, the SWRMS has been implemented. The pilot cities have identified three red lines as the binding indicators for pilot construction, continuously improved the functional orientation and construction pattern of urban water ecological space, and gradually attained "water-sensitive urban and industrial development." The constraining power of water is well reflected. In the first batch of 46 pilot cities, the total water use in 25 cities has dropped significantly, with an average decrease of 7.4 percent, which is higher than the national figure. The water use per 10,000 yuan of industrial added value is 37.2 cubic meters, lower than the national average of 58.3 cubic meters. The average effective utilization coefficient of farmland irrigation water is 0.577, which is higher than the national level of 0.536. The overall water quality compliance rate of water function zones in the first batch of 46 pilot cities is 81 percent, which is higher than the national rate of 70.8 percent.

Second, water security has been improved significantly. The pilot cities have given priority to meeting people's livelihood needs and have adopted measures of supply and demand management, damage alleviation, urban and rural security, and ecological protection. Water security has been significantly improved. Among the first batch of 46 pilot cities, the safety guarantee rate of centralized drinking water sources has increased by 23 percent. More than 80 percent of the flood dikes in 28 pilot cities meet the relevant planning requirements, which is 42 percent higher than it was before the pilot programs.

Third, the water ecological environment has been improved significantly. Through the measures of water ecological protection and restoration, ecological water recharge, source control, and pollution interception, the pilot cities have strictly protected water resources, prevented water pollution, ensured the ecological water use for rivers and lakes, and improved the carrying capacity of water resources and the water environment. Among the 46 pilot cities in the first batch, the average length of rivers whose water quality was classified as class I to III was 77.8 percent of the total river length in 22 cities, which is more than the national level (74.2 percent). The water space ratio in 60 percent of the pilot cities has increased in varying degrees compared with the ratio before the pilot programs. The treatment compliance rate of domestic sewage in 36 cities was higher than 90 percent. The discharge quality compliance rate of industrial waste water in 17 cities was 100 percent, and the discharge compliance rate of industrial waste water in 27 cities was higher than 90 percent.

Fourth, the water resource supervision capacity has been improved. The pilot cities continue to strengthen supervision and management and to comprehensively improve the capacity and level of water resource supervision and management. Among the first batch of 46 pilot cities, the average monitoring rate of urban sewage outlets into rivers is 90 percent, which is 25 percent higher than before the pilot programs. In addition, 27 cities, increased from 11, have achieved full-coverage monitoring of water quality in national or provincial water functional zones within the pilot area; 32 cities, increased from 11, regularly carry out water quality monitoring in more than 90 percent of national or provincial water function zones; and 26 cities, increased from 19, have achieved water quality monitoring for more than 80 percent of the region. In 36 cities, more than 80 percent of nonagricultural water users acquired a water intake license.

Fifth, the water-saving priority policy has been implemented in depth. Pilot cities have comprehensively promoted actions such as industrial water saving with increasing efficiency, agricultural water saving with increasing production, and urban water saving and loss reduction, and they are constantly advancing the development and utilization of unconventional water sources. Among the first batch of 46 pilot cities, 19 cities have formulated water-saving and discharge reduction schemes for high-water-consuming enterprises, and the implementation rate in 17 cities has exceeded 80 percent.

In addition, 27 cities have carried out unconventional water utilization, and the amount of newly available water resources has exceeded 850 million cubic meters.

Sixth, public awareness of ecological civilization has been significantly improved. The pilot cities continue to strengthen publicity and training for the construction of a water-based ecological civilization. In the first batch of 46 pilot cities, 796 publicity and training activities were carried out, and more than 40,000 publications and books were published.

Seventh, the long-term mechanism for construction of a water-based ecological civilization has been preliminarily established. The pilot cities have made many explorations into investment and financing mechanisms, water management systems, and multisectoral cooperation mechanisms under government leadership. Among the first batch of 46 pilot programs, 31 cities have integrated water resource management into the party and government performance evaluation system. In addition, 33 cities have attained initial integrated management of urban and rural water affairs and have gradually established a water resource management system with clear authority and division of labor.

Eighth, the role of demonstration is gradually emerging. The brand effect of a water-based ecological civilization has gradually emerged. Through the pilot programs, 65 cities have become pioneering demonstration zones for the construction of an ecological civilization and 13 cities have become national pilot sponge cities. Driven by the national pilot demonstration of the construction of a water-based ecological civilization, 16 provinces have successively carried out the work in constructing an ecological civilization at the provincial level.

Policy Mechanisms

Since 2005, the State Council of China has listed the construction of ecological compensation mechanisms as annual working points every year. To accelerate the construction of an ecological civilization the General Office of the State Council issued *Opinions on Improving the Compensation Mechanism for Ecological Protection* in May 2016. Relevant national departments for development and reform, environmental protection, water conservancy, agriculture, land, and forestry all regard the ecological compensation system as a basic mechanism for ecological protection. The National Development and Reform Commission drafted the *Ecological Compensation Rule* and offered the general idea and policy measures for establishing an ecological compensation mechanism. The Ministry of Environmental Protection and the Ministry of Finance jointly initiated the transfer payment of national key ecological functional areas. The Ministry of Water Resources has formulated a management method for the collection and use of water and soil conservation compensation fees. In 2011, the Ministry of Agriculture and the Ministry of Finance launched the grassland ecological protection award and subsidy. The Ministry of Natural Resources has implemented a special fund for the mine geological environment to support local governments in carrying out geological environmental management for mines that have been abandoned or lost by mining rights holders. In accordance with the provisions of the *Forest Law*, the Forestry Administration has promulgated measures for the demarcation of state-level public welfare forests and measures for the management of the central forest ecological benefit compensation fund. In addition to the preceding policies and market measures, national laws like the *Environmental Protection Law*, *Water Pollution Prevention Law*, *Water Law*, and *Clean Production Law*, as well as some provincial and ministerial regulations, emphasize the paid use of resources and compensation for protection work.

Water Ecological Compensation

Goal

Based on a comprehensive review of the water ecological compensation cases in China, ecological compensation practices mainly include protection compensation and pollution compensation. The premise is that the beneficiaries of water ecological protection have a responsibility to pay compensation to the water ecological protector, while the water ecological destroyer should pay the costs of reducing the water environmental capacity to those who bear the burden of water ecosystem damage. Based on this premise, work has been carried out in formulating water ecological compensation standards, water ecological compensation methods, and funding channels.

Exploration

According to incomplete statistics, 16 river basins (or regions) in China have explored and carried out water ecological compensation mechanisms. There are 3 cases of state-involved compensation, 10 cases of provincial-level compensation, and 12 cases of local-level compensation. The compensation was delivered in three ways: state transfers of water ecological compensation to water source protection areas, establishment of compensation funds, and direct payment by the beneficiary of water protection.

Subjects and Objects

The premise of establishing a water ecological compensation mechanism is to determine the subjects and objects of compensation. In China, the main subjects of water ecological compensation are the beneficiaries of basin ecological improvement and the destroyers of basin ecology. The water ecological compensation objects are a region or an individual who carries out water environment protection to ensure the sustainable use of water resources and the downstream regions that are seriously affected by overdischarge of pollutants upstream. Therefore, the objects of water ecological compensation include not only the ecological protectors of the basin but also the victims of ecological pollution.

Basic Forms

Financial compensation is the main form of water ecological compensation and is suitable for various scales of water ecological compensation mechanisms. Policy compensation is possible in the form of power and opportunities given by the superior government to the lower government. Within the scope of authorization, the compensated party formulates a series of innovative policies and enjoys preferential treatment in project investment, industrial development, and taxation. The formation of the water ecological compensation market mechanism requires three preconditions. First, the contradiction between supply and demand of ecological services is acute. Second, the public recognizes the function and value of ecological services. Third, the cost-benefit analysis results are positive.

Compensation Standard Calculation

The calculation of ecological compensation standards is the key technical difficulty in establishing an ecological compensation mechanism. The measurement of most ecological compensation standards is carried out based on two aspects: inputs and benefits. Inputs include water resources and ecological protection, as well as losses caused by restricted development because of water source protection. Estimated external benefits are generated by the protection investment in the economic, social, and ecological aspects. The compensation standard is then estimated based on these inputs and benefits.

Conclusions and Suggestions

China has carried out extensive research on and practical exploration of water ecological compensation. However, many immature aspects remain in the theoretical methods and practical operations that restrict comprehensive and extensive implementation of the water ecological compensation mechanisms. The main problems are as follows. A systematic and complete water ecological compensation theory system is still needed, and the concept and definition of water ecological compensation are not standardized. The quantitative measurement method of the compensation standard is not scientific enough and often ignores the influence of natural factors on water quantity and quality changes. Most studies only consider the ecological compensation problems caused by point-source pollution, and the externalities brought by nonpoint-source pollution are overlooked in existing ecological compensation research. Although interprovincial river and lake ecological compensation exploration has been carried out, an ecological compensation mechanism at the whole-basin level has not yet been investigated. Different stakeholders have different understandings of ecological compensation, and there is a lack of consultation mechanisms. The proportion of government compensation is too large, and market compensation is still immature. Finally, the laws and systems related to ecological compensation do not match.

The span of river basins in China is large, involving numerous administrative regions and management departments. Establishing and improving the water ecological compensation mechanism is a complex subject that requires long-term exploration and research. It is necessary to improve monitoring of water quantity, water quality, and sediment concentration in important sections and to conduct joint monitoring of cross-boundary section indicators to form an authoritative, open, and modern monitoring and information release system. It is also necessary to gradually explore types of issues in practice, to summarize experiences through pilot projects, and to continuously improve. The water ecological compensation mechanisms that can be applied to various issues should be gradually established and improved. Various compensation measures need to be explored, including the establishment and improvement of a charging system that is conducive to ecological compensation and a transfer payment system that is conducive to water resources and ecological protection. Diversified ecological compensation led by the government, and involving nongovernmental organizations, environmental protection associations, nongovernmental foundations, and other social forces, should be explored. Various compensation methods to strengthen projects and economic cooperation should be explored as well. Finally, the management mechanisms, laws, and regulations should be improved. A management system, operational mechanism, consultation mechanism, and public participation mechanism with the participation of various stakeholders in water ecological compensation should be established, with the rights and responsibilities of all parties clarified.

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CHAPTER 11

Legislation Process and Improvement Proposals for China's Water Governance

Background

Legislation Process of Water Governance

Since the reform and opening up of China, and to deal with continuously changing issues on water resources, water ecology, and the water environment, China has strengthened its water legislation. Under its constitution, the country has promulgated the *Water Law of the People's Republic of China*, *Water and Soil Conservation Law*, *Flood Prevention Law*, *Environmental Protection Law*, *Water Pollution Prevention Law*, and other relevant documents, departmental policies, and standards, which together form the legal framework of China's water governance. The framework includes water resource management and protection, water pollution prevention, water ecological protection, water infrastructure construction and management, and flood and drought prevention. The legal requirements for water governance are basically met.

In terms of water supervision, China has issued a series of reform documents related to ecological protection and resource management, which has laid the foundation to reform the supervision mechanisms in China's water governance. In September 2016, China issued *Guiding Opinions on the Pilot Reform of the Vertical Management System for the Monitoring, Supervision and Law Enforcement of Environmental Protection Agencies below the Provincial Level*, which aimed to reform the allocation of environmental protection supervision responsibilities; to form a new supervision system that can adapt to the new context and tasks; to strengthen environmental supervision capabilities; to enhance the neutrality, integrity, authority, and effectiveness of environmental supervision and law enforcement; and to curb local protectionism. In December 2016, *Opinions on the Full Implementation of the River Chief System* required government and party leaders to be river chiefs to establish local accountability, to coordinate efforts, and to enhance water governance. This is a major institutional innovation in implementing the green growth concept, promoting construction of an ecological civilization, and improving the water governance system.

Implementing the Strictest Water Resources Management System requires a water resource inspection system that is effective at establishing integrated basin management and transforming

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water administration's roles. The Ministry of Water Resources' *Guidance Opinion on Deepening Water Conservancy Reform* and *Opinions of the State Council on Intensifying Reform Innovations and Accelerating Agricultural Modernization* require China to establish and improve the national water resource inspection system. The Ministry of Water Resources is working on establishing a national water resource inspection system. In 2015, the central government environmental protection inspection system was established.

To tackle challenges such as water resource occupation, water pollution, and water ecological damage, the Supreme People's Court has issued a few judicial interpretations, such as the "Interpretation Concerning Some Issues on the Application of the Law to the Trial of Environmental Civil Public Interest Cases" and "Interpretation Concerning Some Issues on the Application of the Law to the Trial of Environmental Liability for Tort Dispute Cases," making breakthroughs in judicial safeguards. Based on the preliminary work in civil and public interest litigation by prosecutorial departments, the standing committee of the National People's Congress (NPC) amended both the *Civil Procedure Law* and the *Administrative Procedure Law* in 2017 and legalized a pilot mechanism. Environmental civil and administrative procedures have advanced through practice, and the legislation for environmental tort liability disputes has continuously improved. Judicial interpretations regarding environmental and natural resource crimes have improved, and transadministrative-boundary jurisdictions have been clarified, which has provided guarantees for judicial justice of water governance.

Necessity of Legal Reform for Water Governance

In modern society, the rule of law is necessary to tackle water problems. According to the goals of constructing an ecological civilization, as well as the legal perspective of water governance, there is still a lack of legal coordination in water governance. The reform measures need to be legalized. Similarly, legislation is required for water supervision reform and institutional innovations. An integrated inspection system for water resources, water ecology, and the water environment should be established. Although public interest litigation has been preliminarily established for water issues, its effects have been minor, which shows the necessity for reform. The legal reform of water governance has to be comprehensive and in depth.

Research Objectives

Water governance legislation should be guided by the construction of an ecological civilization and draw on successful experiences in other countries, as well as domestic provinces such as Zhejiang. The legal system should be improved, and outdated laws and regulations should be amended. Regulations related to water resources, water ecology, and the water environment should be coordinated. Problem-oriented mechanisms and systems should be established. An integrated water resources, ecology, and environmental supervision system should be established according to documents on establishing the river chief system and basin-level environmental supervision agencies. An inspection system with Chinese characteristics should be legalized and used to drive local water governance. Information transparency and public participation should be enhanced. Public interest litigation by organizations should be enhanced to advance the societal governance process. Overall, the water governance system and capacity have to be improved.

Analysis and Summary

Legislative Analysis for Water Governance

China's Legal System for Water Governance

The legal system for China's water governance includes water resource management and protection, water pollution prevention, water ecological protection, water infrastructure construction and management, and flood and drought prevention. Governance at both administrative and basin levels should be incorporated into the water governance system. The legal status of the basin-level organizations should be defined.

Institutions for water governance have been gradually improved and completed. Innovations have also been facilitated. They have laid the foundation for comprehensive and systematic water governance. However, according to the requirements of an ecological civilization, the existing legislation is insufficient and lacks coordination. China lacks solid and comprehensive legislation on the water ecological red line, joint prevention and governance, public participation, water ecological compensation, and water conservation, which has hindered the legislation process of water governance. For example, because there are no legal requirements on the hierarchy of wastewater pollution discharge permits and environmental impact assessments, two permission application mechanisms are disconnected, which lowers efficiency. Because the existing policies are made by different departments, overlapping, contradictory, and disconnected regulations exist. For example, because the *Water Pollution Prevention Law* and the *Water Law* did not specify the monitoring subject, standard, or information disclosure procedures, multiple departments are undertaking the monitoring work and generating inconsistent data and information. These two laws have regulated the legal status, subject, and procedure for the *Water Pollution Prevention Action Plan* and *Water Resources Protection Plan*. These two plans have overlapping content. However, because of different planning subjects and orientations, the plans are disconnected and their implementation is unsatisfactory.

International Experiences

International experiences offer lessons for China. First, legal actions can be enhanced by joint actions. For example, the riparian countries of the Rhine River have adopted the concept of joint governance and formed unions through legal agreements based on their common interests. Water governance legislation in the United Kingdom has established the concept of comprehensive governance that requires intersectoral coordination. Joint prevention and joint control have been widely acknowledged as a combined scientific concept in comprehensive water governance. Governance concepts and culture play vital roles in basin management. In governing the Rhine River, common interests and clear governance concepts are the links between sovereign countries and have driven each country to fulfill its duty.

Second, legislation and agreements should be emphasized, and the rule of law should be embedded in water governance. Agreements are more common in countries and regions with federal systems; in other areas, legislation is more frequently used. The clearer and higher the legal status of agreements and plans is, the better their implementation. Lessons can be learned by using agreements to motivate riparian governments and using legal instruments to improve enforcement.

Legislative Analysis of Water Supervision

Legislative Construction

China has established a water supervision system led by the water department and joined by multiple relevant departments that combines both governance by basin and governance by administrative region. However, various problems exist. The first problem is that legal enforcement of regulations against basin-level water pollution is incomplete. Basin-level organizations lack legal status or authoritative power and are easily affected by local governments. Legal implementation is not satisfactory. Second, the monitoring system does not meet actual needs. Duplicated monitoring departments, local protectionism, and insufficient monitoring capacity have resulted in inconsistent monitoring data, which affects the reliability and creditworthiness of monitoring. Third, interregional and interdepartmental supervision has not been established, and law enforcement efficiency is low. Fourth, law enforcement is weak, and comprehensive law enforcement has been slow to develop.

Foreign Experiences

Many countries and regions choose to establish basin-level organizations. Basin-level organizations should have clear legal status and certain decision and implementation power. Comprehensive governance, including resources, environment, and ecology, is the general trend. More emphasis should be given to interdepartmental coordination.

Legal Issues of Inspection in Water Governance

A regional environmental inspection system has been established for almost a decade. Six environmental inspection regions have been established. Regional environmental inspection has effectively helped the enforcement and implementation of environmental regulations and policies. However, because of a lack of legal power and low legal status, effectiveness is limited and overall performance is not satisfactory. In July 2015, the "Environmental Protection Inspection Plan (Tentative)" was issued and the central government environmental protection inspection system was officially initiated. The high-level Central Government Environmental Protection Inspection group has broad authority, works as a fast pace, and has strong accountability and transparency. Through pilot programs, the central government environmental protection inspection system has achieved effective results, yet there is room to improve. For example, the inspection system has not been legalized or standardized. Supervision from the NPC and the Chinese People's Political Consultative Conference (CPPCC) is not in place. The authority of the inspection system should be improved.

Judicial Issues of Water Governance

In-depth theoretical research on public interest litigation is lacking. Because of strict eligibility and lack of funding, capacity, transparency, and incentivizing mechanisms, it is difficult for environmental organizations to effectively participate in public interest litigation. Second, there is no consensus on what public interests are, whether they are eligible for compensation, or their differences with private interests. It is controversial whether the compensation should be managed by environmental organizations or governments. In practice, environmental civil and criminal procedures are not yet complete. Environmental accountabilities are not clearly defined. In addition, an integrated judicial system at the basin level needs to be developed.

Judicial supervision of administrative powers is still lacking. In addition, administrative public interest litigation is insufficient. First, it is difficult to file a case. The economic benefits brought by water resources are still an important concern of local governments. To ensure economic growth and reduce unemployment, some governments acquiesce to pollution or even let enterprises pollute. Although China has adopted a case registration system, many water pollution cases are still difficult to file. When the complaint is submitted to the court, the court often notifies the corresponding government and environmental protection department. The government and environmental protection department will try to make the plaintiff withdraw the complaint.

Second, a system of environmental administrative public interest litigation initiated by social organizations has not yet been established. Because of the lack of a direct right to initiate administrative public interest litigation, it is difficult for social organizations and citizens to sue local governments and relevant departments that have neglected their duties. Even if they do, it is difficult to urge the courts to file cases in accordance with the law. This is not in line with the proper meaning of the public interest litigation system and is not conducive to in-depth implementation of the strategy of governing the country according to the rule of law.

Conclusions and Suggestions

Water Governance Legislative Reform

The legislation concept needs to be established scientifically. The construction of a water-based ecological civilization and comprehensive protection of the water ecological system should be established as the fundamental concepts for legislation based on water's ecological and social attributes. Integrated basin-level protection and supervision should be implemented, focusing on improving the water environment and maintaining water ecological security. The integrity and coordination of water governance should be enhanced across administrative levels, boundaries, and sectors. Considering the relationship between ecological protection and socioeconomic development, green growth–oriented water ecological protection should be advanced by improving the industrial structure and promoting technological innovations.

Legislation work should also be advanced. In terms of comprehensive regulations, based on the trend of integrated basin management, promulgation of the *River Basin Management Law* as the basic law for basin management is suggested. The law should include regulations on basin resource protection, utilization, flood prevention and control, ecological protection, and pollution control mechanisms and systems. It should stipulate basin inspection, basin ecological compensation, and basin legal responsibilities. In terms of special laws, promulgation of laws for major river basins, for example, the *Yangtze River Protection Law* and the *Yellow River Law*, is suggested. If it is difficult to promulgate laws quickly, corresponding regulations can be issued first, for example, the *Yellow River Basin Management Regulations* and *Yangtze River Basin Management Regulations*. In terms of administrative regulations, the legislative process of *Water Saving Regulations* should be accelerated, led by the Ministry of Water Resources and coordinated with other departments. The *Water Saving Regulations* should match the *Water Law* and make detailed and standardized regulations on water quota management, water planning, and progressive water price for water overuse. Supervision, management, and funding mechanisms for water saving should be established. The responsibilities of governments, society, and individuals should be clarified. Legislation on public-private partnerships (PPPs) in water governance should be initiated to regulate the objectives of water governance PPPs. Regulations on social capital selection criteria and procedure, managing departments and responsibility, dispute settlement, risk control, limited recourse, compensation termination, and administrative and social supervision should be made.

In terms of departmental regulations, legislation on the water ecological red line should be advanced. Acute conflicts exist in China's water environment, water resources, and water ecology, as well as uneven development within river basins, uncoordinated river basin management, and so on. Basin economic development is not coordinated with ecological protection. Water ecological red line control can effectively manage these issues and promote the balanced development of a social economy, water resources, and water environmental protection. To be specific, the managing organization of the water ecological red line should be reasonably arranged. An index system for water resources and water environmental security should be established. A guarantee mechanism and accountability should be established.

A legal amendment should be advanced to ensure timely effectiveness. The *Water Pollution Prevention Law*, the *Water Law*, and their supporting regulations should be amended. Repetitive content should be combined, and vagueness should be clarified. Related clauses should be matched. For example, water monitoring and information disclosure functions should be clarified. The effectiveness of monitoring data should be clarified. The connection between the *Water Pollution Prevention Action Plan* and the

Water Resources Protection Plan should be clarified. Alternatively, the water department and environmental department can jointly make those plans. In terms of drinking water source protection, regulations on water resources and water ecological protection should be added. Responsibilities of various relevant departments should be clarified. The order for obtaining discharge outlet permission and environmental impact assessment should be clarified to improve administrative efficiency. A total pollution discharge cap should be used as an important basis for water pollution prevention and pollution reductions. Finally, the legislative process on defining the water ecological red line should be advanced.

The legislative process should be improved, and legislative coordination should be enhanced. It is difficult to change the situation of departmental legislation within a short period. Therefore, standardization and coordination of water governance should be strengthened from the drafting stage of legislation. First, the law-drafting department should jointly coordinate with other departments to ensure the rationality of the draft and avoid conflicts among legal norms from the start. Next, to avoid the departmental tendency in the formulation of the lower-level laws for overlapping functions, administrative regulations should be formulated jointly across departments. Finally, the local people's congresses or governments within the river basin are advised to sign joint water legislation agreements, to cooperate in legislation, to jointly formulate water laws and regulations, and to reduce the number of laws, especially repeated ones.

Water Monitoring and Supervision Reform

The first is to establish a supervision mechanism and system. The legal interconnections of the river chief system, lake chief system, and supervision departments should be established. To enhance the legal effectiveness of the river chief system, the river or lake chief system should be connected to the existing legal supervision framework in the next amendment of the *Water Law*. To improve the legal effectiveness of the river or lake chief system within the party system, the central party committee and the State Council could consider including the river chief system in the evaluation and supervision systems by jointly making or amending documents related to water pollution prevention or water environmental protection.

Second, the regulatory system and mechanism should be improved to achieve scientific and effective management of river basins. At the 32nd meeting of the Leading Group of the Central Committee on Comprehensive and Deepening Reform in 2017, the "Pilot Plan for Establishing Environmental Supervision and Administrative Law Enforcement Agencies by Basins" was adopted. The meeting emphasized that the establishment of basin-level environmental supervision and administrative law enforcement agencies should follow the integrity of ecosystems and their natural characteristics. The basin should be regarded as a management unit. Upstream and downstream resources should be coordinated, with clarified powers and responsibilities. Regional environmental supervision and administrative law enforcement functions and allocations should be optimized to achieve unified planning, standards, environmental assessments, and monitoring and law enforcement. Therefore, the overall effectiveness of environmental protection can be improved. In terms of institutional building, comprehensive administrative law enforcement pilot projects should be actively carried out for large river basins, such as the Yangtze and Yellow River Basins, across provincial administrative regions. A river basin management committee should be set up to take charge of integrated water management in the river basin. After the completion of the pilot projects, experiences should be summarized to facilitate corresponding legislative processes.

Third, cooperation among regions and departments in the river basin should be strengthened to form a joint force of supervision. First, an information-sharing platform should be established to ensure that information exchange is achieved among water-related departments within the basin and the region. Second, the cooperation mechanism regarding law enforcement should be established and deepened. River basin organizations and local governments can negotiate to formulate rules and regulations for joint law enforcement, and to unify relevant standards. Through information sharing, joint meetings, joint patrols, onsite special law enforcement, and multilevel inspections at higher and lower levels, all departments can form joint efforts and improve the efficiency of water administration and law enforcement of water pollution prevention and control.

Fourth, accountability mechanisms for river basin law enforcement should be established, and social participation and supervision should be increased. An internal supervision mechanism should be established. Through laws, administrative agreements, and institutional agreements, the supervision mechanism of law enforcement cooperation responsibility can be formed, the procedural design of law enforcement can be strengthened, and the administrative power can be supervised and restricted by procedural provisions. The internal horizontal supervision mechanism can be improved by establishing a scientific institutional system. The internal vertical supervision mechanism can be improved by establishing an internal auditing mechanism. The supervision mechanism on judicial and power organs, as well as the social supervision mechanism, can be improved by establishing an external supervision mechanism. The public accountability mechanism should be strengthened. The problem of managing and supervising symptoms and root causes should be dealt with. The construction of a social governance system that enables social supervision should be strengthened. Increasing social participation should be prioritized, with unobstructed channels. To remedy the deficiencies of administrative monitoring, supervision, law enforcement, and licensing roles, public accountability mechanisms should be introduced and strengthened to make the new regulatory system open, transparent, and accountable.

The fifth is to improve basin dispute settlement. Among governments at the same level, disputes should be settled with negotiations. Vertically, disputes can be settled by the same superior agencies. The horizontal mechanism seems cost effective. However, because water disputes often involve substantial interests, agreements are difficult to reach, which increases the coordination cost. In China, because a superior agency has significant power over its subordinate agencies, coordination and decision making by the superior agency is a more ideal option. In terms of basin pollution control, dispute settlement can be managed by basin organizations. The basin organization should listen to opinions from practitioners, experts, and the public and organize a settlement or make decisions based on extensive data.

Water Inspection Reform

A water resource inspection system should be established. A water inspection organization should be set up in the name of National Water Resources Inspection. Various effective measures such as notification, announcement, and interviews should be fully used. The main responsibility of water resource conservation and protection should be defined. Public participation through multiple channels should be strengthened to achieve synergies with media exposure. A long-term mechanism of legalized inspections should be gradually established.

The regional environmental protection inspection system should be improved. The inspection methods should be changed moderately. Law violations should be reported to the Central Environmental Protection Supervision Office to cooperate with the central supervision work and strengthen its authority. Consequently, reform of the inspection system can be advanced. The river basin committee should carry out comprehensive inspections and improve the efficiency of inspections.

A long-term central ecological inspection system should also be established. Regulations on environmental protection supervision should be promulgated to stipulate the scope, content, and process of supervision. Inspections should be reviewed, and achievements should be enhanced. The inspection authority can be enhanced with ministerial leaders joined by officials from the CPCCC Organization Department and the Supervision Department of the Central Commission of Discipline Inspection. The NPC and CPCCC should send officials to participate in the inspections. Local people's congresses are encouraged to undertake environmental protection power supervision, and local CPPCCs are encouraged to carry out public supervision of environmental protection.

Reform of Water Environmental Public Interest Litigation

The conditions, scope, and procedures of public interest litigation for water governance should be improved, and the legal supervision role of prosecution offices should be enhanced. Because of the particularity of public interest litigation, the procedure of public interest litigation initiated by prosecutors should be distinguished from the general procedure of other types of litigation. In addition, because of the particularity of the status of the prosecution office, attention should be paid to the procedural differences between public interest litigation initiated by prosecutors and that initiated by social organizations. According to the authorization by the Standing Committee of the NPC, appropriate breakthroughs can be made in the procedural provisions of the *Civil Procedure Law* and the *Administrative Procedure Law*. In addition, to improve efficiency, it is necessary to establish two preprocedures for prosecution offices to initiate environmental administrative public interest litigation. For suspected illegal acts by administrative offices, the prosecution offices should first issue prosecution suggestions, requesting that the illegal acts be corrected within a time limit. If the administrative office disagrees or does not correct its mistakes, the second preprocedure will automatically be initiated, wherein the Communist Party of China (CPC) Central Committee of Politics and Law and the Organizational Department of the CPC Central Committee will formulate internal party regulations, requiring the prosecution office's party group to submit the case and related materials for prosecution to the committee of the local party at the same level for discussion before instituting environmental administrative public interest litigation. If coordination by the standing committees of local party committees is successful, the administrative offices will correct their mistakes in time and will not be prosecuted; if coordination is unsuccessful, they will be prosecuted. In this way, China can achieve the organic cohesion and coordination of the party's laws and regulations and national legislation in environmental protection, as well as reduce political risks.

The eligibility of social organizations to participate in civil public interest litigation on water pollution and water ecological damage should be loosened. The threshold for environmental protection organizations to initiate litigation should be lowered. For example, the requirement on years specializing in public welfare activities related to environmental protection and the requirement of registration could be reduced; registration should be only required at the national level. In terms of the right to know, the Ministry of Environmental Protection's "Measures on Environmental Information Disclosure of Enterprises and Institutions" and "Measures on Public Participation in Environmental Protection" should be upgraded to *Regulations on Environmental Information Disclosure of Enterprises and Institutions* and *Regulations on Public Participation in Environmental Protection*, respectively, to enhance their coverage and effectiveness. The procedure for information disclosure should be simplified. The scope of enterprise and government information disclosure should be broadened and increased. Penalties for not disclosing information can reduce the difficulty of investigation and evidence collection by social organizations. In terms of funds, financial guarantee and incentive measures for social organizations should be set up. It is advisable to encourage social donations, to improve the financial management legislation of social organizations, and to standardize the operation of social organizations; these changes not only can reduce the financial pressures of social organizations and avoid the abortion of public interest litigation caused by high appraisal fees but also can improve the enthusiasm of social organizations to participate in and promote the standardization of public interest litigation. In terms of talents, opening up the regulations on part-time jobs in enterprises and institutions could be considered to allow professionals to take part-time technical jobs in public welfare organizations free of charge and thus protect the environmental interests of society and the public. To cultivate the supervisory ability of social organizations, the government should increase its financial support in purchasing social services.

The system and mechanisms of judicial supervision over the administrative power of water governance should be improved. To prevent legal requirements from being shelved by the local authorities or departments; to prevent serious damage to local water resources, water ecology, and the water environment; to ensure that strict legal responsibilities such as daily penalty and administrative detention can be implemented; and to reduce the occurrence of local protectionism, it is necessary to amend the *Criminal Procedure Law* and to construct a system in which social organizations can initiate criminal public interest litigation against public officials. It is also necessary to amend the *Administrative Procedure Law* to construct a system and mechanism for social organizations and individuals to initiate environmental administrative public interest litigation.

In accordance with the provisions of the *Environmental Protection Law*, the "Pilot Scheme for the Exit Audit of Leading Cadres' Natural Resources Assets," and the "Accountability Measures for Ecological Environmental Damage of Party and Government Leading Cadres (Trial Implementation)," administrative officials who should be handled but are not, or those who should resign but do not, should be held accountable. Systems and mechanisms can be established for social organizations to initiate administrative public interest litigation. They should require local people's governments to initiate relevant accountability procedures. The judicial scale of water governance should be unified to curb local protectionism. The Supreme People's Court should give judicial interpretation and uniformly stipulate the judicial organs for transregional water damage cases. Regional and river basin circuit courts can also be established, covering public interest litigation in water resources, the water environment, and water ecology.

The conditions, claims, and management of compensation in public interest litigation on water pollution and water ecological damage should be clarified. The Supreme People's Court should establish a list of the scope of social and public interests and a list or guideline for litigation requests for environmental public interest litigation. In the short term, the executive tribunals of people's courts at all levels can manage compensation funds according to the ecological restoration plans or purchase social services. Publicly selected financial institutions can also carry out compensation management. In the long term, it is advisable to establish a management model that has a board of trustees to manage the compensation.

A system of criminal incidental civil public interest litigation for water pollution and water ecological damage should be researched and established. In the criminal judicial practices of the prosecution offices, environmental criminal incidental environmental civil public interest litigation has important practical significance. It not only conforms to the functions of the legal supervisors of prosecution offices but also has the institutional advantages of saving judicial costs, improving judicial efficiency, simplifying litigation procedures, and reducing the burden of collective litigation of victims. Regarding environmental criminal incidental environmental civil litigations, it is necessary to design various mechanisms, such as conditions, methods, procedures, and rules of court acceptance and adjudication, as well as connect the public prosecution department and the civil department within the prosecution system. Lessons can be learned from the existing criminal, incidental, and civil system, especially the civil practice path of public interest criminal and incidental litigation, which can be combined with the characteristics of public interest litigation. These need further study, and the Supreme People's Court and the Supreme People's Prosecutor's Office could jointly issue judicial interpretations. In addition, the principles and methods of allocating joint liabilities among the subjects for joint infringement of environmental private rights and social and environmental public interests should be defined.

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CHAPTER 12

China's Administrative System and Reform for Water Governance

Background

Water shortages and water pollution are prominent problems facing the sustainable development of China's social economy. In some regions of China, a serious water crisis has directly affected the sustainable development of the social economy and the healthy life of the people. The *World Water Resources Report* published in 2006 highlighted that the water crisis is mainly caused by poor management. Reforming and perfecting the water administration system is guaranteed to improve the efficiency of water resource utilization and attain sustainable development. Through water governance, with the main purpose of ensuring water safety and water equity, the government, society, and other parties employ legal, administrative, economic, cultural, educational, information, and technological means to plan, control, coordinate, and guide human water-related behavior so as to continuously improve the capacity and level of water resource security, water environment quality, water ecological services, and urban and rural water supplies. Water governance generally includes water resource governance, water environment governance, water ecological governance, urban and rural water supply governance, water conservancy project governance, and water relations governance. The administrative management system of water governance includes the organizational structure, the list of powers, and the guarantee system of water-related government departments. With the development of China's economy, increasing water use, and increasing pressure on water ecology, there is an urgent need for the administrative management system of water governance to be updated to improve the efficiency of water resource utilization and achieve sustainable development.

New Concepts of Water Governance

The core of the water governance system reform includes the following concepts: improve the distribution of administrative responsibility for water governance; clarify the responsibility-power relationships among departments, river basins, and administrative regions; unify water quality and quantity management; gradually establish a market mechanism; and promote public participation in water governance decision making.

National Water Security Requirements

In April 2014, President Xi Jinping proclaimed the concept of "priority on water-saving, spatial

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equilibrium, systematic governance, and the combined efforts of government and the market" at the special meeting on ensuring national water security. The Third Plenary Session of the 18th Central Committee of the Communist Party of China proclaimed the concept of "improving the management system of national natural resources assets and exercising the owner responsibility of all natural resources assets by all people." The report of the 19th National Congress of the Communist Party of China suggested "setting up the state-owned natural resources assets management and the natural ecological supervision agency," which marks further improvement of the property and management systems of natural resources. The management system of natural resources includes organizations, division of power, and a guarantee system to manage natural resource assets. Water is an important natural resource. It is urgent that China accelerate the reform of the water management system from the aspects of the management concept, organizational structure, responsibility list, assessment, and accountability to achieve the goal of improving the natural resource supervision system in the field of water management.

Research Objectives

This report systematically analyzes the evolution of the water management administrative system in China from decentralized management to centralized management and the gradual development of combined river basin management and territorial management. It also analyzes the main characteristics of the administrative system with horizontal-vertical fragmentation. Focusing on cross-sectoral and cross-regional cooperation in water management, it discusses the lack of a water-related information-sharing mechanism, the lag in river basin legislation, and the imperfection of the administrative accountability system, as well as directions for improvement of the water-related administrative management system in China. Then, some suggestions are offered.

Analysis and Summary

Evolution and Characteristics of the Water Resource Management System

Decentralized Water Resource and Environmental Management (1949–87)

Before the late 1970s, China's water-related responsibilities were scattered among many departments. The Ministry of Water Resources was only responsible for flood control and water conservancy construction of interbasin water transfers (Jia Shaofeng 2011). In the same period, there were no relevant institutions for water environmental protection and water pollution control in China. In 1974, because of the pollution of Guanting Reservoir in Beijing, the formation of the Leading Group of Environmental Protection under the State Council marked the formal establishment of China's water environmental protection agency. In May 1982, the State Council established the Ministry of Environmental Protection for Urban and Rural Construction, with an Environmental Protection Bureau within the ministry. In 1984, the State Council established the Ministry of Water Resources and Electricity as the department responsible for water resource administration. The *Water Pollution Prevention and Control* Law was promulgated in the same year, establishing a water pollution prevention and control management system by region and by department. Before the promulgation of the *Water Law of the People's Republic of China* in 1988, China's water resource management was decentralized, and water environmental protection had to be built from scratch.

Unified and Strengthened Water Resource and Environmental Management (1988–2002)

In 1988, China promulgated the *Water Law*, which established the water resource management system of "unified management across administrative levels and departments," emphasizing that the water administration department under the State Council is responsible for the unified management of water resources throughout the country. During the same period, the State Environmental Protection Administration became a deputy ministerial department directly under the State Council and responsible for the comprehensive management of environmental protection. The function of unified management of water resources has been continuously strengthened in the subsequent institutional reforms of the State Council, while the function of water environmental management has been concentrated in the State Environmental Protection Administration. The revised *Water Pollution Prevention and Control Law* promulgated in 1996 stipulates that environmental protection departments will exercise unified supervision over the prevention and control of water pollution. In 1998, the final arrangements of the Ministry of Water Resources approved by the State Council confirmed that the Ministry of Water Resources is an integral part of the State Council in charge of water administration, urban flood control, and groundwater management. The State Environmental Protection Administration has been upgraded to the ministerial level. During this period, water resource protection bureaus under various river basin organizations were under the dual leadership of the Ministry of Water Resources and the environmental protection department. By the end of the 1990s, because of management differences, the dual-leadership role of environmental protection departments at the level of basin organizations had gradually weakened.

Combined Basin and Territorial Management (2002–Present)

In mid-2002, the water law made it clear that "the state implements a management system combining river basin management with territorial management for water resources." The water resource administration department under the State Council will be responsible for the management of water resources throughout the country. The new water law clarifies and centralizes provisions on the legal status of river basin organizations. In 2008, the State Environmental Protection Administration was upgraded to the Ministry of Environmental Protection and became an integral part of the State Council. The division of water governance responsibilities was further clarified. The Ministry of Environmental Protection is responsible for water environmental protection and water pollution control. It is also responsible for publishing water environment information. In contrast, the Ministry of Water Resources carries out unified management of water resources (Portal of the Central People's Government of the People's Republic of China 2009). In terms of water pollution control and management, interministerial joint meetings and a leading group on water pollution prevention and control in river basins have been established. Since 2001, the dual-leadership model of water resource protection has ceased to exist.

Overall, China's water management administrative system is characterized by horizontal multidepartmental management and vertical hierarchical responsibility. The management of water-related issues is still carried out by numerous departments in collaboration, showing a pattern of fragmentation. The main body of water-related management is complex. The functions of river basin management are scattered among many administrative departments at the national level, and the boundaries of responsibilities and powers are blurred, which leads to unclear powers and responsibilities for river basin organizations and local governments.

Progress in Water-Related Management System Reform

Integration of Water Management

China's water governance has long been described by the metaphor "nine dragons managing water" and the process of horizontal-vertical fragmentation. Targeting these problems, the integration of water affairs was initiated in 1990. By establishing local water affairs bureaus, water resource protection, development, utilization, disaster prevention and control, and pollution prevention and control in urban and rural areas are managed in a unified way (Lu Xinmin 2010). In 1993, Shenzhen City and Luochuan county of Shaanxi province set up municipal and county water affairs bureaus successively and became the first to implement integrated water management in China. According to statistics from the Ministry of Water Resources, at the end of 2016, there were 2,698 water bureaus or corresponding agencies responsible for water management functions at or above the county level, accounting for nearly 83.6 percent of all county-level administrative units. There were also 213 water affairs bureaus at the prefectural level. As of October 2017, there are four division-level provincial water affairs bureaus, namely, Beijing, Tianjin, Shanghai, and Hainan, and nine deputy division–level provincial water affairs bureaus. The integrated management of water affairs should merge the water-related functional departments, which will enhance the benefits of all kinds of water projects. The integrated management of water resources in urban and rural areas is an important innovation in China. However, in the reform of integrating water affairs, there are still some problems, such as transformation from the original Water Resources Bureau to the Water Affairs Bureau, lack of substantive functional adjustment, and lack of coordination and management capacity of departments.

Vertical Environmental Management Reform

In September 2016, the General Office of the Central Committee and the General Office of the State Council jointly issued *Guiding Opinions on the Pilot Reform of the Vertical Management System for the Monitoring, Supervision and Law Enforcement of Environmental Protection Agencies below the Provincial Level*. This marks the formal start of the reform of the vertical management system of monitoring, supervising, and enforcing laws by environmental protection agencies below the provincial level.

On February 6, 2017, the "Pilot Plan for Establishing Environmental Supervision and Administrative Law Enforcement Agencies by Basins" adopted by the Central Leading Group for Comprehensively Deepening Reform proposed to establish water environmental supervision and administrative law enforcement agencies at the river basin level.

River Chief System

In December 2016, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council issued the *Opinions* *on the Full Implementation of the River Chief System*, which called for the establishment of the river chief system by the end of 2018. In the river chief system, the main party and government leaders at all levels (provinces, cities, counties, and townships) act as river chiefs responsible for the prevention and control of pollution in rivers and lakes within their jurisdiction and for ensuring the improvement of water environment quality. The Ministry of Water Resources and the Ministry of Environmental Protection jointly issued the implementation plan of the previously mentioned opinion, and the Ministry of Water Resources issued the "Supervision and Inspection System for Fully Implementing the River Chief System." The river chief system clarifies the requirement that local party and government leaders take overall responsibility for water environment quality. Based on the standards of water quality in different jurisdictions, the distribution of responsibilities and assessment of water environmental protection and water pollution control are carried out. As of December 2017, provincial governments have issued opinions or plans for implementing the river chief system, which has proposed establishing a five-level river chief system at the provincial, municipal, county, township, and even village levels. All working plans of provinces, cities, and counties throughout the country have been issued and implemented, and 98 percent of the township-level plans have been issued. Seven major river basin commissions have formed corresponding implementation plans to different degrees and carried out supervision and inspections. River chiefs at the provincial level have all been assigned to the governors of 31 provinces (autonomous regions and municipalities directly below the central government) and the Xinjiang Production and Construction Corps, as well as other provincial leaders. The leaders of the provincial party committees or governments are the main people in charge. 330 provincial leaders are chiefs of important rivers and lakes, and 99 percent of city-level and 97 percent of the county-level river chiefs are designated. Six supporting systems for the river chief system in 27 provinces (river chief meetings, information sharing, information submission, work supervision, acceptance, and assessment and incentives) have been introduced. On November 20, 2017, the Central Leading Group for Comprehensively Deepening Reform adopted *Guiding Opinions on Implementing the Lake Chief System* to strengthen the water governance of lakes. According to the Ministry of Water Resources, the system of river chiefs was expected to be fully established throughout the country before the end of June 2018.

Integration of Water Governance Activities

In 2014, the central government set up a leading group to promote the development of the Yangtze River Economic Belt, headed by Zhang Gaoli, a member of the Standing Committee of the Political Bureau of the Central Committee and vice premier of the State Council. In September 2016, the "Development Planning of the Yangtze River Economic Belt Outline" was issued to promote the construction of the Golden Waterway of the Yangtze River and to promote the establishment of a consultative and cooperative mechanism among local governments along the Yangtze River. In July 2017, the Ministry of Environmental Protection, the Development and Reform Commission, and the Ministry of Water Resources jointly issued the *Eco-environmental Protection Plan for the Yangtze River Economic Belt*. From April 24 to 26, 2018, President Xi Jinping emphasized the importance of ecological protection and green development during his visit to the middle reaches of the Yangtze River Economic Belt.

Problems

Inter-departmental Issues

The development and utilization of water resources for different purposes, such as production and domestic water use, transportation and shipping, agricultural irrigation, and aquaculture, as well as water pollution prevention and control and water environmental protection, are disconnected. Water resource, water environmental, groundwater, and surface water management belong to different departments, which greatly reduces the efficiency of water governance (Wang Yahua 2007). The interdepartmental collaboration mechanism is insufficient. With the increase of cross-departmental affairs, the frequency of joint interministerial meetings on water-related issues is increasing. However, because of a lack of administrative power and authority, the effect of interministerial coordination is limited.

River Basin Organization Issues

For a long time, water governance has focused on regional management. A cooperation mechanism among local governments has not been established, and there is a lack of operable norms (Zhou Hao et al. 2014). The powers and responsibilities in river basin organizations and regional governments are unclear, and the ways to execute those powers and responsibilities are uncertain. There is a fight for rights between river basin organizations and local governments in the river basin. At the river basin level, river basin organizations lack authority over all water issues. Because the existing major river basin organizations are the subordinate agencies of certain ministries, it is difficult for them to implement cross-departmental integrated basin management.

Information Issues

Many departments concerned with water issues are undertaking monitoring, and they have accumulate a large amount of data on water resources, the water environment, and water ecology according to their own mandates. These data belong to different water-related departments, and the interministerial data exchange and sharing mechanism is insufficient. In addition, even within the same ministries, there is a lack of basic information sharing. Because of inconsistencies in analysis methods and technical specifications followed by various departments in the process of data acquisition and analysis, the data at the same monitoring point could be inconsistent. The monitoring results are often quite different or even contradictory, which is counterproductive to the comprehensive, objective, and accurate evaluation of China's water ecological quality and makes it difficult to support relevant decision making in water governance.

Legal and Accountability Issues

Regional laws and regulations are mainly used to deal with problems involving a whole river basin, and legal protection is insufficient. The existing river basin legislation cannot support integrated basin management. When river basin organizations carry out administrative law enforcement, the legal system cannot deal with local illegal acts. The ability for and means of law enforcement are insufficient. In particular, the ability to mediate interprovincial water disputes is weak. In addition, in the process of water governance, the supervision and accountability mechanism for leaders has not been used well (Li Hao 2014). Problems include simplification of the main body of accountability, absence of criteria for determining responsibility, and imperfection of the accountability procedure.

Public Participation Issues

For a long time, the decision-making mechanism involving government, enterprises, and public participation in consultations has not been established in water governance in China. The existing laws and regulations only stipulate public participation in principle, and public access to relevant information is limited. The lack of rules, public initiatives, feasibility, and enthusiasm means public participation has not been fully mobilized.

Directions for Improvement

The core goal of administrative system reform for China's water governance is to improve efficiency. Various factors should be taken into account, such as the lack of legislation, organizational structure, management power distribution, accountability mechanism, policy instruments, regulatory capacity, room for improvement, feasibility of reform, and possible negative effects, to clarify the path of administrative system reform.

"Nine Dragons Managing Water"

Although many studies have shown that institutions described as "nine dragons managing water" reduce the efficiency of water governance in China, some studies have shown that decentralization of functions in water management is not the key issue; rather, it is the lack of effective cross-sectoral cooperation mechanisms. Some studies even conclude that decentralization of power and benign competition are conducive to achieving better governance results. This study argues that although the "nine dragons" management system has affected the performance of water governance in China, it is not the fundamental reason for inefficiency. Reforms to establish large departments characterized by merging institutions have drawn attention, but these can only change the situation to a certain extent, because the problem of interministerial and intraministerial coordination still exists. At the same time, such reforms may raise the issue of sectoral monopoly. The core problem of China's water governance is that the cross-sectoral and cross-regional cooperation mechanism is not smooth. It is necessary to promote information sharing and mutual cooperation among departments on the basis of clarified powers and responsibilities from legal and procedural perspectives, to formulate operational cooperation norms, and to form legal, standardized, and procedural cooperation and accountability mechanisms.

Basin Organization Reform

The reform of river basin organizations is a hot topic tied to the water governance system in China. Some experts believe that the main reason for the inefficiency of water governance is that the administrative level of river basin organizations is too low and should be elevated. Some experts also believe that the composition of river basin organizations is too homogenous. The diversity of the members of basin organizations should be increased, and committee functions should be introduced. Based on international experience and systematic analysis, this report finds it difficult to improve the performance of river basin water governance by strengthening the administrative status of river basin management agencies and changing the organizational composition. Basin organizations already have high administrative status. For example, the Yangtze River and Yellow

River Water Conservancy Commissions are both deputy ministerial bodies. Strengthening or even changing their subordinate relationship to the corresponding ministry will not necessarily improve the performance of water governance, but it may change the pattern of river basin governance system too much and lead to ineffective implementation of the organizations' original functions. Under the existing administrative system, it is difficult to increase the membership in the river basin organizations, as is introducing the role of a committee.

Relying solely on the reform of water governance administrative systems not only will fail to improve water governance performance but also will introduce cost for the changes. This report finds that the way to reform the existing river basin management system is to implement and strengthen the responsibilities of existing river basin organizations and to implement and strengthen river basin management through procedural and institutionalized coordination. Therefore, it is necessary to establish and improve basin legislation, to strengthen the functions of basin management agencies in formulating common water management objectives and undertaking overall management according to the laws, and to promote collaboration among the basin agencies under various ministries and commissions. It is also necessary to broaden and strengthen the functions of river basin management agencies in the overall management of both water quality and water quantity. It is suggested that integrated management of landscape, fields, forests, lakes, and grasses within the river basins be broadened to rationally regulate the development and utilization of water resources.

Conclusions and Suggestions

Main Conclusions

At present, the core problem of water governance is the lack of a cross-sectoral and cross-regional cooperation mechanism. It is necessary to share information among superiors, subordinates, regions, and departments according to laws and procedures. It is also important to form operational cooperation norms and legal, standardized, procedural cooperation and accountability mechanisms. Against the backdrop of further integration of water governance powers, the establishment of a water governance cooperation mechanism becomes increasingly urgent. Water resource supervision and water environmental protection belong to the Ministry of Natural Resources and the Ministry of Ecology and Environment, respectively, which can maximize the advantages of interagency checks, balances, and collaboration and call for the support of a good collaboration mechanism.

The reform of basin management institutions is a hot topic. The keys to reforming the river basin management system are implementing and strengthening the responsibilities of existing river basin management institutions, in addition to strengthening river basin management through procedural and institutionalized coordination. Basin legislation must be established and improved. The functions and overall management ability of basin agencies must be strengthened, particularly in terms of formulating common and law-based water management objectives for the whole basin. Collaboration among the basin agencies under various ministries and commissions also needs to be promoted.

Policy Recommendations

Departmental Improvements

To reform China's water governance, the powers and responsibilities of water-related departments should be clarified, and the establishment of a coordinated and effective regulatory system for water resource conservation, water ecological protection, and water pollution prevention and control should be promoted. By improving cross-sectoral cooperation, policy instrument coordination (involving water quantity and water quality) and collaborative management of water withdrawal rights, water use rights, and sewage discharge rights can be promoted. The construction of an ecological civilization is an opportunity, via the supervision system and accountability mechanism, to constantly enhance the division of labor and responsibilities among various water-related departments, thus establishing an effective and standardized cross-sectoral cooperation mechanism. It is advisable to establish an effective interministerial joint meeting mechanism and interdepartmental communication mechanism for water-related issues. The water resources and water environmental collaborative management mechanism, led by water resource departments and environmental protection departments, should be enhanced. It is necessary to improve the legal norms of joint interministerial meetings, to improve the corresponding procedural rules, to formulate specific implementation rules, and to promote the institutionalization, standardization, and proceduralization of interministerial coordination mechanisms.

River Basin Organization Improvements

By amending laws, regulations, and basin legislation, the law enforcement capacity and authority of basin management agencies can be strengthened, and the performance of basin management agencies can be enhanced. The powers and responsibilities of river basin management agencies should be clarified. The administrative law enforcement system of water management at the river basin level should be improved by establishing law enforcement mechanisms across provincial boundaries and strengthening the administrative law enforcement functions of river basin organizations. At the basin level, the basin agencies of the Ministry of Water Resources, the basin law enforcement agencies of environmental protection departments, and the regional environmental supervision bureau should be encouraged to establish a standardized coordination mechanism.

Basin-Territorial Integration Improvements

To improve basin-territorial integrated and coordinated water governance, it is advisable to establish a water governance mechanism integrating regional implementation with overall river basin planning. Furthermore, power should be divided between river basin organizations and regional governments, and integrating the two institutions will improve the water governance mechanism. Basin management organizations should emphasize macromanagement and effectively stimulate the enthusiasm of local governments and departments. River basin organizations should be given the right to evaluate the main leaders of the local water-related departments, and they should balance overall and regional interests within the river basin. Under unified planning and the goals set by the river basin organizations, local governments should break down their evaluation objectives, take responsibility for the water governance within their jurisdiction, and achieve the goal of water governance within their territorial areas by mobilizing the collaboration of various water-related departments. It is therefore possible to jointly guarantee the attainment of the river basin management goals. Powers and responsibilities should be constantly clarified through consultations and other means.

Vertical Environmental Management Reform and River Chief System

Vertical management reform of environmental protection agencies below the provincial level and the river chief system should be linked effectively. Environmental supervision and administrative law enforcement agencies should be set up by river basin, and the workflow among different levels of institutions should be clarified. Through relevant accountability mechanisms such as the river chief system, the Strictest Water Resources Management System, and the evaluation and assessment of the objectives of constructing an ecological civilization, it is necessary to strengthen the cross-sectoral coordination mechanism and establish a top-down, multilevel, and cross-sectoral working mechanism on the basis of clarifying the powers and responsibilities of various departments. To set up a transbasin environmental supervision agency, effective cooperation with the basin organizations affiliated with the water resource department should be comprehensively considered. The establishment of a working mechanism and sharing of water-related information can be used as the starting point for promoting cooperation among departments at the basin level. Basin organizations dealing with environmental protection should focus on the coordination of cross-administrative areas. Their environmental law enforcement authority and the corresponding territorial environmental law enforcement should be linked.

Information Improvements

In establishing an unobstructed water-related information-sharing mechanism, it is advisable to strengthen the standards and regulations for a water-related database and promulgate relevant standards to lay the foundation for follow-up national platforms for water information. The construction of a unified and standardized information-sharing platform at the river basin level should be promoted to achieve cross-sectoral, cross-jurisdictional, and cross-user water information sharing. Technical exchanges among departments of environmental protection, water conservancy, land resources, and related areas should also be promoted in terms of water-related information communication, monitoring methods, and evaluation criteria. An institutionalized information-sharing mechanism should be established. It is advisable to strengthen the publication of water information and maximize the synergies between water resource protection and environmental protection.

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CHAPTER 13

Technological Innovation and Information Platform Construction for China's Water Governance

Background

The old problems of uneven spatial and temporal distributions of water resources and frequent floods and droughts in China are intertwined with new problems such as water shortage, water environmental pollution, and water ecological damage, which have become constraints on sustainable economic and social development. To better meet the needs of socioeconomic transitions, it is urgent to strengthen the technological innovation and information platform construction for water security in China, and to enhance the level and capacity of water governance.

In general, China's water resource security is weak. Water environment quality improves slowly. The water ecology is seriously damaged, and there are many hidden risks related to water environmental pollution. It is difficult for the existing technologies and information platforms to support the demand of water governance. There are also many problems with water-related data, such as missing items, insufficient coverage, insufficient time series, and segmentation. Integrating multilevel and multisource data urgently requires technical solutions and institutional arrangements.

Water is a basic natural resource and a strategic economic resource. From a scientific point of view, water governance is divided into water resources, the water environment, water ecology, water disasters, water management, and other fields. From the perspective of water users, it covers agricultural water, industrial water, municipal water, ecological water, residential water, and so on. Technological innovations can be separated into three levels: technological thinking, technological equipment (hard technology), and technological solutions. Technological innovations should meet the goals of technological feasibility, economic rationality, and environmental friendliness and form a model that can be popularized and replicated. Information platforms can be divided into public platforms that can be shared and government platforms and enterprise platforms that can support decision making.

This study has drawn lessons from numerous scientific research outcomes, policies, regulations, and plans. It discusses the development and utilization of water resources, water saving and efficiency, water pollution control, water ecological conservation, water disaster prevention and management, and conducted case studies. Based on these lessons, building a standardized, unified, and shared water governance information platform throughout the country is suggested. Because water security under climate change is a hot research topic all over the world, it is also considered in this study.

This chapter is based on a summary of the Thematic Report prepared by Hongchun Zhou and Xiaojun Huang Development Research Center of the State Council.

Research Objectives

Using a problem-oriented approach, the existing situation with China's water management technology and water information-sharing platform and the gap between China and global advanced levels are analyzed. Key technologies and their supplies that are urgently needed for water security management, as well as international development trends, are summarized. The main objectives, goals, key technologies, organization of innovation activities, supporting policies, and countermeasures for building information platforms are offered.

Analysis and Summary

Technological Innovation

China has implemented the High-Efficiency Development and Utilization of Water Resources special project, requiring key research and development, as well as demonstration of several advanced technologies in comprehensive water resource distribution, water saving, comprehensive utilization of water resources, water conservancy engineering construction, unconventional water development, and utilization. Aiming at ensuring a safe supply of water resources, it is advisable to popularize and apply advanced and applicable technologies such as artificial precipitation, seawater desalination, and reclaimed water utilization, as well as technologies in water resource allocation, groundwater storage, and rainwater utilization and management, to promote scientific and technological innovations in water products and equipment.

Areas and Priorities

Technological innovation priorities include developing technologies for efficient development and utilization of water resources, focusing on the comprehensive allocation strategy of water resources, construction and operation of water projects, safety and emergency management technologies, intelligent dispatching, and refined management of water resource systems. Technical equipment also needs to be created for the development and utilization of unconventional water resources such as rainwater, seawater, reclaimed water, mine water, and brackish water, which would require breakthroughs in several key equipment areas. Integrated applications should be used in economic zones such as the Beijing-Tianjin-Hebei region and the Yangtze River Economic Belt.

Rural Water Infrastructure and Technical System

China's agricultural water consumption is large and inefficient. Agricultural water conservancy should be developed, and the construction of water conservancy facilities should be strengthened. The last kilometer of farmland water conservancy should be completed, and the allocation capacity of water resources should be improved. River and lake water system connectivity projects should be carried out according to local conditions, relying on natural river and lake water systems, storage, and diversion projects. The rates of centralized water supply, tap water supply, water supply guarantee rate, and water quality compliance rate in rural areas should be improved. The construction of water conservancy in pastoral areas should be steadily promoted. The construction of drought-resistant water sources should be improved, and the regional capacity of the emergency water supply for drought resistance should be enhanced.

Urban Water Supply Structure and Basin-Level Layout

Urban water priorities include improving the guaranteed rate of urban water supply and emergency water supply capacity. According to the principle of "utilization by quality and distance," sewage reclamation facilities should be constructed. Reclaimed water should be prioritized in industrial production, urban greening, road cleaning, vehicle washing, construction, and ecological landscaping. The construction of emergency and backup water sources should be strengthened. For cities with groundwater overexploitation, new water sources should be developed or external water sources should be used. In cities with poor water quality, emergency water source areas and reserve water source protection areas should be strictly delineated to ensure water source safety.

Water Saving and Efficiency Improvements

Water saving has always been an important part of China's water security. Forward-looking water-saving technologies should be researched and developed. Standard water-saving systems should be improved. Water use efficiency should be constantly improved to develop the spatial pattern, industrial structure, production mode, and consumption mode for water resource conservation. During the 13th Five-Year Plan period, water consumption of 10,000 yuan of gross domestic product and 10,000 yuan of industrial added value decreased by 23 and 20 percent, respectively, compared with that in 2015. The leakage rate of the urban public water supply network is controlled within 10 percent, and the metering rate of urban and industrial water use has reached more than 85 percent. The effective utilization coefficient of farmland irrigation water has been raised to more than 0.55, and the metering rate of agricultural irrigation water in large-scale irrigation areas and key medium-size irrigation areas has reached higher than 70 percent.

Agricultural Water-Saving Technology System

Agricultural water accounts for a high proportion of use in China and is the area with the largest water-saving potential. To manifest the principle of "first saving water, then using water," it is suggested to start with drought-resistant crops and water-saving (sprinkler irrigation and microirrigation) technologies and irrigation projects and then to build several moderate-scale, advanced-technology, and scientifically managed high-efficiency water-saving irrigation demonstration projects.

Xinjiang Tianye Co. has been promoting an agricultural water-saving technology called mulched drip irrigation and popularizing it in China. There are more than 40 types of drip irrigation crops. The technology has also been applied to the greening of deserts and desert slopes and has achieved remarkable results (box 13.1).

Industrial Water-Saving Technology System

It is necessary to develop advanced and applicable water-saving technologies with different characteristics, to formulate water quotas for key industries, to carry out water balance tests, to optimize and transform water-saving technologies, and to promote the application of technologies on high-efficiency water use, clean water and both sewage and wastewater recycling, water system intelligent management, and so forth. By 2020, China's water consumption of industrial added value of 10,000 yuan is expected to be reduced by 20 percent, the water quota and planning management for enterprises above a certain scale (annual water consumption of 10,000 cubic meters or more) is expected to be fully covered, and industrial parks in water-deficient areas are expected to meet water-saving standards. Water intake per ton of steel in key iron and steel enterprises is expected to be reduced to 3.2 cubic meters per ton, and the water reuse rate is anticipated to increase to more than 98 percent.

Urban Water-Saving Technology Systems

The goal of urban water-saving technology systems is to control the leakage rate of the urban public water supply network so that it stays under 10 percent. The utilization rate of reclaimed water in water-deficient cities should be more than 20 percent. Water-saving appliances should cover all new public and residential buildings. Water-deficient cities at the prefecture level and above should meet the national standards of water-saving cities.

To achieve these goals, water-saving appliances should first be popularized. Old residential areas should be encouraged to renovate independently. All new renovation and expansion projects should use water-saving appliances. Second, leakage control and renovation in residential areas and public institutions should be undertaken. District metering areas should be encouraged for residential zones. Third, rainwater utilization projects in buildings or residential areas should be implemented to promote the construction and transformation of ecological purification or storage facilities. Fourth, the construction of reclaimed water utilization projects or facilities in public buildings or residential areas should be carried out. Reclaimed water facilities should be installed in new public buildings of a certain scale. Reclaimed water should be used, preferably for toilet cleaning and dust suppression.

Box 13.1 Xinjiang Tianye Co. Promotes Agricultural Water-Saving Technology of Mulched Drip Irrigation

Mulched drip irrigation technology is a drip irrigation technology that places a covering film over the drip irrigation belt or capillary (soft rubber tube) to reduce water losses. After a water source is filtered (to prevent the drip holes from clogging with sediment), it enters a controllable water conveyance trunk-branch-capillary system and drips evenly, regularly, quantitatively, and drop by drop to the root system of crops. When a crop is to be fertilized, the fertilizer and water are fully mixed to form a fertilizer-water solution and then drip irrigation.

The Tianye Group of Xinjiang Corps uses the application of mulched drip irrigation as a platform to integrate a series of water-saving agricultural technical measures, such as irrigation, fertilization, pesticide application, cultivation, and management, and to improve the agricultural technology level.

Compared with traditional irrigation methods, the application of mulched drip irrigation not only reduces labor intensity and improves agricultural labor productivity but also makes agricultural industrialization gradually come true.

Source: Lin Jiabin and Zhou Hongchun, Water-saving technology of mulched drip irrigation leads a major change in agricultural production mode (Development Research Center of the State Council 2013).

Water Pollution Control and Ecological Protection Systems

The existing scientific and technological resources for water pollution control and ecological protection technology systems should be integrated. Fundamental research and forward-looking technological research and development on water environmental benchmarks, water pollution's effects on human health, water environmental damage assessment, and reclaimed water utilization should be carried out. Advanced technologies and equipment for water pollution control should be promoted. The market of environmental protection industries should be standardized, and the industrialization of advanced technologies and equipment should be promoted.

Construction of Pollution Control and Reduction Projects

To provide systematic solutions to environmental problems and to develop an environmental protection technology system, water environment monitoring and early warning technology, as well as river basin water environmental management technologies, should be promoted. A technical system of source control, cleaner production, end-use management, and ecological restoration should be established. Acceleration is suggested for research and development of technologies for advanced treatment of wastewater, low-cost and high-standard treatment of domestic wastewater, desalination of seawater and industrial high-salt wastewater, treatment of trace toxic pollutants in drinking water, remediation of groundwater pollution, and emergency treatment of hazardous chemical accidents and oil spills in water. The construction of water quality monitoring and forecasting and early warning technology systems for important water bodies, water sources, and water conservation areas should be strengthened, with breakthroughs in key technologies such as health-risk control of drinking water quality, prevention and control of groundwater pollution, reuse of wastewater, and safe utilization.

Urban Black and Odorous Water Treatment

Influenced by various factors such as concentration of sewage, inadequate interception, insufficient stream flows, and unreasonable planning, urban water bodies are generally heavily polluted and can even be black and smelly. To treat urban black and odorous water bodies, implementation of the requirements of prioritizing sewage interception, and governance-based and systematic management is suggested. Treatment programs should adhere to a problem-solving orientation and implement the “one river, one policy” guidance to solve the problems of direct sewage discharge in built-up urban areas. Long-term management should be implemented, innovating the operation and maintenance mode of the projects. Finally, the status of the urban water environment should be strictly assessed and a list of urban black and odorous water bodies, as well as the processes of treatment, should be routinely published.

Pollution Control in Key Industries

It is advisable to formulate and implement special treatment schemes for 10 key water-related industries, such as papermaking, printing and dyeing, to greatly reduce the intensity of pollutant discharge. Focusing on the transformation to ultralow emissions of coal-fired power plants, coordinated control of sulfur dioxide, nitrogen oxides, smoke, dust, heavy metals, and other pollutants can be implemented in power, steel, building material, petrochemical, and nonferrous metal industries. Special governance plans should be created and made publicly available, and projects with insufficient pollution control should be exposed.

Pollution Prevention and Control in Key River Basins

For key river basins, promotion of urban and rural environmental improvement should continue. Focusing on the important water sources along the South-to-North Water Transfer Line, the Three Gorges Reservoir Area, and the Yangtze River, the extension of urban sewage and wastewater treatment facilities and services to the countryside should be promoted. Transformation of rural toilets should be facilitated, as well as unified planning, construction, and management of rural sewage treatment.

Pollution Control of Livestock and Poultry Farming

With the rapid development of livestock and poultry farming in China, problems such as unreasonable sector layout and direct discharge of livestock and poultry manure have arisen. Livestock and poultry manure has become one of the sources of eutrophication in lake and reservoir water. According to the process control concept of adjusting layout, building facilities, and promoting utilization, cleaner production and resource utilization of manure in aquaculture farms should be implemented to reduce pollution of the water environment. Biological treatment is the main treatment method for rural sewage.

In 2013, the Sound Group signed a franchise agreement with the Changsha county government to organize small and medium-size sewage treatment projects in villages and towns into a project to provide integrated solutions (box 13.2).

Integrated Control of Surface Water and Groundwater Pollution

Groundwater pollution incidents occur frequently in China. The coordinated prevention and control of surface water and groundwater pollution should be systematically considered to change the firefighting-style of pollution control.

Since 2013, Zhejiang province has comprehensively promoted sewage control, flood prevention, drainage, water supply, and water saving (the components of so-called five-water co-governance); formulated river pollution regulation plans for each river; implemented the river chief system; and accepted supervision by the public and the media.

Information Technology and Water Governance in China

There are various problems with China's water-related data, such as missing items, insufficient coverage, insufficient time series, and segmentation. Water-related information involves multiple departments, such as water resources, natural resources, agriculture, environmental protection, and meteorology, as well as enterprise, public, economic, and social development data. The lack of general standards for database use and inconsistent data formats and technical routes have resulted in many data islands. Interdepartmental data exchange and sharing are imperfect; even within the same department, there is a lack of a normal sharing mechanism.

China's information platform is unable to meet water governance needs. It is urgent and necessary to break through the key technologies of big data in water security; to build a standard system of open and shared data; to build a nationally unified, standardized, and shared water information platform; and then to form a social governance structure involving the government, enterprises, water users, and trade associations.

The application of information technology in water governance has been explored by many enterprises. The application of an intelligent pipe network management system in Shanghai World Expo Park is one of them (box 13.3).

Water Information Improvements

To promote information technology for water resources, the following improvements are suggested: Optimize and improve the layout and functions of

Box 13.2 The SMART Changsha Mode of Rural Wastewater Treatment

The SMART Changsha Mode is a mnemonic, using S for small-scale and land occupation, M for modularization and multifunction, A for automation, R for rapid construction period, and T for technological equipment. In the Changsha project, which uses a public-private partnership model, the Sound Group joined with the government to invest, build, operate, and transfer 16 township sewage treatment plants (29,400 tons per day) and to build and transfer supporting pipeline network projects, as well as the operation and management, of two sewage treatment plants (5,000 tons per day). Thus, the Sound Group has provided one-stop service, including investment, equipment procurement, installation, operation, and maintenance, for 18 township sewage treatment plants from design to operation.

The intensive and intelligent operation mode of the Sound Group not only guarantees the long-term operation of rural sewage treatment facilities but also saves on operation and maintenance costs and facilitates the supervision of the body responsible for operation and management.

Source: Sound SMART small town comprehensive wastewater treatment solutions and the Changsha project fieldwork (2014).

Box 13.3 Intelligent Pipeline Network Management System and Its Application in Shanghai World Expo Park

During the 2010 Shanghai World Expo, to ensure the security of the drinking water supply and its water quality, Shanghai Pudong Veolia Company integrated the control center, testing center, and customer call center. To identify a problem, a geographic information system would locate any customer complaint in the call center database or any water quality problem found by the supervisory control and data acquisition system. It not only can analyze the location and cause of the problem but also can predict the possible consequences downstream to help eliminate downstream faults in each network maintenance operation (washing, repairing, valve maintenance, and so on).

After the success of the "three centers in one" architecture in the Expo Park, Veolia applied this experience to some water supply projects in Europe that have achieved remarkable results in improving local customer service and emergency management capabilities.

Source: Materials provided by Xiaojun Huang, Xiaobo Zhang, and others.

hydrological stations. Strengthen the construction of water quality and quantity monitoring systems for soil and water conservation monitoring networks, key water functional areas, and major provincial boundaries. Enhance the service capabilities of hydrological patrol, water quality analysis, and hydrological information processing. Establish advanced, accurate, and timely water resource, water environmental, water ecology, and urban hydrological monitoring systems.

Hydrological and Water Resource Database

The construction of a water resource monitoring and management system should be completed. This includes the following developments: Establish water metering facilities and an online, real-time monitoring system covering industrial water users in cities and towns, as well as large and medium-size irrigation areas. Promote the integration and sharing of water information. Establish a national water information infrastructure platform, and improve the social service level of water information. Strengthen the construction of water information network security, and build a safe and controllable water resource network and information security system.

To ensure public safety and focus on the theoretical issues of natural disasters, such as meteorological disasters, floods, droughts, and marine disasters, key scientific and technological research and integrated demonstrations should be carried out on monitoring and early warning of major natural disasters, as well as risk prevention and control and comprehensive emergency response. Acceleration is recommended for the construction and integration of a national flood control and drought relief command system; mountain flood disaster monitoring and early warning system; large-reservoir dam safety monitoring and supervision platform; water resource management information system that covers large, medium, and small water projects; and water resource data center to improve comprehensive decision-making and management capacity. The construction of an urban meteorological and hydrological information monitoring and early warning system would improve the timeliness and accuracy of rainstorm and flood forecasting. Other tasks are to improve emergency plans for flood control and drainage, strengthen urban waterlogging and flood risk management, and improve the capability to cope with climate change.

An ecological monitoring network system should be constructed, and an intelligent environmental protection and technical support system should be established. A national environment quality monitoring network covering the elements of atmosphere, water, and soil should be built with a reasonable layout and perfect functions. The monitoring sites of atmospheric and surface water environment quality should cover about 80 percent of the districts and counties. Full coverage should be achieved in densely populated districts and counties. The monitoring sites of soil environment quality should achieve full coverage.

Several other tasks should be undertaken that relate to the development of a hydrological and water resource database: Improve the capabilities and level of the hydrological information service. Strengthen the development and utilization of water information, and improve the level of atmospheric environment quality prediction and pollution warnings. Develop a national water quality monitoring and early warning platform. Strengthen monitoring of persistent and bioconcentration pollutants in drinking water sources and soils that are harmful to human health. Strengthen monitoring and early warnings of water quality and radioactivity of urban, centralized drinking water sources in key river basins. Establish an integrated remote-sensing monitoring system to attain a network of environmental satellites. Strengthen remote-sensing monitoring of unmanned aerial vehicles and ground ecological monitoring, which provide information and scientific and technological support for environmental pollution control and quality improvement, as well as improved competitiveness of the environmental protection industry.

Conclusions and Suggestions

Main Conclusions

Technological innovations in water governance can be divided into five areas: water resources, the water environment, water ecology, water disasters, and water management. It can also be divided into two levels: hard technological innovation and soft institutional arrangements. Applications of advanced technologies can be found throughout China.

Technological progress can change the distributional patterns of water resources. For example, artificial intervention can change the spatial and temporal distribution of rainfall, desalination can alleviate water shortages in coastal areas and islands, and reclaimed water utilization can change the water source structure of cities.

Water resource allocation technologies (such as water diversion) should pay attention to the economics and sustainability of the projects. Water saving, especially agricultural water saving, has greatly improved irrigation efficiency, but the potential is still huge. The research and development of water-saving technologies and their popularization and application are still important tasks.

There are many models for water pollution control in China, such as black and odorous water treatment, biological treatment of scattered sources in rural areas (specialized and scaled), strengthened technological integration (such as a water treatment concept plant) and applicability, and promotion based on learned experiences. The essence of Zhejiang's five-water cogovernance model is to form a synergistic effect and should be promoted.

The existing water information platform, including government and enterprises, still faces difficulties in jointly developing and sharing information. The development of water governance technologies and an information platform needs increased investment and supporting policies.

Thoughts and Principles

Scientific and technological innovations should be combined with the improvement of people's livelihood. Improving people's well-being and promoting their all-round development can be taken as the starting point of water governance. It is suggested to solve the most direct and realistic problems concerning flood control, water supply, water environmental pollution control, and water ecological improvement and then enable the public to share the benefits of water reform and development.

Make Overall Plans and Improve Efficiency

Consideration should be given to both the present and the long term. The water infrastructure should be improved, taking into account both water saving and water control, surface water and groundwater, freshwater and seawater, and good water and poor water, to make overall arrangements for production, domestic, and ecological water use. Efforts should also be made to control the total amount of water use, improve water efficiency, and guarantee ecological water use to comprehensively promote the conservation of mountains, rivers, forests, and lakes. Basins should be regarded as units to strengthen overall protection, systematic restoration, and comprehensive treatment. A good grasp of key pollutants, industries, and regions is needed to improve the quality of the water environment. The discharge amounts and time periods from dams should be scheduled to maintain ecological water uses of rivers and lakes.

Improve Water Quality

The core quality of the water environment would improve with comprehensive control of pollutant discharge and the construction of a comprehensive, multistep, and coordinated pattern of water quantity, water quality, water ecology, water disasters, and water management. Emphasis should be placed on banning "ten small" enterprises, renovating the 10 major polluting industries, controlling industrial agglomeration areas, and preventing urban domestic sewage to deepen the work of reducing pollution. Large-scale livestock-forbidden breeding areas should be delimited to achieve resource utilization of livestock manure sewage. Additional tasks are to accelerate the comprehensive renovation of the rural environment and strengthen pollution control of shipping ports. By capping pollutant discharge, the total amount of pollutants discharged from industry, urban life, and rural agriculture can be reduced.

Manage Water According to the Law and Science

The water rule of the legal system requires improvement. This includes strengthening the guiding and binding roles of standards, policies, and plans in water-related activities. Additional benefit would arise from enhanced supervision and management of rivers and lakes, water resources, and the water environment. Inferior class V water bodies should be eliminated, and the safety of drinking water should be ensured. Engineering and management measures should be taken simultaneously. Engineering measures should focus on water governance and water cleaning through projects, and management measures should focus on water governance and water saving through institutions. Treatment should be strengthened for ditches and small river branches that receive large public interest and concern. It would be beneficial to publish the lists of black and odorous water bodies, responsible people, and time limits for meeting standards and to implement a water quality assessment and accountability system for key river basins.

Suggestions

Strengthen Scientific and Technological Support

Suggestions to strengthen scientific and technological support for water resources are as follows: Improve the scientific and technological innovation system. Strengthen the construction of hydrometeorological infrastructure, optimize the layout of stations and networks, and accelerate the construction and capacity of emergency monitoring systems. Strive to achieve breakthroughs in key areas, key links, and core technologies; obtain several research outcomes of significant practical values; and enhance the introduction and application of technologies. Improve the level of hydraulic engineering technology and equipment.

Enhance Legal and Scientific Water Governance

Suggestions to comprehensively enhance law-based water governance and scientifically develop water resources are as follows: Comprehensively strengthen the construction of the rule of law for water governance, accelerate the transformation of water administration functions, strengthen social management of water-related affairs, and effectively improve the capacity of water management according to the law. Promote legislation in key areas. Speed up the promulgation of the regulations on water conservation and groundwater management, and carry out research on amendment of the *Water Law of the People's Republic of China* and the *Flood Control Law*. Establish and improve the system of public consultation, expert consultation, and postlegislation evaluation to improve the quality of water governance legislation. Improve the system of technical standards. Strengthen the development of basic, general, and common industrial technical standards. Improve the standards of environmental protection, energy saving, water saving, material saving, safety indicators in production processes, and market access. Promote the standard leader mechanism, and coordinate the innovations of science, technology, standards, and industry. Make full use of trade associations, and enhance the influence of China's water treatment standards.

In addition, the comprehensive law enforcement of water administration should be strengthened. The certification and qualification management system for water supervisors should be improved. The responsibility system for law enforcement should be implemented. Administrative law enforcement procedures and the benchmark system of law enforcement discretion should be improved. A record system for the process of law enforcement and a review mechanism for the legitimacy of major penalty decisions should be established. Routine law enforcement inspections and onsite law enforcement should be enhanced, and illegal water acts should be punished according to the law.

Implement the Strictest Water Resources Management System

Implementation of the Strictest Water Resources Management System begins by establishing a system of total water use control and efficiency control. It is also important to establish the red line of water resource development and utilization control and to establish the index system of total water withdrawal control. Strict administration of the examination and approval of water withdrawal permits is suggested. The examination and approval of new water intake for construction projects in areas where the total amount of water withdrawal reaches or exceeds the control targets should be suspended. New water withdrawal in areas where the total amount of water intake is close to the control targets should be limited. Strict manage and control of groundwater use are key to achieving balance between exploitation and recharge; coordinating domestic, agricultural, industrial, and ecological water uses; and improving the utilization efficiency of water resources. A system should be established that restricts the acceptance of pollutants in water functional zones. The total amount of sewage discharged into rivers and lakes should be strictly controlled by verifying the capacity of water to receive sewage. Where the amount of sewage discharge exceeds the limit of the total amount of sewage discharge in the water functional area, the examination and approval of new sewage outlets into rivers should be restricted.

Innovate the Water Governance System and Mechanism

Suggestions to develop an innovative water governance system and mechanism are as follows: Increase efforts to reform key areas and key links and promote the reform of water pricing, rights, investment, and financial mechanisms. Focus on building a complete, scientific, standardized, and effective water management system. Establish precise subsidies and a water-saving incentive mechanism for agricultural water use. Comprehensively promote the reform of water prices for urban water supplies. Comprehensively implement the blocking price system for urban residential water uses and the progressive price system for nonresident water uses that exceed the quota to widen the water price gap between high-water-consumption industries and other industries. Establish a price incentive mechanism to encourage the use of unconventional water resources. Establish a water ecological compensation mechanism. Broaden the financing channels and alleviate the pressure of local financing. Actively strive to broaden the scope of collateral (pledges) and the source of repayment for water conservancy construction projects, and allow water conservancy, hydropower assets, and related income rights to be used as the source of repayment and legal collateral. Encourage and support eligible water conservancy enterprises to list and issue corporate bonds, and expand the scale of direct financing.

Strengthen the education of national water resources, raise awareness of water crises and water protection throughout society, develop social consensus, and stimulate the enthusiasm for development and protection. Enhance the cultivation of talents to construct a perfect professional service system of grassroots water governance, form a combined force of water control and water development, and build a water-saving society.

Acknowledgments

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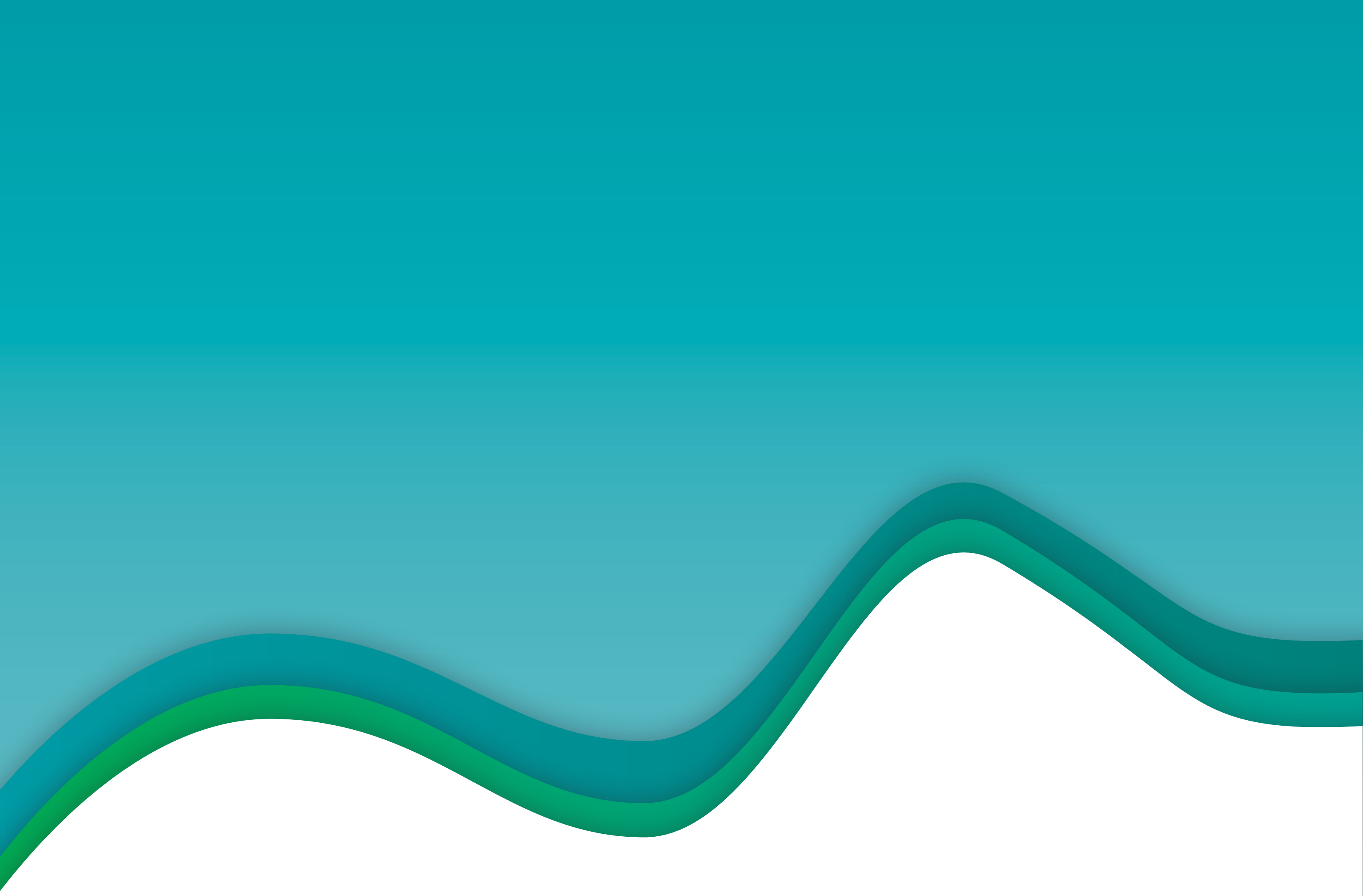

CHAPTER 14

Introducing Public-Private Partnerships into China's Water Governance

Background

In the 1990s, China started to introduce the public-private partnership (PPP) model into its urban water supply sector. In the new century, the marketization process of urban water services (including urban water supply, drainage, sewage treatment, and reuse) has been gradually accelerated, and various types of social capital have been involved in the construction and operation of urban water facilities.

The introduction of the PPP model into China's water governance has gone through four stages:

1. *Initial stage (mid-1990s–2001).* To solve the problem of slow construction of urban water facilities (mainly water plants), the initial stage focused on local independent practices and attracting capital (especially a large amount of foreign investment).
2. *Development stage (2002–08).* At the policy level, the state established market-oriented reform of municipal public utilities and water services. Various types of private capital, foreign investment, and publicly listed companies flocked in. The level of water infrastructure and service capacity achieved a great leap in a short period, initially forming diversified investment and financing, the coexistence of various economic components, and a pattern of competition.
3. *Adjustment stage (2009–13).* In the adjustment stage, questions and disputes arose in the marketization of urban water services, and the pace slowed. At the same time, the expansion of government investment began, and numerous government investment and financing platforms for various urban construction and infrastructure projects, including water investment and financing companies, emerged, promoting a leap forward in China's urban infrastructure. Although private capital still participates in funding water governance, there is no standardized operation system.
4. *Taking off again (2014 and on)* Beginning in 2014, the central government has been comprehensively cleaning up local debt and local financing platforms. Against a backdrop of standardizing the government's investment behavior, this stage emphasizes that what belongs to the government should return to the government and what belongs to the market should return to the market.

This chapter is based on a summary of the Thematic Report prepared by Yining Wang and Guizuo Wang from the Development Research Center of the Ministry of Water Resources.

The central government has issued a series of policy documents to promote the implementation of the PPP model, and PPPs have received great development. In terms of water governance, the traditional field of urban water services and other fields of water conservancy engineering construction and operation, water environmental management, farmland water conservancy, and so on, have issued policies introducing PPPs. However, a development trend remains to be seen.

By practicing the PPP model, the water industry has extensively introduced external funds, advanced management experience, and technology designed to promote the development of the water industry and improve the level of services. In the future, through the practice of the PPP model, it is of great significance to promote reforms of the construction and operational mechanisms of public water facilities and improve the efficiency and level of public water services. However, the goal, the direction, and the path of PPP model reform still need to be explored in depth. The interconnection of increasing facilities, improving operational efficiency, improving service levels, ensuring water safety, and so on should be examined to steadily promote PPP operations.

Research Objectives

This study aims to analyze the inherent mechanism of introducing the PPP model into water governance, to analyze the implementation environment and the evolution of PPPs in China, and to offer countermeasures and suggestions for promoting the reform of the PPP model in water governance in China. Based on this research, the reform of the water security governance system can be advanced and the efficiency and level of public water services can be improved.

Analysis and Summary

Status of PPPs in China's Water Governance

This study mainly focuses on PPPs in four areas: major water conservancy projects, water environmental management, urban water services, and farmland water conservancy.

Comprehensively considering factors such as local enthusiasm, project profitability, and the progress of preparation work for major water infrastructure, the National Development and Reform Commission and Ministry of Water Resources identified 12 PPP pilot projects: Heilongjiang Fengfen Reservoir, Zhejiang Zhoushan Inland Water Diversion Phase III, Anhui Jiangxiang Reservoir, Fujian Shangbaishi Reservoir, Guangdong Hanjiang Gaopi Water Conservancy Project, Hunan Mangshan Reservoir, Chongqing GuanJingkou Reservoir, Sichuan Lijiayan Reservoir, Sichuan Daqiao Reservoir Irrigation Area Phase II, Guizhou Maling Water Conservancy Project, Gansu Datao Water Supply Phase II Project, and the Xinjiang Dashixia Water Conservancy Project. In addition, Shaanxi, Gansu, Jiangxi, Zhejiang, and other provinces have explored the PPP model in water conservancy projects.

For environmental protection, as of September 2016, the National Development and Reform Commission has publicly introduced three batches of PPP projects to the public, of which about 17 are water pollution prevention and control PPP projects, involving about 20 billion yuan.

The introduction of PPPs has a long history and a high degree of development in the area of urban water services. By 2011, there were 309 projects involving private capital investment in China's water market, with a total investment of US$8.2 billion, accounting for 58 and 23 percent of the global water market, respectively. Build, operate, and transfer (BOT) is still the dominant route for private capital to enter the water industry.

However, the farmland PPP project model for water conservancy is still in the exploratory stage because of a lag in the property rights system for farmland facilities and low return despite large investments. The Dayu Water-Saving Group has implemented the first pilot project, introducing social capital to invest in farmland water conservancy construction in Lulianghenhu Reservoir in Yunnan province. The project has built a 10.8 million mu intelligent drip irrigation demonstration area of integrated water and fertilizer utilization.

Main Problems of PPPs in China's Water Governance

The understanding and implementation of introducing PPPs into water governance deviates from the original intentions of PPPs to some extent. PPP operation is often used to solve a shortage of financial funds. But if the partnership does not pay attention to follow-up supervision, performance evaluation, policy objective balance, and so on, it is difficult for the project to operate for a long time, and the PPP could be abandoned eventually. The essence of a PPP is not privatization but to balance the relationship between government and market rationally and to achieve maximum benefit through cooperation between government and social capital. The fundamental purpose of the reform is to transform the way the government provides public services and to improve the operational efficiency and public service level.

Water governance planning is not comprehensively coordinated, which affects the quality of PPP projects. For a long time, there has been the so-called nine dragons managing water in China. Because of uncoordinated planning and differences in quality, PPP projects introduced by different departments do not bring overarching effects and even face great uncertainties in the follow-up construction and operations. The root cause of the use of the metaphor “nine dragons managing water” is not the decentralization of management functions; it is only the symptom. Whether water-related affairs are managed by one department or by multiple departments, the core purpose is to achieve integrated planning and an organic connection of all aspects of water-related affairs, from planning to construction and operation. To solve the problem of “nine dragons managing water,” the key is to improve the decision-making, supervision, and implementation mechanisms of water governance, rather than simply merging and integrating the functions of different departments.

PPPs lack sufficient supporting policies and regulations. Because of the situation in China, contradictions exist between the PPP model and the existing laws and regulations, project approval, investments, and financing mechanisms. The core problem is that the government acts as both a participant and a supervisor of PPPs. It is bound by both administrative law and civil law. However, China’s relevant policies tend to define PPP contracts only by public laws. In addition, with the rapid expansion of the PPP model, related legal issues have emerged, such as land resource allocation and state-owned asset management. The existing normative documents are not enough to solve such contradictions. The legislative process of supporting laws and regulations should be advanced.

The economic sustainability of water PPP projects is insufficient. In some regions, a PPP is carried out because of policy requirements or financial difficulties. Therefore, places with better financial resources are not very active in promoting PPPs. Cities and counties with poor financial resources prefer to keep profitable projects rather than to bring in social capital and share the profits. As a result, the quality of recommended projects is generally unsatisfactory. They do not have sustainability of profits; therefore, enthusiasm for their social capital is not high. Furthermore, many water projects have an imperfect charging mechanism, and the basic conditions for the operation of social capital are not available. The profitability of these projects should be enhanced through government subsidies, land resource allocation, related business portfolios, loan discounts, public welfare expenditure compensation, tax and fee relief, and other means. Otherwise, it is difficult for them to operate long term. However, social capital is concerned with whether the relevant preferential policies are in place, whether they can be sustained, and whether they will be abolished because of a change of government.

The specialized operation system of water PPP projects needs to be strengthened. Implementing PPPs requires a sound, professional operation system. In the five stages of project identification, project preparation, project procurement, project execution, and project transfer, evaluation, demonstration, and negotiation of contract terms are involved. Differences in project nature, the diversity of fund sources, the diversification of participants, and increasingly stringent policy requirements make the introduction of PPPs into the domestic water sector increasingly complex. It is necessary to combine the characteristics of different water projects to decide whether to adopt a PPP model and which PPP model to choose. The contract terms should also be studied and set according to background and conditions of each project. But the PPP model is not only limited by insufficient consultation and supporting capacity but also affected by the mentality of quick success and instant benefits. In some places, PPP projects for water governance have been launched in a hurry without sufficient evaluation or careful preparation. Lack of specialization affects the operational quality of PPPs.

Finally, the supervision system for water governance PPP projects has been slow to develop. Water governance is different from other commodity products and services. It requires a huge initial expenditure. The technology and management system for later operations is also complex. It is difficult to obtain comprehensive information for supervision. In the last round of PPP reform for urban water affairs, one of the major criticisms is that more attention was paid to financing, reconstruction, and construction than to operation and supervision. If a supervision system cannot be incorporated into a sound government regulatory system, the introduction of PPPs will not achieve the desired purpose and may even cause greater negative effects. Therefore, the PPP operation in water governance should pay attention to the regulatory and supervision system to achieve all-round performance appraisal and life cycle supervision of PPP operations.

Profit Models for PPPs in Water Governance

The profit model of PPP projects raises wide concerns. Most infrastructure and public service projects are not fully profitable but instead are not profitable or are quasiprofitable, requiring government payments or consumer payments with government subsidies. Such model is not sustainable for either governmental or social capital. The problem of return on investment needs to be addressed through an innovative profit model.

According to relevant domestic research, PPP projects mainly have the following profit models: (1) Optimize the income structure, which includes supplementing the rights to develop resources to make up for lack of revenue, authorizing supporting services to expand the profit chain, developing by-products to increase revenue sources, and naming public services to improve the reputation of investors. (2) Optimize the cost structure, which includes properly segmenting the projects and applying the PPP model only to the parts that are closely related to operational cost and efficiency, packaging project operations to generate scale effect and reduce unit production cost, and innovating management and technologies to reduce operational cost. (3) Stabilize target profits, which includes bundling products with different profits and losses to improve the sustainability of target profits and setting a reasonable base in the early stage to improve the stability of target profits.

It is generally believed that the investment and operation modes of social capital in water governance are mainly determined by the investment scale and profitability of the water governance projects, that is, whether they have price-charging mechanism and the possibility of expanding their profit model. Water infrastructure and public service projects with a flexible price adjustment mechanism and a certain degree of marketization can be funded and operated independently by government-authorized social capital. If the investment scale is huge, it is more difficult for social capital to be invested independently and instead requires government investment. The government and social capital can form project companies jointly. For public welfare projects without a charging mechanism, it is more suitable to adopt the method of governmental purchasing services. Based on the nature of operation, it can be divided into the four following modes.

Stable Charging Mechanism and Cost Recovery

Examples of projects with a stable charging mechanism that basically meet cost recovery requirements include urban tap water, sewage treatment, and so on. The investment needs of these kinds of projects are within the capacity of social capital, and stable operation can be maintained by using water user charges to generate a certain amount of income, which has a strong attraction for social capital. The government can use BOT; toll, operate, and transfer; build, own, and operate; and other franchising methods to bring social capital into such projects. However, the water price is generally not sufficient, which hinders the introduction of social capital for some water supply and sewage treatment projects. Therefore, the formation mechanism for the water price should be constantly improved, and the level of the water price should cover the cost of construction and operation and generate reasonable profits.

For projects for which water prices are not adjusted or are difficult to adjust, the government can make up the difference for basic operating costs and improve profitability by giving appropriate preferential policy guarantees, authorizing the provision of supporting services, and developing by-products.

Stable Charging Mechanism but Huge Investments and Public Welfare

Examples of projects with a stable charging mechanism but huge investments and public welfare include important water source projects and water diversion projects. These kinds of projects have a huge investment scale and long cost recovery period. Although they also have a stable income source, the overall risk is relatively high and the long-term return on investment is difficult to guarantee. Moreover, such projects play a strategic and fundamental role in the national economy, and the government cannot withdraw completely if it is to provide public welfare. The project company can be set up with legal responsibility for the construction and operation of the project via joint investment by the government and social capital.

The profit for social capital include the following modes: (1) The basic reasonable profit of the project company should be guaranteed through normal water price adjustment. (2) Social capital can contribute to the part of the project that is more operational, while the other parts can be funded by the government. (3) The government can issue preferential policies such as financial subsidies, tax preferences, and the right to supplement resource development.

Weak Charging Mechanism and Investment Overlap

Projects with a weak charging mechanism and overlapping investment subjects and beneficiary groups are mainly farmland water conservancy projects. For example, for water-saving irrigation projects and small-scale farmland water conservancy projects with clear and centralized beneficiary groups, joint-stock companies can be set up by agricultural enterprises and farmers as project companies. The companies are responsible for the construction and operation of projects, and the government provides incentives and subsidies. Agricultural enterprises and farmers are both share owners and beneficiaries of water conservancy facilities, who consciously promote the sound operation of water conservancy facilities.

No Charging Mechanisms

Water projects that can be regarded as pure public services, including flood control and water ecological control, are often projects that lack charging mechanisms. Such projects mainly generate social benefits but do not have direct economic benefits and therefore have obvious characteristics as public services. It is difficult to determine the reasonable prices for project products and services. It is also difficult to determine the charging objects; therefore, these types of projects may have free-ride problems. The collection cost is also high. Because of these characteristics, such projects mainly rely on financial expenditures.

Government purchasing services can provide reasonable returns for social capital and therefore attract social capital and attain specialized construction and operation. There are also some ways to enhance the attractiveness of capital returns of such projects, such as packaging the operations of several small projects, forming a scale effect, reducing unit product costs, and naming public services to improve the reputation of investors.

Conclusions and Suggestions

The overall planning of water governance should be strengthened, and the quality of PPP projects should be improved. Comprehensive planning of water governance and special planning on flood control, waterlogging control, irrigation, shipping, water supply, hydroelectric power generation, water ecological control, soil and water conservation, and water conservation should be coordinated to build a sound water governance planning system. With such planning, water governance projects can be fully integrated, the scale effect can be attained, comprehensive benefits can be maximized, and the quality of a water PPP project can be improved.

Improvements should be made to PPP legislation of water governance and the PPP market system. At the national level, special laws and regulations on PPPs for water governance should be formulated as soon as possible. The focus of legislation is to build unified market access, market competition, and market regulation rules and to clarify the authority and process of government approval, the core rights and obligations of governments and private enterprises, the contract framework and risk-sharing principles, an exit mechanism and dispute settlement mechanisms, financial rules and accounting standards, government supervision, the public participation system, and so on. Legislation should also specify the conditions, means, and procedures for the government to take nonstandard interventions to prevent major water security risks.

The public financial support system and public service purchasing system for water governance should be established or improved. Suggestions include increasing the government's public financial support for water resource development and reforming the methods of public financing and investment. The responsibility of government financing should be clarified, and the proportion of direct and indirect payment by consumers should be determined according to the nature and characteristics of different water services. From top to bottom, the channels of public financial funds for water-related projects should be reviewed and integrated. The financial responsibilities and resources of the central and local governments should be balanced. The investment priorities and areas of water-related projects by governments at all levels should be clarified. It is advisable to change the approach to public financial investment, to shift more financial funds from supporting projects to purchasing products and services, to link financial support with the effect of water public services, and to actively develop the government's public purchases of all kinds of water service products and trading markets.

It is crucial to cultivate specialized water business operators. It necessitates defining the respective responsibilities of the government and enterprises and their respective risks. with the goal of gradually improving the system of government investment support for water public facilities and government purchase of water public services, the corresponding performance evaluation and reward and penalty systems for water enterprises should be established. Water enterprises (operators) and governments (regulators and service purchasers) should operate independently. When providing high-quality services, enterprises should be compensated and rewarded with full costs and expenses. When the services provided by enterprises are not up to the expected standard, they should be penalized accordingly to promote the continuous improvement of the urban water service level and operation efficiency.

Efforts should be made to improve the preferential policy system and enhance the profitability of water PPP projects. It is necessary to strengthen top-level design, complete the relevant preferential policy system, and improve the profitability of water PPP projects in the investment, financing, pricing, market access, service quality supervision, and other stages involved in PPP projects. According to the nature of the project, the scale and mode of financial subsidies should be reasonably determined and appropriate subsidies should be given for maintenance and management, considering the factors of construction and operation costs. Supporting project resources should also be developed by authorizing the provision of supporting services and developing by-products, such as land resources, tourism resources, property resources, and forestry and fishery resources, as necessary operational compensation to enhance the attractiveness of the project. Finally, project content and structure settings should be rationally optimized. For example, large projects can be appropriately divided to attain reasonable allocation of investment according to functions and benefits. Only part of the project should adopt the PPP model. Small-project operations can be packaged to form a scale effects and reduce unit production costs. Products with different profits and losses can be bundled to balance profit objectives.

The professional supervision system should be improved, and the supervision of PPP services for water governance should be strengthened. In the process of PPP project construction, relevant departments should follow up and supervise the planning, bidding, government procurement, contract formation, and construction safety. During the implementation phase, the relevant departments should strengthen the supervision and management of the enterprise's industry, establish a performance appraisal system of the enterprise's management quality, and strengthen the supervision of costs, product and service quality, operation safety, and emergency response. Information disclosure and project transparency should be strengthened. Social intermediary agencies and professional institutions should be used to undertake commission sampling and forensics, onsite inspection, and evaluation. The professionalism, independence, and credibility of supervision should be enhanced.

Integration of the water industry structure and cultivation of large-scale cross-regional water groups are recommended. With the acceleration of the urbanization process in China, the demand for public water products and services is likely to usher in a rapid development period. On the one hand, large-scale renovation of the water supply and drainage network will strongly stimulate relevant markets. On the other hand, some potential emerging environmental protection and resource-saving industries, such as water-saving irrigation, rainwater utilization, reclaimed water utilization, seawater desalination, and sewage treatment, will bring new growth areas to the development of the water industry. The development of the water industry should be based on several large-scale and experienced water groups. Local governments should actively innovate the corresponding systems and policies, take the market as the leading factor, adjust the capital structure to promote industrial integration, encourage and guide financial institutions to increase financing for water construction, promote the rapid growth of water enterprises, and accelerate the formation of several water groups with strong capital, clear ownership, a modern corporate structure, and certain international influences.

Finally, risk prevention and control for PPPs in water governance should be strengthened. The government should share risks reasonably between the public sector and the private sector and bear risks such as changes in laws and policies. Social capital should bear risks such as project construction, cost in operation, construction period, and service quality. The risks of PPP projects for water governance should be assessed reasonably beforehand and adjusted as needed to account for changes in project progress. It is advisable to establish and improve the penalty mechanism for dishonesty, improve the credit record system, and prevent and resolve credit risks. Trust companies and insurance institutions are encouraged to participate in water governance PPP projects to reduce their investment risks.

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CHAPTER 15

Comprehensive Research and Systematic Design of China's Water Governance System

Background

China's economy enters into the "New Normal" status and seeks new energy for sustainable economic development. Cultivating the new energy and promoting the shift to the new energy have become key factors affecting the achievement of sustainable economic development.

China is committed to establishing a moderately well-off society for all people. Water governance is critical to the building of a well-off society. The country is also in a new era of state governance system modernization and capacity building. Promoting the establishment of a water governance system is essential to achieving an environmentally friendly society. China is striving to develop and realize Ecological Civilization and a Beautiful China.

The following are impact factors of China's water governance system design:

- *Water-related factors.* Water resources, water for the environment, water ecosystems, water-related infrastructure, and water relationships
- *Economic factors.* Sustainable economic growth, economic structure adjustment, and investment capacity for water governance
- *Social factors.* Transition to a resource-saving, environmentally friendly, and ecologically conservative society, as well as water-saving society development
- *Governance factors.* Powerful governments and government reform
- *Market factors.* Enhancement of market roles and uneven development of markets in different sectors and regions
- *Institutional factors.* Roadmap of institutional reform for an ecological civilization and other institutional reforms related to water governance

Research Objectives

The main objectives of China's water governance should include five aspects:

(1) China's water governance needs to contribute to state governance system modernization and capacity building. In the long history of China, water governance has always been closely linked with state governance. In other words, the history of China is the history of water governance. Water governance is essential for national governance. The capacity of water governance is considered

This chapter is based on a summary of the Thematic Report prepared by Shuzhong Gu and Liang Zhang from the Development Research Center of the State Council.

a critical criterion for the selection and nomination of the government officers. China has increasingly emphasized the importance of water governance. However, more efforts are needed for water governance capacity building.

(2) China's water governance needs to contribute to achieving an ecological civilization and establishing its system. Water governance is a critical component of developing an ecological civilization. The design of China's water governance system should include the aspects of water rights, water development and protection, water planning, total water utilization control, water saving, ecological compensation, environmental management, market-oriented ecological protection, evaluation, and responsibility designation.

(3) China's water governance should be embedded in the capacity building to ensure national and regional water security. Water security is the capacity of a country or a region to provide sustainable, available, stable, affordable water and water-related products and services and to maintain a sustainable environment. It includes water resource security, water environmental security, water ecology security, water-related infrastructure security, water supply security, and security of international water relationships. Enhancing water security is the major objective of China's water governance system design.

(4) China's water governance should focus on the long-term improvement of people's welfare. Water governance should focus on mitigating flood and drought risks and effects, promoting urban and rural water supply security, and restoring the ecosystem and environment.

(5) China's water governance should contribute to regional and global water governance. The ideas, framework, capacity building, and lessons learned from China's water governance can provide experience for regional and global water governance.

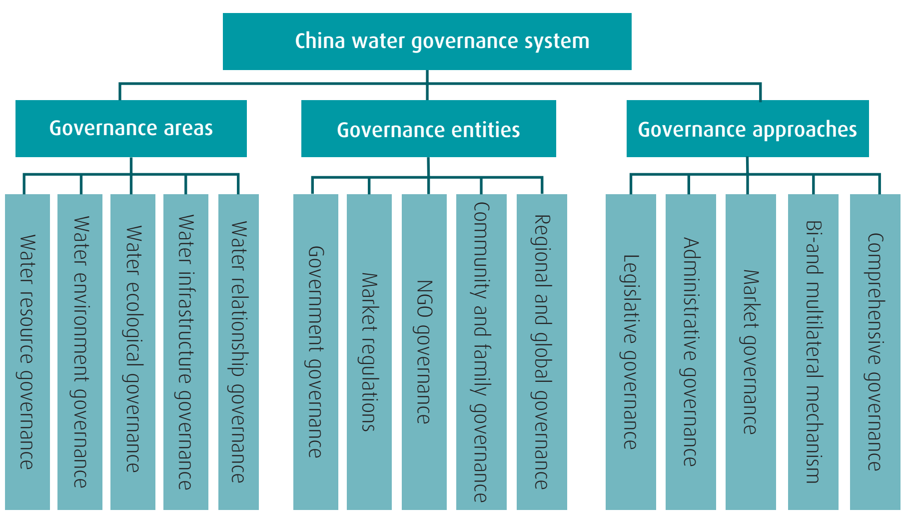
Analysis and Summary

The design of China's water governance system should adhere to five basic principles to reach balance between equity and efficiency, success and innovation, national integrity and regional divergence, independence and systematicness, and official direction and social participation. The design of China's water governance system should consider the justification standards, including the degree of water resource security, the quality of water ecology and the environment, the loss of water-related disasters, the effects of water-related conflicts, the value of water-related assets, public satisfaction with water services, and the costs of water governance.

Basic Framework

China's water governance system is designed to include aspects of water governance areas, governance entities, and governance approaches. The basic framework of China's water governance system is shown in figure 15.1.

Figure 15.1 Framework for the China Water Governance System



Note: NGO = nongovernmental organization.

Framework Design for Water Governance Areas

Water governance has at least five major areas: water resource governance, water environment governance, water ecological governance, water infrastructure governance, and water relationship governance.

Water Resource Governance

Water resource governance includes the development, utilization, saving, and protection of water resources. It is composed of the following aspects: the implementation and improvement of the total water utilization control system, including the identification of primary water rights; the preparation and implementation of national and regional planning for water resource development and protection; the establishment and implementation of groundwater development and utilization, especially in areas of groundwater overutilization; the reform of the water pricing mechanism; adjustment and improvement of the water resource fee; the promotion of the shift from a water resource fee to water resource taxes; the regulation of and permission for surface water and groundwater withdrawal; the control and management of water supply quality; the building of water-saving institutions; and the establishment of harmonious relationships among water resource sustainability, urbanization, and industrialization.

Water Environment Governance

Water environment governance emphasizes two key aspects: reduction of pollutant emissions and environmental restoration. In general, it is composed of the following main areas: the improvement of the water environment monitoring system, the planning and implementation of the water pollution discharge standards, the management of water pollution, the integrated management of water and the environment in critical regions or watersheds, comprehensive environmental management in the key water source areas for concentrated drinking water supplies, the integrated management of black and smelly water in urban areas, adjustment and improvement of the pollution discharge fee system, market-oriented reform of sewage disposal enterprises, third-party management of water pollution, and recycling and reuse of polluted water resources.

Water Ecological Governance

Water ecological governance emphasizes conservation and restoration of water ecology to maintain and improve water ecological services. In general, it includes the following aspects: monitoring of the water ecological system and services (water storage, soil and water erosion, lake and wetland conservation, water biomass, and so on), the preparation and implementation of ecological conservation and restoration planning in groundwater overdraft areas, ecological compensation for major drinking water source areas, critical water bodies and wetlands, the improvement and implementation of soil and water conservation planning, and the exploration of a rational investment mechanism for water ecological conservation and restoration.

Water-Related Infrastructure Governance

Water-related infrastructure governance aims to improve the rational construction and efficient operation of water-related infrastructure. In general, it includes the following aspects: the improvement and implementation of the management system and technical standards for water-related infrastructure, the enhancement of water-related infrastructure management, the exploration of a rational investment mechanism, the preparation and implementation of the infrastructure security management system, and the improvement of the evaluation system for water-related infrastructure management.

Water-Related Relationship Governance

With the increasing occurrence of water-related conflicts, water-related relationships gradually become the key concern of water governance. The key areas of water-related relationship governance are the improvement of the mediation mechanism of related conflicts, adjustment and implementation of water resource planning in areas with severe water-related conflicts, the establishment of emergency management planning for water-related conflicts, and the establishment and implementation of the negotiation mechanism for transboundary rivers.

Framework Design for Water Governance Entities

The water governance entities include governments, market subjects (enterprises and others), social organizations or nongovernmental organizations (NGOs), and international cooperation. Therefore, the water governance system should consist of governmental water governance, water market regulation, social and NGO water governance, and global and regional water governance (bilateral and multilateral cooperation mechanism).

Governmental Water Governance

Governmental water governance includes improvement of the governmental (official) evaluation system to encourage local governments to emphasize water governance. The new evaluation system should include water resource development, utilization, protection and saving, water environmental protection and management, and water ecological conservation and restoration. This aspect of water governance also includes enhancement of water-related administrative system reform to clarify the functions and responsibilities of each sector and department, as well as promotion of the changes of government roles, from the management of water-only issues to the management of wider water-related social issues.

Water Market Regulation

The critical factors affecting water market regulation are the roles of the market in resource allocation, including eliminating irrational controls on water markets and improving the water market mechanism. The main areas of water market regulation are (1) the expansion of the scopes and functions of water rights trading, (2) the promotion of market-oriented reform of water supply enterprises, (3) the enhancement of sewage market development and reform, especially the promotion of third-party sewage disposal management, (4) the introduction of social capital into water-related infrastructure investment, using public-private partnership (PPP) models, (5) the introduction of market-oriented entities into water ecological restoration, and (6) the improvement of the market mechanism to promote water saving.

Social and NGO Water Governance

The roles of society and NGOs are reflected in several aspects of water governance, including (1) public education and training, (2) participation and supervision, (3) the introduction and promotion of advanced technologies and skills, and (4) the establishment of negotiation mechanisms between governments and the citizens. In the future, more efforts are needed to improve the legislative system, promote NGO development, and enhance public participation to improve and strengthen the effects of social participation into water governance.

Global and Regional Water Governance

The key points of global and regional water governance are (1) the improvement of bilateral and multilateral cooperation in the protection, conservation, and restoration of water resources, the water environment, and water ecology; (2) the improvement of communication and a negotiation mechanism in water-related areas; and (3) the establishment of bilateral and multilateral cooperation mechanisms to address water issues and challenges and improve the water governance capacity at the country, regional, and global levels.

Framework Design for Water Governance Mechanisms

Water governance mechanisms include administrative, legislative, market-oriented, and integrated government system approaches, as well as the bilateral and multilateral cooperation mechanism. Water governance within China mainly relies on administrative approaches. More efforts are needed to promote the application of other mechanisms. Therefore, China's water governance should emphasize the following aspects: (1) reform of the water administrative system; (2) definition of the responsibilities for each administrative area; (3) improvement and reform of legislative supervision on administrative actions; (4) improvement of the legislative system for water governance; (5) enhancement of the water-related responsibility system for water governance; (6) promotion of water market reform; (7) encouragement of market investment in water-related infrastructure and regulations, such as water rights trading, water market rules, and water market supervision; and (8) improvement of the social participation mechanism.

Roadmap for Establishing China's Water Governance System

The roadmap for the establishment of China's water governance system includes the following steps:

(1) Prepare the overall scheme for China's water governance. This scheme should include the goals of each stage, the key and basic institutions for water governance, and the framework for water governance.

(2) Identify and clarify the responsibilities of each entity. Based on the clarification of the functions and responsibilities of water governance-related entities, the cross-entity coordination mechanism will be established. The responsibility lists for each entity should be defined.

(3) Encourage local governments to launch specific practices to improve their water governance, aligning with uniform national schemes.

(4) Establish a national water governance evaluation system, and encourage local governments to implement stricter evaluation systems aligned with the national system.

(5) Supervise and evaluate the implementation of water policies.

(6) Improve water policies based on the evaluation results.

Timeline for Establishing the System

The establishment of China's water governance system should have a clear timeline that is well aligned with institutional reforms required for an ecological civilization and focuses on the key areas of water governance. There are three stages of the timeline.

Until 2020, the main tasks that should be completed include preparation of the comprehensive scheme for water governance system reform and improvement; formulation of the primary framework for the water governance system; periodic reform of the water administrative system, especially rational reform of administrative relationships; and the pilot water-related policies and regulations, especially in water shortage areas. By the end of the first stage, there will be an initial improvement in water resources, the ecosystem, and environmental conditions.

Until 2025, the main tasks that should be completed include establishment of an integrated water governance system and reform and improvement of the water administrative system, with harmonious and effective relationships between related entities. By the end of the second stage, there will be a significant improvement in water resources, the ecosystem, and environmental conditions.

By 2030, a rational and advanced water governance system should be established, and a rational, effective, and efficient water administrative system should be set up. By the end of the third stage, the comprehensive water governance capability will be lifted to a worldwide advanced level.

Policy Instruments

The main policy instruments for China's water governance are as follows.

Legislative

The water governance system can be adjusted and managed through legislation and the justice system. The instruments of legislation include preparation and revision of water laws and regulations to strengthen the legal basis for water governance. The instruments of justice include improvement of the administration by laws, penalties for water-related illegal activities, strict prohibition of the denial of justice, and improvement to justice procedures. The instruments of supervisions include supervision of the enforcement of laws and regulations and prohibition of the abuse of laws and regulations.

Administrative

The administrative instruments for water governance include restrictive standards or indicators, instructions, and ordinances. The regulations on water-related activities include establishment of lowest or highest limitations for such activities. For example, the highest cap of water utilization is used to control total water use. Similarly, the wastewater discharge limitation, the water use efficiency requirement, and the entry-level standards of water supply sectors are useful to regulate water-related activities and behaviors. The regulations on water management include implementation of the river and lake chief system, supervision of the water monitoring system, evaluation of water governance management, the system of water-related infrastructure management, and security management and maintenance of infrastructure.

Market Mechanisms

The market instruments for water governance mainly include water price, taxes, fees, and water rights exchanges. For example, the instruments comprise water resource charges and pollution fees, cross-regional economic compensation standards for water ecology, third-party water environmental restoration, PPP investment in water sectors, and the market-oriented system design of water rights trading, water pollution discharge trading, and the ecosystem compensation mechanism.

Information

The information instruments apply information technology to achieve data-driven water governance and promote data and information sharing. China is still at the stage of limited water-related data and information sharing. These issues have increased public concern and will limit the improvement of water governance.

Technology

The technical instruments for China's water governance include water resource development and utilization technologies, water pollution control and regulation technologies, water-saving technologies, water ecological restoration technologies, and water-related disaster control and management technologies.

Conclusions and Suggestions

Policy Issues

China's short-term water policy issues include the irrational water pricing mechanism, which fails to sufficiently reflect the true situation of water shortage and water supply costs; the low water resource fee and irregular fee collection methods; and the cost of pollution control and regulation, which is higher than the cost of pollution discharge and leads to the difficulties in reducing pollution discharge. Issues also include the lack of the following: a water ecological monitor and evaluation mechanism, an investment mechanism and an ecological compensation mechanism for water ecological conservation and restoration, a social participation mechanism for water ecological conservation and restoration, a rational investment mechanism in water sectors, and an efficient mechanism to address water conflicts.

Policy Suggestions

Gradual, Stage-Based Improvement

In the short term, it is important to establish a powerful water decision-making and coordination mechanism to synchronize various water governance activities and entities. The reform will improve the coordination and management of issues related to water resources, water ecology, and the water environment. In the long term, it is critical to promote the reform and integration of water governance entities, to reduce the costs of water policy coordination, and to align with long-term water governance reform planning.

Embedded Top-level Institutional Design

The first part of the high-level design is to enhance the capacity of water resource management. The tasks include improvement of the water governance capability to strengthen water resource feasibility evaluation at project, regional, and planning levels to act according to local water resources capacity; continue reform of the water pricing mechanism to attain hierarchical pricing based on whole-cost accounting; improvement of the collection standards of water resource fees and promotion of the adjustment mechanism for water resource fees and for the shift from water resource fees to a water tax; improvement of the institutional capacity for the establishment of a water-saving society; and strict implementation of a water withdrawal permit system.

The second part of the high-level design is to strengthen water environmental management. The tasks include raising of government focus on water environment governance and consideration of the water environment quality indicators as the critical parts of local government assessment, implementation of integrated water and environmental management using various approaches, enhancement of the standards for the pollution discharge fee, promotion of market-oriented reform of wastewater treatment enterprises, sustainability of wastewater treatment enterprise operation, encouragement of third-party participation in environmental management, and application of new technologies to enhance the capability of water environmental management.

The third part of the high-level design is to strengthen water ecology protection and restoration. The tasks include establishment of a water ecology spatial protection system; definition of the red lines for water ecology protection; establishment of water ecology management; establishment of an evaluation system for water ecology management; reform and improvement of the ecological compensation system, especially for the water source areas, critical wetlands, key lakes, and reservoirs; establishment of a stable and variable financial investment system; establishment of ecosystem protection mechanisms according to the different ecological properties and needs; and enhancement of public concern for ecology protection and restoration.

The fourth part of the hig-level design is to promote reform of water-related infrastructure management and the investment and financing mechanism. The tasks include improvement of the investment and financing mechanism of water-related infrastructure construction, expansion of financing sources, enhancement of reform of the water-related infrastructure management mechanism, clarification of the rights and responsibilities of the water resource management and administration bureaus and the water-related infrastructure management departments, establishment of a differentiated management mechanism according to the categories of water-related infrastructure management departments, promotion of the separation between operation and administration, and changes from the construction-focused method to a management-focused method.

The fifth part of the hig-level design is to improve the management of water conflicts. The tasks include the prevention-based mechanism and the combination of prevention and mediation, enhancement of the mediation mechanism and the internal coordinating mechanism for water conflicts in different areas, capacity building for the officers who mediate the conflicts, improvement of the law consciousness of water users through public education, and guidance to help water users express their interests rationally and legally so that they can deal with the conflicts efficiently. In addition, it is important to establish a regular communication mechanism to coordinate and negotiate water-related issues between regions and countries.

Strong Institutional Mechanism

The first task in strengthening the institutional mechanism to promote institutional reform is to include water resource development, utilization, conservation, and protection, as well as water environmental protection and governance, water ecological protection and governance, water ecology protection, and restoration, in the government evaluation system. The second task is to establish a rational monitoring system according to the institutional capacity and system. For example, the establishment of a vertical management mechanism can prevent irrational interventions and promote the clarification of responsibilities.

The third task is to improve relevant laws and regulations and to establish a more stringent accountability system for every level of officials. The fourth task is to integrate different agencies to establish a joint supervision and law enforcement mechanism. The fifth task is to establish a system of reporting incentives to fully mobilize social organizations and encourage the public supervision.

Strong Market-Oriented Management

The first task in strengthening the application of market-oriented methods in water management is to establish an incentive system for advanced policy mechanisms to encourage enterprises with advanced management and technologies to participate into water governance processes. The second task is to generate incentives to encourage market-oriented entities to participate into water governance processes. The third task is to promote the trading system in the water sector, such as the establishment of water rights trading, to fully apply the advantages of the market mechanism in resource allocation.

Diversified Participation

To address the issues of insufficient participation in water governance by nongovernmental entities, it is critical to encourage society to participate into water governance processes, to establish a joint governance mechanism with diverse entities, to make the shift from government management to society management, to achieve the joint governance mechanism, and to promote the transformation and improvement of the water governance mechanism.

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Watershed

A New Era of Water Governance in China — Thematic Report

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