



A New Era of Water Governance in China — Synthesis Report

Watershed



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Foreword

Victoria Kwakwa

Vice President for East Asia and the Pacific
The World Bank

Globally, many countries are facing unprecedented pressure on water resources. Estimates show that with current population growth and water management practices, the world will face a 40 percent shortfall between demand and supply of water by 2030. Furthermore, chronic water scarcity, hydrological uncertainty, and extreme weather events such as floods and droughts are perceived as some of the biggest threats to global prosperity and stability.

To improve water management, the World Bank is supporting clients to invest in institutional strengthening, information management systems, 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 is needed for proper monitoring, planning and decision making under uncertainty. Investments in modern infrastructure and innovative technologies are also needed for enhancing productivity, conserving and protecting resources, recycling and developing non-conventional water sources, and increasing water storage.

China has experienced a period of rapid economic growth and social development following 40 years of reform that shifted the country to a market-based economy with Chinese characteristics. GDP growth has averaged almost 10 percent a year over the past few decades — the fastest sustained expansion by a major economy in history — and has lifted more than 800 million people out of poverty.

Water is central to the realization of China's sustainable economic prosperity and the realization of an ecological civilization. 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 is one-fourth the global average. To address these challenges, the Government invested more than RMB 717.6 billion in 2017 alone, and continues to address issues around water scarcity, pollution, and flooding.

China's rapid economic ascendance to the upper middle-income status achieved today has brought

with it environmental challenges. Recognizing this, China is committed to transitioning to a structurally rebalanced growth model and implementing a series of policy adjustments 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), with the 19th National Congress further highlighting the goal of building a "beautiful China" to address environmental and social imbalances.

Within this context, a new approach to the governance of water is needed that reflects the changing value that society places on water. A new approach is also needed to align water management with the goals of an ecological civilization and its aims to balance economic growth against increasing water demand under conditions of water scarcity. The Three Red Lines outlined in the Strictest Water Resources Management System provide a strong foundation for this new era by controlling water resources development and utilization; establishing targets for improved water use efficiency; and defining compliance targets for water quality.

The China Water Governance Study represents a major contribution to the proposed policy and institutional reforms in China's water sector. This builds on a long and productive history of collaboration between the World Bank and the Development Research Center of the State Council. This collaboration leverages the Chinese experience, combined with the Bank's global knowledge, to provide 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 economies, as well as informing efforts to address global risks to economic progress, poverty eradication, and sustainable development.

The Bank appreciates the partnership that has been established with China around water issues, and we look forward to continuing this collaboration.

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 Synthesis Report 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 Synthesis Report 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 the entire report, 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 Synthesis 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 Synthesis 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), and officers of the Ministry of Ecological Environment (formerly Ministry of Environmental Protection), the Ministry of Natural Resources (formerly Ministry of Land and Resources), the Ministry of Finance, the Ministry of Housing and Urban-Rural Development and the Ministry of Agriculture and Rural Areas (formerly 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 Synthesis Report was launched 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 Synthesis Report was 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, 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 Liuguan, 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. Production of this publication was provided by Pascal Saura (Senior Knowledge and Learning Officer), Erin Barrett (Publishing Associate), and Francis Gagnon (Information Designer). Their contributions have helped to enhance the quality of this report.

The Synthesis Report highlights the key priority reforms jointly identified by the World Bank and the DRC through 15 supporting thematic studies. These are summarized in an accompanying volume and were undertaken by a designated team including the following:

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 Analyses 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;

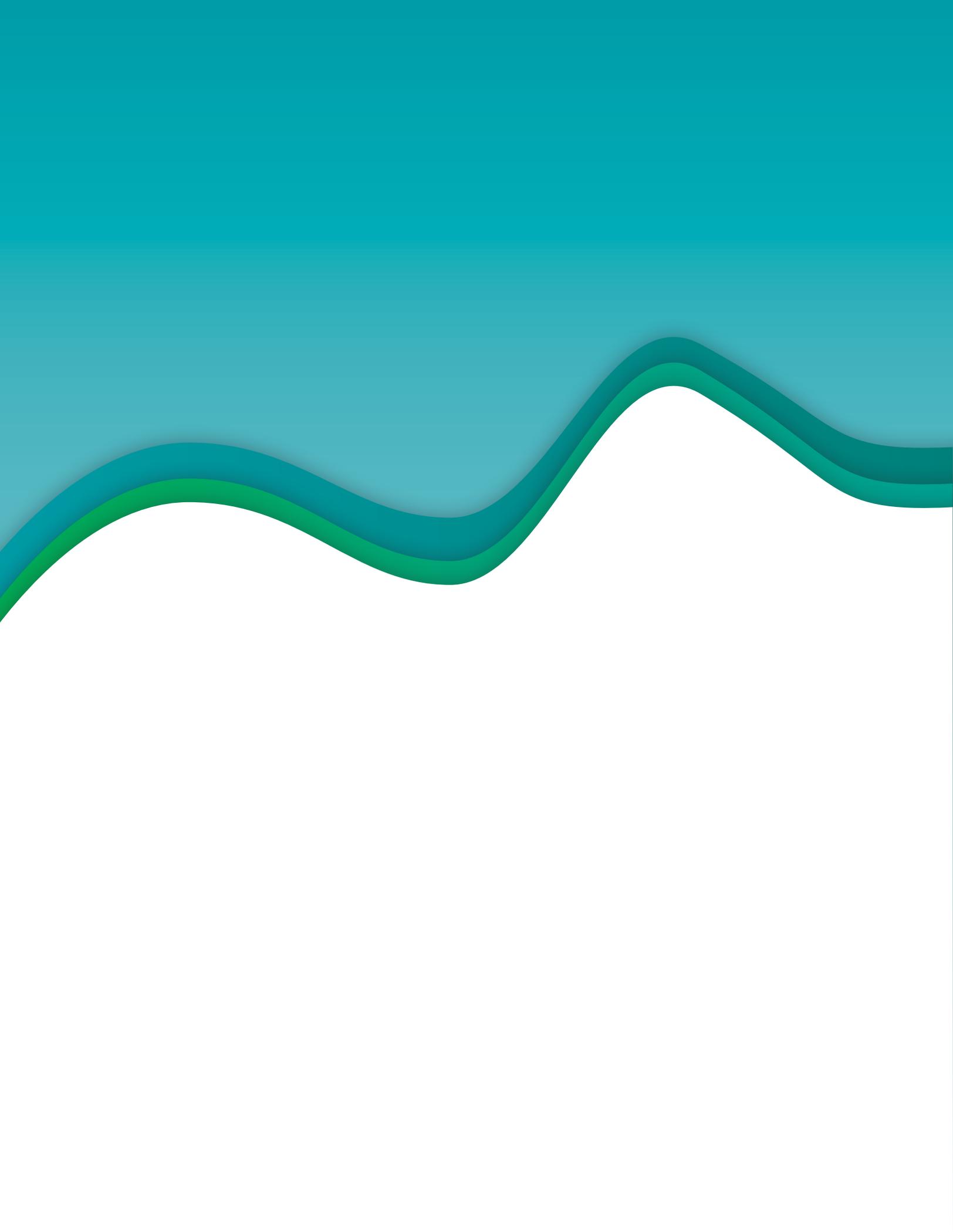
Topic 12: China's Water Management Administrative System and Its Reform was prepared by the Development Research Center of the State Council under the leadership of Gao Shiji and Chen Jianpeng;

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 this 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. The Synthesis Report also draws on international examples and best practices to inform the recommendations. In addition to this Synthesis Report, 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).



Executive Summary

From the perspective of sustainable development, China stands at a crossroads. China's transition to slower but structurally rebalanced growth continues. Gross Domestic Product (GDP) expanded by 6.9 percent in 2017 and the service sector has replaced manufacturing as the economy's primary driver of growth. China also continues to make remarkable progress in poverty reduction. The poverty headcount of US\$1.90 per day (purchasing power parity) was estimated to have been as low as 0.7 percent in 2015. China's overarching challenge now is to implement the necessary reforms to ensure a successful economic transition toward higher value-added industries. While significant progress has already been achieved in some areas, deeper reforms are needed to increase the role of markets, the private sector, competition, and domestic consumption for driving productivity-led and greener growth in the future.

Good water management is essential to achieving these high-level development objectives. Water scarcity, pollution, and flooding threaten China's continued sustainable development. Despite being the world's second-largest economy and most populous country, China possesses only 6 percent of the world's freshwater resources. Water use efficiency is relatively low and measures of industrial added value and irrigation efficiency are both lower than global averages.

In some areas the development of water resources exceed the renewable capacity and several large cities face severe water shortages. Water pollution meanwhile imposes serious economic, ecological, and health-related costs. About 67 percent of monitored groundwater sites are polluted and 32 percent of major rivers fail to meet basic quality standards required for sources of drinking water supply. While China has made significant progress over the last 30 years in improving access to water supply and sanitation, there are a number of challenges in closing the service gaps for the last segments of the population, with roughly 70 million people without access to an improved source of drinking water on their premises. According to the data from the Ministry of Water Resources, only 76 percent of the rural area have access to tap water in 2015 while JMP data suggest 64 percent of rural areas have access to use of an improved sanitation facility. To effectively address these complex water challenges, improved approaches to water management are needed. **This report presents a forward looking strategy for a new era of water governance in China.**

China's Water Resources Challenge

China has made significant and high-impact investments in water management and infrastructure. Over the past over 60 years, China has developed an

impressive foundational level of infrastructure to better manage its water resources. A total of 413,679 kilometers of river dikes and 98,002 reservoirs, accounting for more than 800 billion cubic meters in storage, have been constructed; flood control structures have been built in all major river basins; 5,887 rural water supply projects provide services to 812 million people; hydro-power capacity now stands at 341,000 megawatts. This infrastructure has helped China support 22 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. This has been made possible through significant public investment, with the government having allocated RMB 717.6 billion (roughly US\$ 104 billion equivalent) in 2017 alone for investments in the water sector. **Despite these significant achievements, China is still facing acute challenges with respect to both water quantity and quality.**

Water use remains unsustainable and inefficient even as demand grows rapidly. China's per capita endowment of water resources is only one-fourth of the global average. While industrial and agricultural water abstractions have remained relatively constant in recent years, domestic water use continues to increase, driven primarily by population growth and rapid urbanization. These rapidly growing demands come at a significant cost, with increasing competition between the various sectors. Moreover, China's low water use efficiency rates mean that many water uses are highly wasteful. China's water consumption per RMB 10,000 (roughly US\$1,450) industrial added value is two to three times greater than the average upper-middle-income country (UMIC). The effective utilization factor of irrigation water is 0.52, much lower than the 0.7 to 0.8 average among UMICs.

Improving water quality remains a serious issue that requires long-term investment. Industrial, agricultural, and organic pollutant discharges pose significant risks to human health. In 2015, the nationwide chemical oxygen demand – depleting pollution discharge volume reached 22 million tons, and NH₃-N (ammonia) discharge volume was 2.3 million tons, greatly exceeding natural absorption capacity. In 2017, the water quality of 32.1 percent of monitored sections in major waterways were lower than Class IV, 8.3 percent of tested water received the lowest rating for water quality based on China's five-tiered rating system and 31 percent of monitored lakes and reservoirs were subject to eutrophication. Among 5,100 monitored underground water sources, 66.6 percent were rated as poor or very poor. Six of nine major bays or coastal inlets likewise have poor or very poor water quality. Going forward, both water consumption and sewage discharge volume will keep growing. Agricultural pollutants and non-conventional water pollutants will

accordingly continue to grow rapidly in the absence of sustained interventions. The control of water pollution is also becoming more complex and without major policy interventions, water pollution will impose significant economic as well as health-related burdens. While these were estimated at 2.3 percent of GDP in 2007, the Government has introduced a series of stringent measures in recent years to control water pollution and improve water quality.

Ecosystem services are under severe pressure from urbanization and growing water use. Too often, urbanization has come at the expense of natural habitats, and has severely damaged ecosystems. Natural ecological systems such as wetlands, coastlines, lakes, and riverbanks keep decreasing in size, reducing the ability of many waterways to provide ecosystem services like flood protection and water retention. For example, major wetland areas in the Hai River Basin are estimated to have decreased by approximately 83 percent, while the number of lakes in the middle and lower reaches with hydraulic connections to the Yangtze River have reduced from over 100 to only two, namely the Dongting and Poyang lakes. Continued reduction of wetland areas and reduced hydrological connectivity continues to undermine ecological integrity. Coastal wetland areas have also been significantly reduced. The biodiversity in offshore coastal areas has decreased precipitously and offshore fisheries have been considerably impacted. The stock of unmodified natural coastline now accounts for less than 35 percent of the total. The area affected by soil and water erosion has moreover reached 2.95 million square kilometers, accounting for 31.1 percent of China's total land area.

Drought and local water scarcity plague large parts of the country. China's water resources are unevenly distributed across place and time, with the south and southwest featuring the most abundant reserves of water. Rainfall is also highly variable in many regions. Water shortages are especially acute in China's energy-producing regions, where the high water requirements of coal and gas extraction and production risk exceeding local water supplies. Producing a single ton of coal for example requires 5 to 6 cubic meters of water, while it is estimated that nearly 10 cubic meters are required for a ton of oil. Specific regulations of water consumption within the energy and chemical production sectors under the Three Red Lines are improving efficiency and reducing withdrawals within projected limits. Though it is well understood that water scarcity is an issue for the northern and northwestern parts of the country, the eastern and southern central parts of the country also face potential water constraints with growth in demand anticipated to rapidly surpass supply due to urbanization and industrial growth.

Gaps remain in water supply, sanitation, and flood protection. China's small and medium sized cities and rural areas remain unevenly served by water supply, sanitation, and flood protection infrastructure. China has made significant progress over the last 40 years in improving access to water supply, with most of the population estimated to have access to an improved source of drinking water on their premises. However, while most rural households have some form of on-site sanitation, the wastewater management, water supply and sanitation services often lag behind those in urban areas. Quality is also a concern, with about 9.5 percent of the monitoring points for the centralized drinking water sources in prefecture-level cities and above recording values below the national quality standard in 2017. In addition, some small and medium sized cities rely on a single source of water, making them vulnerable to pollution and undermining the security of supply. Securing supplies for the large mega-cities and keeping up with increasing demands also remains a challenge. Surveys carried out by the Ministry of Water Resources also show that there are still many small and medium sized cities located along a large number of small waterways without adequate flood protection structures.

Ongoing Water Governance Reforms

Water resource management in China faces central-local and inter-jurisdictional coordination problems. In addition to a constellation of actors at the central government level, most water resource management functions are in practice organized and implemented by provincial and local officials. Water Resource Bureaus typically exist at provincial, prefectural or municipal, county, and sometimes township levels. These are typically collectively responsible for planning, allocating and regulating local water use and conservation measures, water saving and flood control measures as well as developing and providing water infrastructure services. These measures should be implemented in accordance with the master plans for water resources development and utilization prepared for each of the river basins. Other entities, usually called "Environmental Protection Bureaus," are responsible for monitoring and enforcing compliance with pollution regulations. These two agencies have historically had some overlapping responsibilities for water pollution control. These were addressed in the institutional reforms introduced in March 2018. In addition to these hierarchically-organized bodies, river basin commissions exercise many management functions, including water use planning, protection of water resources and flood risk mapping at a basin scale. Despite these many institutions, implementation of national water resource management policies and regulations is uneven at local

levels, and in some cases local officials are hesitant to cooperate with neighboring jurisdictions to address issues such as pollution and flood management.

China has embarked on a series of effective reforms to address these technical and institutional water-related challenges. Especially in recent years, China has implemented a series of reforms and pilots designed to address the many water-related challenges, including water scarcity, water pollution, ecological degradation, and the increased risks and impacts of floods and droughts. In 2012, the State Council issued formal guidance on Applying the Strictest Water Resources Management System, setting three major control objectives, known as the Three Red Lines: (i) water resources development and utilization control; (ii) water use efficiency control; and (iii) water functional zone control. To strengthen water pollution control, the State Council issued in 2015 the Action Plan for Prevention and Control of Water Pollution (Ten Action Plans). China has also piloted innovative economic approaches, including pilots on water rights and pollution rights trading. Finally, a new system of "River and Lake Chiefs" has been established, making local senior officials responsible for each stretch of every major lake and waterway.

China recognizes the important role that water plays in the quality of the environment for society. Especially since the 18th National Congress of the Communist Party of China in 2012, the construction of an "ecological civilization" has become one of the government's highest policy priorities. This includes a high-level focus on resource management, environmental governance, and ecological protection. The 19th National Congress of the Communist Party of China in October 2017 further highlighted the goal of building a "beautiful China" to meet increasing public demand for improved environmental quality. Notably, the State Council announced a series of institutional reforms in March 2018 to substantially redefine the responsibilities for water resource management. Highlighting a determination to address institutional barriers to effective environmental and resource governance, these reforms include the establishment of the Ministry of Ecology and Environment (MEE) and the Ministry of Natural Resources (MNR), along with consolidation and optimization of responsibilities within the Ministry of Water Resources (MWR) and other related ministries. In announcing these changes, the Government cited a renewed commitment to environmental protection and sustainable use of natural resources.

Institutional reform is a continuous process and more remains to be done. Despite these reforms and the re-organization announced in March 2018, institutional weaknesses remain in China's water governance

system. Coordination, communication, and consensus-building among key stakeholders, including central and local governments and water user groups, should be strengthened through more robust institutionalized processes. In addition, the roles and responsibilities of key institutions, such as the river basin commissions, require revision and re-thinking in light of the possible transfer of many responsibilities for water pollution control to the Ministry of Ecology and Environment and those functions assigned to the Ministry of Natural Resources. Indeed, these recent reforms invite a broad re-thinking of the institutional framework for water governance in China.

A New Era of Water Governance in China

To address its water resource challenges, China needs to address five key water governance reform priorities. First, China needs to revise water-related laws and regulations to further strengthen the legal basis for water governance. This includes updating the existing Water Law to reflect current challenges and strengthen the enforcement of existing water pollution laws. Second, the status and responsibilities for existing water governance institutions, both at the national and river basin levels, should be enhanced and their role in ecosystem protection expanded. Focal points for policy coordination between different agencies, jurisdictions, and sectors need to be clarified. Third, existing economic policy instruments, especially mechanisms such as water rights trading, should be improved upon and scaled-up where appropriate. More empirical evidence is also needed to assess the effectiveness of these instruments. Fourth, human and ecological systems need to be made more resilient to meet future threats and challenges. This includes expanding the use of green infrastructure approaches for flood management and experimenting with water pollutant discharge permit trading and alternative financial mechanisms to reduce non-point source pollution. Fifth, data and information sharing need to be improved to maximize China's capacity for scientific and participatory water decision making. The establishment of a national water information sharing platform will help to foster coordination and collaboration across agencies and will support innovation in the water sector.

Recommendations

Priority 1: Enhance the legislative foundation for water governance. Many of China's most important water sector reforms are based on, but not specifically mentioned in, existing legislation. It is essential that China codify recent major existing principles and reforms into laws to send strong policy signals to local

officials and enterprises that compliance will be taken seriously. China should take several steps to enhance the legislative foundation for water governance.

Update the 2002 Water Law. In many countries, legislation serves as the foundation for water governance. The challenges of sharing water between different uses and between upstream and downstream users have in many parts of the world resulted in a complex body of water law that determines, among other things, basic principles for how water is allocated and by what means or institutions. The Water Law stands as the core of China's water governance framework. Since the latest major revision of China's Water Law in 2002, many important laws and policies have been promulgated that have reshaped the landscape and shifted priorities for water governance in China. Accordingly, the Water Law should be revised to reflect these new principles and challenges that have emerged recently for water resource management in China.

The Water Law should be updated to: (i) reflect the objectives of national ecological civilization reforms in terms of water governance and reflect the key water resource management policies; (ii) establish a clear institutional mechanism for addressing inter-jurisdictional water pollution, including through the River and Lake Chief System; (iii) strengthen provisions related to water quality enforcement and environmental impact assessment, including improving the linkages with other laws such as the *Environmental Protection Law*, *Water Pollution Prevention and Control Law*, *Water and Soil Conservation Law*, and the *Flood Control Law*; (iv) enhance the institutional mechanisms and provide the legal foundations for river basin management, including a more effective role for basin management authorities; (v) provide clear legal support for water related data and information sharing; and, (vi) clarify the allocation of powers and responsibilities for implementing key water resource management policies following the establishment of the Ministry of Ecology and Environment, the Ministry of Natural Resources, and existing entities, such as the Ministry of Water Resources, including those in relation to the Action Plan for Prevention and Control of Water Pollution, the Most Stringent System for Water Resources Management, and the Ecological Civilization Construction pilot. While there is a clear need to update the Water Law, there are many options for how these updates can be undertaken, and the supporting regulations should be amended accordingly.

Strengthen enforcement of existing water quality standards. In China, as in many countries, the most important approaches of addressing water pollution is a set of legislative and regulatory provisions that establish water quality standards and penalties for

violating them. These regulations are an especially important means of controlling pollution from point sources such as factories and enterprises. China has established standards for water quality indicators, including temperature, nitrogen, and chemical oxygen demand for surface and wastewater, along with specific discharge and effluent standards for various industries, including iron and steel manufacturing, and mining. Policies and regulations such as the Action Plan for Prevention and Control of Water Pollution and the Most Stringent System for Water Resources Management establish stringent standards for water quality. However, enforcement remains a challenge, and several options should be considered to strengthen enforcement of existing water quality standards. Current methods of enforcement include the increased use of fines, public identification of cities and enterprises that violate pollution regulations, and providing a set of incentives, such as tying the promotion of local officials to meeting water quality standards. Each of these methods should be considered as part of a holistic strategy to strengthen enforcement.

Codify and strengthen the role of public-private partnerships (PPPs). China has become one of the world's most important and active markets for public-private partnerships (PPPs) in the water sector. Since 1990s, China has accounted for a substantial fraction of the total number of water sector PPPs globally. From 1990 to 2017, some 511 water sector PPP projects were initiated in China. Many of these projects involved wastewater treatment and urban water supply. The 18th Party Congress's Third Plenum reforms, announced in 2013, envision a Decisive Move to the Market in which PPPs are expected to play an even more important role in water infrastructure provision and as a source of needed financing. The government has already identified water sector priorities for PPP investment (e.g., dams, urban water supply, and water pollution control). Several important regulations have been promulgated to establish a basic framework for PPPs. These include a set of State Council guiding opinions issued in 2014, as well as separate directives issued by the Ministry of Finance and the People's Bank of China. The Ministry of Finance also established a National PPP Center to provide policy research, advice, training, and inter-agency coordination. The regulatory framework makes clear that PPPs are expected not only to contribute to a stronger and more diversified financing base but also to improve coordination between the public, private, and civil society sectors in furtherance of policy goals. To fully realize this potential, existing regulations concerning PPPs need to be both codified and strengthened further.

Codifying the existing regulatory framework would send a strong signal to private sector actors

regarding the opportunities for PPPs in the water sector. Consolidating key policies and regulations issued by various national authorities, such as the guidance issued by the State Council in 2014, the National Development and Resource Commission's 2014 Guidance on the Social Capital Cooperation Model and that from the Ministry of Finance, into a uniform set of regulations or enabling legislation would enhance the operating environment for private sector engagement in the water sector. Enhanced provisions, such as inclusion of model dispute resolution systems as proposed by the World Bank International Center for the Settlement of Investment Disputes (ICSID), can also further encourage the participation of PPPs. These reforms could take the form in a separate National Government and Social Capital Cooperation Law (currently under formulation).

Priority 2: Strengthen national and basin water governance. A fundamental challenge for water resource management is that many issues, including water resource, water environment and aquatic ecosystem issues, are inherently inter-jurisdictional. These issues are shaped more by the boundaries of watersheds than political and administrative jurisdictions. Better integration across policy areas is needed to achieve policy objectives such as the Three Red Lines. Achieving water quality and pollution discharge standards, for example, depends in part on erosion control, managing fertilizer use in the agriculture sector, and rangeland management far upstream. Continuous improvement of national and river basin entities can help to ease coordination problems and promote cooperation horizontally (i.e., across sectors) and vertically (i.e., across administrative levels).

Create a national coordinating mechanism for water governance. China's water governance has historically spanned many central government ministries as well as relevant agencies at provincial and local levels of government. Key agencies have included those for Water Resources, Environmental Protection, Housing and Urban-Rural Development, Agriculture, Land Resources, as well as the National Development and Reform Commission. Each has had responsibilities that are not always harmonized. Historically, for example, the fragmented responsibility between the former Ministry of Environmental Protection and other ministries has hampered policy responses to water pollution. The institutional reforms introduced in March 2018, including the transfer of relevant responsibilities for water pollution to the Ministry of Ecology and Environment, are expected to partly address this situation.

Nonetheless, China could benefit from creating a high-level, inter-agency mechanism with representatives

from the primary ministries concerned with different aspects of water governance. The primary function of this mechanism should be to coordinate policy efforts, help reach consensus on key water policy issues, identify national strategic priorities to guide local officials, and provide guidance to river basin commissions. The coordinating mechanism could take several forms, ranging from a council or committee to an ad hoc working group or joint conference platform. All regulatory and administrative functions would remain with the individual ministries. This mechanism could be replicated at sub-national levels and also help guide the reform of river basin commissions to improve policy coordination.

Strengthen basin level coordination. One of the longest-standing principles of water resource management has been, so far as is practical, to organize water governance institutions at least partly along the boundaries of river basins rather than political boundaries. This approach has been advocated as a solution to the problem of concurrently addressing such issues as water allocation, pollution, flooding, and navigation. Functions that a river basin institution can perform range widely and can include advisory, executive, regulatory or judicial powers. The allocation of these functions is dependent on the context and purpose for their creation. There are a wide range of possible institutional models for strengthened river basin governance, and these need not possess all possible functions. Subsequent experience and research have shown that while there is often value in creating institutions that encompass whole river basins, they often face practical obstacles in terms of authority, autonomy, resources, and legitimacy. Many accounts stress the need for such institutions to serve a convening function by incorporating diverse stakeholder groups, as well as the need to forge links among river basin management organizations, central and sub-national governments, and smaller-scale organizations at the sub-basin level.

China has established river basin commissions, also called water conservancy commissions, for seven major river basins. Legislation has moreover established the river basin as the unit for planning. The primary purpose of these commissions is to ensure the rational development and utilization of water resources within the basin. These have been established as agencies of the Ministry of Water Resources and traditionally focused on water infrastructure and do not officially feature representatives from other ministries or local governments. As currently constituted, the commissions lack sufficient statutory authority to perform key coordination functions, and moreover do not include representatives from provincial and local governments.

River basin commissions should be given enhanced authority and clarity in the key areas of planning, coordination, implementation, enforcement, and financing. This enhanced authority is not intended to diminish or duplicate powers currently exercised by other existing entities, but rather to create the sorts of cross-scale linkages necessary to effectively govern resources shared between users in multiple political jurisdictions. Five key reforms could help to re-shape China's existing river basin commissions to make them more effective. First, the roles and responsibilities of the commissions relative to existing territorial jurisdictions, such as counties, municipalities, and provinces, should be further clarified and codified through legal means. Second, the representation of different ministries and entities on the commissions should be re-visited to ensure commissions are effectively capable of addressing the many water-related issues (present and future) in the basin. Third, greater clarity over the roles and responsibilities of the various ministries is needed, in particular, as it relates to integrated management of water quantity, water quality, and environmental health. This is especially necessary in the context of the establishment of the Ministry of Ecology and Environment and the Ministry of Natural Resources. Fourth, the commissions may also establish implementation units to execute policy decisions, support planning, and provide technical support, along with sub-basin level committees or other decision-making structures to ensure that water resource management policies are better implemented at local levels. Fifth, the commissions should be more inclusive and adaptive to enable them to take an overall role in water governance at the basin scale, serve as public, multi-stakeholder platforms for addressing key water related issues and balance the different roles and responsibilities with local water management in the various jurisdictions. These reforms could be developed using a pilot approach, selecting one sub-river basin for initial implementation, and can be accomplished either through provisions of a revised Water Law or through a separate National River Basin Management Law.

Establish clear coordination between the provincial River and Lake Chief System and existing river basin commissions. In December 2016, the Chinese government took a significant step in establishing a new system for coordinated management of the country's major rivers through "River Chiefs" (*hezhang*). This was later extended to include major lakes and other water bodies through "Lake Chiefs." This system clearly establishes river chiefs at four-levels: provincial, municipal, county and township, as well as village-level river chiefs in some areas. These individuals are typically senior officials who are then responsible for each stretch or section of every major waterway and lake.

The primary purpose of the river and lake chief system is to strengthen enforcement and accountability concerning key water policy measures. These officials are responsible for meeting environmental protection and water quality targets in their respective jurisdictions, with the main responsibilities including water resource protection, river bank management, water pollution prevention and control, improvement of the aquatic environment, and ecological restoration. River and lake chiefs at the provincial level are also responsible for dealing with inter-jurisdictional issues.

Formally linking provincial River and Lake Chiefs with China's existing river basin organizations will help to institutionalize the River and Lake Chief System and promote effective implementation. These linkages also provide a platform for helping reach consensus on matters of common concern, along with a forum in which to share data and information to facilitate better decision making. Formal coordination with the system of River and Lake Chiefs can also enhance the authority and effectiveness of river basin organizations themselves. Providing a platform to integrate the perspective of senior administrative policy makers can further enhance the ability of the river basin organizations to coordinate sectoral and administrative policies across different ministries and jurisdictions.

Priority 3: Improve and optimize economic policy instruments. China's ambitious policy reform agenda has created multiple (and at times overlapping) sets of economic policy tools whose use and application need to be coordinated for maximum effect. Different prices, taxes, and fees are levied on water users to encourage conservation, capture externalities, and move closer toward cost recovery. Some policies currently being piloted (e.g., tiered pricing, water rights trading) can be expanded and represent global models. Further empirical research is however needed to assess the effectiveness of these instruments to optimize their impact.

Expand the use of economic policy instruments to promote more sustainable water use. Of the possible tools to promote sustainable water use, perhaps none is as important as water pricing and other economic policy instruments. The crucial role that water pricing plays in water resource management was recognized by the High Level Panel on Water (HLPW), whose 2018 final report notes that *"valuing water appropriately is a cornerstone for better water management"* and that *"appropriate pricing of water, or water services, is a critically important way of recognizing part of the value of water"* (HLPW 2018). The power of pricing arises from its ability to send a clear signal to water users about the scarcity value of the resource, and the importance of conserving it. Proper water pricing can also help to re-allocate water from lower- to

higher-value uses, such as from irrigation to industry, and be an important source of revenue for cost recovery (for both infrastructure capital costs and operation and maintenance). Globally, however, water prices remain generally too low to achieve these objectives.

China has enjoyed considerable success in leveraging economic policy instruments to pursue various water policy objectives. The People's Political Consultative Conference Decision on Comprehensively Deepening Economic Reforms, announced in November 2013, envisions a much greater role for the use of market-based policy instruments, and a corresponding re-orientation in the role of the state in water resource management. China has applied a range of economic policy instruments to promote sustainable water use, including water pricing reforms (e.g., tiered approaches, differential fees depending on source) to promote conservation and water rights trading to facilitate the re-allocation of water to its highest-value uses. These reforms are broadly on the right track, but require further analysis of their effectiveness before being expanded. This includes detailed empirical analysis of the value of water in the era of ecological civilization and on whether current pricing structures and policies are having their intended effects (e.g., reducing water use, curbing groundwater over-extraction, and moving closer to cost recovery and financial sustainability). To achieve the targets in the Three Red Lines and other water resource management policies, continued experimentation with these instruments should be undertaken.

Strengthen the effectiveness of the Three Red Lines. The most important element of China's current water governance system is the Most Stringent System for Water Resource Management, otherwise known as the Three Red Lines. The core of this system consists of targets that limit total national water use, specify minimum standards for water use efficiency, and establish clear limits on pollutant loads in water functional zones. The experience thus far with this system has been largely positive. Under China's hierarchical water management system, these national targets are broken down by province and local jurisdictions according to a detailed, formulaic process. The target-setting process relies on a comprehensive monitoring and evaluation system established in 2014 that measures progress on several key indicators: total water quantity use, industrial water productivity, agricultural water use efficiency, and water quality. In 2016, two additional indicators were added: reduction in water use per unit of GDP and reduction in total pollutant loads in key water functional zones.

The target setting process could be improved in four ways. First, targets could also be defined in terms of

actual water consumption amounts (and not only withdrawal volumes) and used as the basis for water quantity permitting and control. This consumption-based control can be aided by remote sensing technologies (as has been piloted in Turpan prefecture and other places in China). Second, further target setting should be formulated jointly by relevant ministries, including the ministries of Ecology and Environment, and Natural Resources, to ensure that both human and environmental water requirements and issues are adequately addressed. More broadly, wider participation in the target setting process can help ensure shared responsibility and accountability and consideration of ecological as well as human water requirements. Third, the use of different indicators, such as consumption-based standards, can help ensure that proper signals are being sent to this sub-sector. Moreover, actual field-based irrigation efficiency measurements should be taken. Finally, greater flexibility may be introduced with the caps on withdrawal in the context of water rights trading. That is, local level targets can serve as established caps for which the holder can then be empowered to buy and sell with other local entities. By allowing such trades, participants can better minimize the cost of compliance of reaching national targets. Such an approach would also help to better leverage China's existing pilot efforts to institute water rights trading systems at the national scale on a gradual basis.

Cross-reference water withdrawal permits and pollution discharge permits. As is the case in many countries, China regulates water withdrawal (or abstraction) primarily by granting water withdrawal permits to individual water users. Water withdrawal permits are granted for five years, during which holders may request modifications to the original conditions, including changes to the permitted use volume or purpose. Similarly, China began establishing pollutant discharge permit systems in parts of the country in the late 1980s, which prohibit discharge of designated water pollutants into waterways without securing a permit to do so. In 2017, the Ministry of Environmental Protection issued instructions strengthening and expanding the pollutant discharge permit system nationwide, requiring all stationary water pollution sources across 82 designated industries to apply for permits to discharge into waterways. Unlike users with water withdrawal permits, pollutant discharge permit holders may sell excess emission volumes to other holders, thereby creating a pollutant emissions trading system. China uses separate nationwide permitting systems for both water withdrawal permits and pollutant discharge permits.

China could strengthen the administrative and regulatory ability to control water pollution as well as total water consumption by cross-referencing these water use and discharge permit systems. For example, if an

enterprise discharges pollution more than its permit, that violation could trigger a limitation of the enterprise's right (permit) to withdraw its supply of water (in addition to the fine or limitation associated with the pollution violation). Currently, many firms routinely violate their pollution discharge permits, and either ignore fines or pay fines as a small cost of doing business. This dual penalty would send stronger signals to the firm and incentivize improved stewardship of China's water resources in terms of both quantity and quality of water. Formulating regulations that explicitly cross-reference these systems can moreover promote further pollution and water use control.

Priority 4: Strengthen adaptive capacity to climate and environmental change. Macro-scale pressures, including increasing urbanization and climate change, will require China's policy makers to strengthen the resilience of both human and ecological water systems to flooding, drought, and other forms of environmental change. While drought will likely continue to impose significant economic costs on parts of China, future flooding may be an even greater challenge considering China's rapid urbanization and the increasing numbers of people at risk from coastal and inland flooding. At the same time, additional investments must be made to preserve the functioning of aquatic ecosystems and the services they provide, including water purification. China's current water governance framework faces two notable challenges relating to environmental protection: maintaining ecosystem services and addressing non-point source pollution, especially from agricultural sources. Fully addressing both challenges will be essential to meeting China's policy objectives with respect to improving the water ecological environment, requiring coordinated joint efforts by relevant authorities at both central and local scales.

Strengthen resilience to floods. Flood control has long been a priority for China's water resource managers, and it has enjoyed considerable success in reducing flood risk and exposure. Over the past 70 years, about 47 million hectares of land area and 500 million people have been protected from flooding, and the average annual number of deaths from flooding has been reduced from about 9,000 in the 1950s to 1,500 by the early 2000s. Overall investment in flood control infrastructure increased by over four times just from the 1990s to the early 2000s. Much of this progress, however, is built on a comprehensive flood control system that includes infrastructure, early warning systems, and a closely coordinated flood response structure that includes disaster response headquarters at central, river basin, provincial, municipal, and county levels. China's 1997 Flood Control Law, amended in 2007, designates certain regions as flood-prone, and requires authorities to develop appropriate flood management

plans. Consequently, an area of focus is the integration of weather prediction and forecasting into decision support systems to allow local officials to respond more quickly to predicted flood emergencies, helping further improve the capacity of the Flood and Drought Control Headquarters. Full dam and reservoir operation and evacuation plans have also been developed for 98 areas designated as national flood storage and detention zones.

China has built considerable physical infrastructure to control flooding. In many parts of the country the introduction of both structural and non-structural flood control measures have helped to mitigate the risk of catastrophic flooding. To further improve flood resilience, greater adoption of integrated flood risk management approaches will be necessary. China should (i) expand the use of green approaches to flood management, such as flood retention basins, aquifer flood storage, and natural wetlands; (ii) strengthen the legislative basis for an integrated approach to flood risk management; and (iii) create and promote nationwide flood insurance schemes. These efforts will help to further bolster flood resilience and adaptation to increasing flood risk due to climate change, urbanization, and other macro-scale changes.

Explore Red Line targets for ecological water flows.

Although the Three Red Lines include important targets for water quality, these targets do not fully address broader ecosystem functions and hydrological requirements. Ecological systems provide important ecosystem services and functions that can generate significant benefits to human societies and economic development. Such ecosystem services include purification and regulation of water flows, oxygen generation, soil formation and retention, food supply, habitats for plants, animal and micro-organisms, and recreational opportunities. A 2008 study, for instance, puts the value of water retention and water purification provided by wetlands and water bodies in the city of Shenzhen at about RMB 100 million, while a similar figure estimated in 2015 for Beijing's Miyun District is about RMB 60 million. Unfortunately, both studies conclude that urbanization and the attendant destruction and modification of wetlands and water bodies have substantially reduced the value of these ecosystem services. New ecological targets can nonetheless be set with due consideration to the value of these critical ecosystem functions.

A target such as the river and lake health index would incorporate the wider range of ecological water requirements. To ensure that ecological water requirements are met, China can choose between a new red line target or a separate mechanism. One option would be to establish a legal requirement that water allocations fully account for environmental

water demands. Such a reform could be accomplished through a revision to the Water Law, which presently refers only to environmental flows rather than the broader issue of environmental water demands. A second approach would be to follow the model of Australia's Commonwealth Environmental Water Holder, and establish a designated entity to manage a portfolio of water permits to meet agreed ecological water requirements. This option would likely be more appropriate if China expands the use of water rights trading. A Chinese Environmental Water Holder could be established through legislation or amendments to the various regulations governing China's water rights system. Either option could be integrated into the Three Red Lines target setting system as modalities for ensuring environmental water requirements are met.

Sharpen policy focus on non-point source pollution.

China has made significant strides in improving enforcement of point source pollution regulations, as well as expanding wastewater treatment. Non-point source (NPS) pollution, however, remains a major challenge. Because NPS pollution is so diffuse, it is much more challenging to monitor, regulate, and reduce. Moreover, managing NPS pollution often entails significant changes to agronomic and land management practices, which are often outside the remit of water resource management agencies. Much of the rapid growth in pesticide and fertilizer use has been due to a combination of subsidies and policies encouraging farmers to boost yields, which has had the perverse effect of dramatically increasing organic pollution.

Recognizing these challenges, the Chinese government has implemented a number of policy reforms to address the problems of non-point source pollution. In 2015, the Ministry of Agriculture announced that it would promote activities to reduce fertilizer application, increase fertilizer use efficiency, reduce pesticide use and introduce more sustainable pest control measures. Targets were set to effectively cap national fertilizer and pesticide use through zero annual increases in application by 2020. The Water Pollution Prevention and Control Action Plan, a landmark State Council directive formulated with input from 12 ministries, singles out pesticide production and nitrogen fertilizers as sectors targeted for more stringent enforcement and technological improvements designed to reduce pollution emissions. These include the promotion of actions to control agricultural non-point source pollution and the preparation and implementation of integrated agricultural non-point source control plans. While these steps are important in reducing non-point source pollution, the scale of the challenge is such that China will require more ambitious, far-reaching policy options.

Non-point source pollution therefore represents a promising area to engage in policy experimentation. These may include (i) water quality trading programs, which promise to reduce the cost of compliance with more stringent water quality standards under certain conditions; (ii) improved management of environmental water quality to assist in complying with water quality standards; (iii) research on policies for non-point source pollution control approaches, particularly in rural areas; (iv) pilots for total pollutant load discharge control at the basin scale to mitigate water pollution risks; and (v) innovative financing mechanisms such as eco-compensation, payment for environment services approaches, or water funds to help finance natural capital alternatives to conventional water treatment technologies. The former approach has enjoyed success internationally and warrants further consideration as part of an effort to push the frontier on non-point source pollution management.

Priority 5: Improve data collection and information sharing. China possesses strong technical capabilities in water resource data collection and monitoring. However, these rich data-sets need to be more widely shared, particularly across government agencies, and better incorporated into decision-making processes. Greater incentives and more effective data sharing mechanisms are required among government agencies and between agencies within basins to share data and information. This is particularly important following the consolidation of responsibilities in the Ministry of Water Resources and the establishment of the Ministry of Ecology and Environment and the Ministry of Natural Resources, and provides opportunities to develop and support coordination through integrated information management systems that are based on complete, accurate and consistent data across the national, basin and local scales. Open data platform approaches can help to foster coordination and collaboration across agencies and will support entrepreneurship, innovation, and scientific discovery in the water sector.

Improve the legislative framework for producing and sharing water-related data. It is widely recognized that producing and sharing high-quality data are essential for good water governance and management. The importance of making such data accessible to a variety of stakeholders, including water user groups as well as policy makers, is heightened by the increasing variability in water availability as a result of climate change and other global environmental changes. In its March 2018 report, the HLPW recognizes that access to water data is a prerequisite to better water resource management around the globe. The HLPW also issued Good Practice Guidelines for Water Data Management Policy, which identifies seven key elements of water data policy: (i) identifying priority water management

objectives; (ii) strengthening water data institutions; (iii) establishing sustainable water data monitoring systems; (iv) adopting water data standards; (v) embracing an open data approach to data access; (vi) implementing effective water data information systems; and (vii) employing water data quality management processes. Implementing these principles as part of a coherent water data policy often requires reform, which is best accomplished through building a legislative framework.

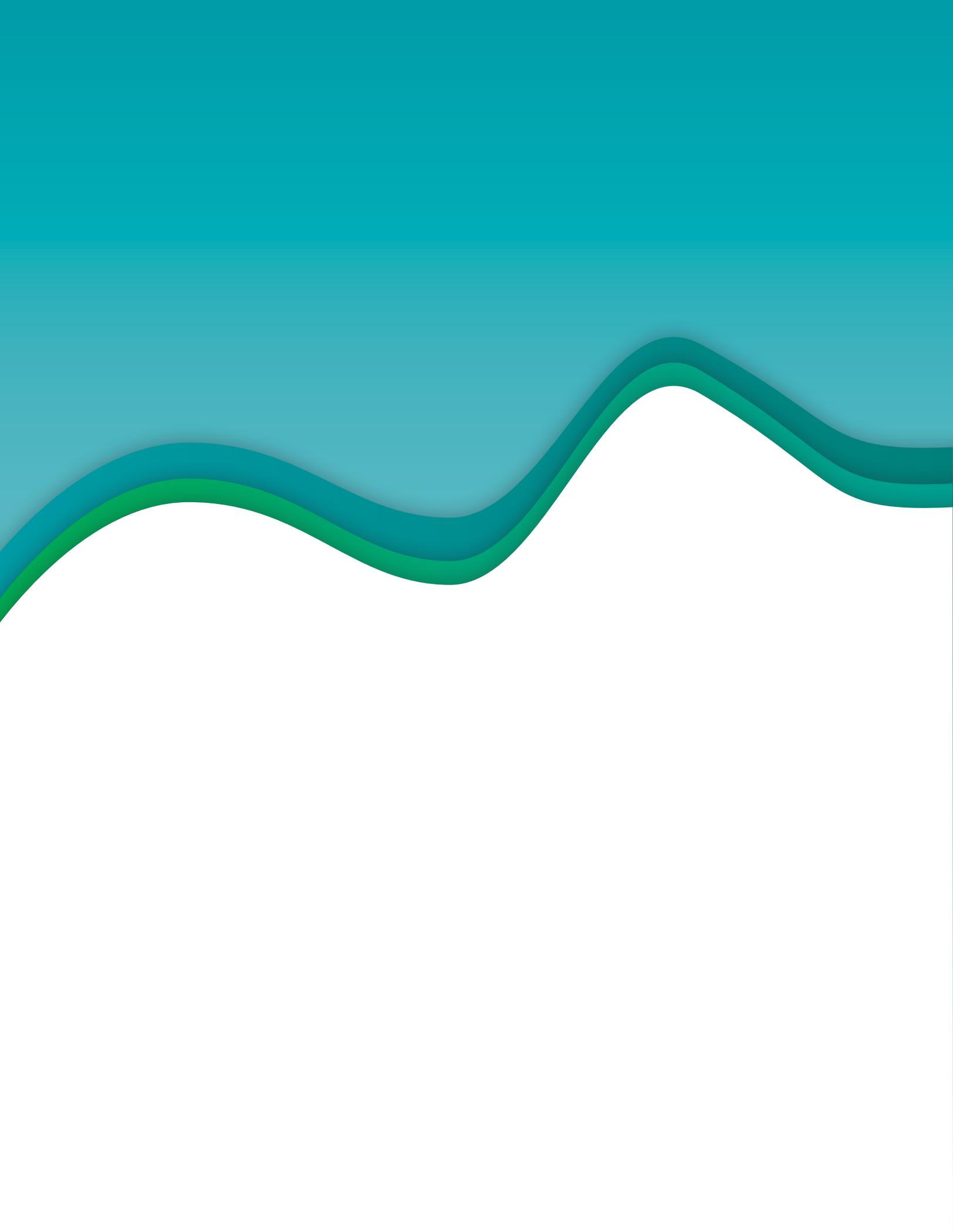
Currently, various ministries and government agencies collect water-related data for their own analysis and use. There are often a number of challenges in sharing important data across sectors and agencies. These can prevent optimized and integrated approaches to China's water resource challenges. A strong, clear legislative mandate is needed for collecting and sharing water-related data, as well as for specifying standards and key parameters on which data should be collected and by whom. These regulations or legislation should mandate data-sharing between agencies and departments concerned with water resource management and, where appropriate, disseminate it to relevant stakeholders and the public at large. This can be considered with updates to the Water Law and related regulations.

Create a National Water Information Sharing Platform. Open access to water data can enhance the efficiency of water trading markets, improve water availability forecasts, help agencies and stakeholders to collaborate more effectively, and give policy makers a more integrated view of the challenges and potential solutions in water resource management. Data currently reside in several different data management systems and not in a shared, central location. A unified, National Water Information Sharing Platform should be created, and government agencies collecting data on water should be obliged to share their data through this platform. Making the portal open-access and real-time also promises to improve response to flood and drought disasters. This portal should be fully integrated into the Ministry of Water Resources as well as that of the Ministries of Natural Resources and Ecology and the Environment.

Strengthen the role of public awareness and participation. China's approach to water resource management has been heavily dependent on regulation and administrative measures. While this approach has enjoyed some significant successes on issues like flood control, it does not necessarily engage the full range of relevant stakeholders, from non-governmental groups to private businesses, necessary to address complex water resource management issues. Engaging the public can help ease the task of monitoring water quality, which has historically been a significant challenge for China's local environmental protection authorities. Several reforms would help to improve public participation in

China's water governance system. First the public's "right to know" water-related data and information should be clearly established. Adequate data and information sharing can help reduce transaction costs to policy implementation and improve outcomes. Second, the public, including individual citizens and non-governmental organizations, should be given the right to participate in water resource decision-making, such as through public hearings or comment periods. For example, the government should continue the process of strengthening water user associations. This right should be established through revision of relevant legislation, including the Water Law. Third, more specific mechanisms should be established to solicit the options, recommendations, and complaints of individuals to water resource management authorities. This may take the form of online or application based platforms to, for example, quickly and anonymously enable users to report high levels of water pollution. Finally, the Water Efficiency Leaders program should be fully utilized as a means of promoting water conservation throughout the public and private sector. These reforms should together support the government's objective to foster a "water-saving society," in part through increased public awareness.

In summary, China's leadership recognizes that managing the country's water resources effectively is critical to achieving sustainable economic growth. Existing legislation, institutions, and policy have helped to ease water scarcity, have begun to address serious water quality problems, and have greatly reduced the risk of flooding. But overuse and pollution of limited water supplies continue to threaten China's strategic development priorities. To achieve these priorities in this new water governance strategy, China needs to strengthen and better integrate water management at both national and regional scales, provide more water for environmental uses, expand the use of market mechanisms to drive more sustainable water use, and adopt transformational approaches to combat water pollution. Together, these measures provide a strategy for a new era of water governance that will enable China to move to a higher quality, more environmentally conscious economic structure. Meanwhile, the proposed water management approaches can provide useful experience and duplicable models for other countries in tackling the challenges of water sustainability in the 21st century.



Introduction

History demonstrates the importance of good water governance to China's prosperity, productivity, and political stability. Since ancient times, the Chinese people have treated water as a top priority. Sound management of water resources has always underpinned China's prosperity and served as a foundation for state governance. Large-scale water works were instrumental in unifying the Chinese nation and propelling its development. In a tradition said to have begun under Yu the Great, successive dynasties placed great importance on flood control and irrigation, creating special water offices and codifying irrigation and water conservancy. The famous official and philosopher Guan Zhong is said to have remarked: "Those who desire to be good at ruling their country first have to eliminate the five evils. Water is the greatest of these evils. ... Water could bring state prosperity and people wealth, and also destroy a country and bring social disorder if the water is not well controlled."

The seriousness with which water governance is viewed has persisted into the modern era. In 2011, the Chinese government's No. 1 Policy Document, intended to outline the most important policy priorities, proclaims:

Water is the origin of life, the essence of production and the basis of ecology. Water conservancy and flood control are instrumental to human survival,

economic development, and social advancement. Water governance is central to other governance matters in the country (e.g., environmental, economic, political). To promote steady and rapid long-term social and economic development, boost social harmony and stability ... we must be determined to ... achieve sustainable use of water resources.

During the 19th Party Congress held in October 2017, President Xi Jinping re-affirmed the importance of environmental issues, and pledged to further enhance China's ecological protection and environmental supervisions systems. This was followed by the establishment in March 2018 of a Ministry of Natural Resources and a Ministry of Ecology and Environment. Thus, improving China's water governance can contribute greatly to national and regional water security, economic and sustainable development, and can strengthen China's overall national governance system.

The institutional landscape for water governance in China is complex. China's water sector is both large and complex. Prior to a ministerial reorganization initiated in March 2018, at least nine ministerial bodies were concerned with various aspects of water resource management. These included the Ministry of Agriculture, the Ministry of Housing and Urban-Rural Development, the Ministry of Land

and Resources, the Ministry of Health, the Ministry of Transport, the Ministry of Finance, and the State Forest Administration. The two most important ministries, however, are those of Water Resources and Environmental Protection. The former is responsible for large-scale water infrastructure projects for water supply, flood control, and prevention. The latter, meanwhile, is responsible for most aspects of water quality as well as environmental water issues.¹ This was followed by the establishment in March 2018 of a restructured Ministry of Water Resources, a new Ministry of Natural Resources and a Ministry of Ecology and Environment. These changes are expected to consolidate many authorities and clarify the responsibilities pertaining to water governance that were previously spread among different ministries.

China has made significant and high-impact investments in water management and infrastructure.

Over the past over 60 years, China has developed an impressive foundational level of infrastructure to better manage its water resources. 41,3679 kilometers of river dikes and 98,002 reservoirs accounting for more than 800 billion cubic meters in storage have been constructed; flood control structures have been built in all major river basins; 5,887 rural water supply projects provide services to 812 million population; hydro-power capacity now stands at 341 million kilowatts. The significant public investment help China reach the achievement of supporting 22 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. In 2017, the government allocated RMB 717.6 billion of investment in water sector. Despite these significant

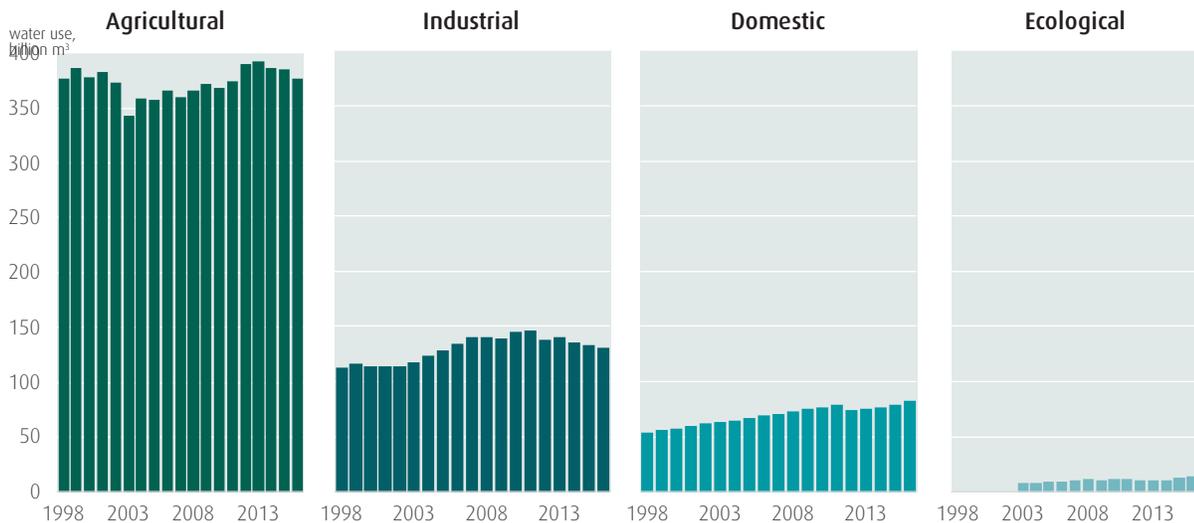
achievements, China is facing acute challenges with respect to both water quantity and quality.

China's Water Resource Challenges

Water use is inefficient despite the limited resources and growth in demand. China's per capita endowment of water resources is only one-fourth of the global average. Rapid urbanization is driving increasing demand for water from all sectors, on top of inadequate reserves for environmental uses (see figure 1.1). Domestic water use is estimated to be increasing at approximately 2.5 percent per year. At the same time, agricultural water use will need to increase in order to serve the proposed development and expansion of irrigated areas by 2020. Efforts to shift the structure of the economy to a more resource-efficient development model are intended to address some of these potential constraints, but there will continue to be challenges between supply and demand. Moreover, China's low water use efficiency rates mean that many water uses are highly wasteful. China's water consumption per RMB 10,000 industrial added value is two to three times greater than the average for high- and upper-middle- income countries (HUMIC). According to supporting documentation for the Action Plan for Prevention and Control of Water Pollution², the effective utilization factor of irrigation water is 0.52, much lower than the 0.7–0.8 average among HUMICs.

Groundwater overdraft threatens water security, particularly in northern China. Long-term and large-scale groundwater pumping can result in significant declines in groundwater levels and is the main cause

Figure 1.1 Changes in Sectoral Water Use in China, 1998–2016



Source: Data from Ministry of Water Resources.

of land subsidence. Globally there are a number of major cities facing the threat of significant land subsidence due to overpumping of groundwater resources, including Bangkok, Jakarta, Mexico City and the Houston-Galveston Region in the USA. Groundwater is one of the most important water sources in China. However, groundwater overexploitation has occurred in many areas, especially in North China. Areas of Hebei Province have historically relied heavily on groundwater resources in the absence of other sources. Over the past 30 years over-abstraction has resulted in an overdraft of 150 billion cubic meters. This has become the largest cone of depression in China, covering an area of 67,000 square kilometers and accounting for 92 percent of the total plain area within the province. The groundwater overexploitation has induced serious environmental and ecological issues and significant economic impacts. In response, Hebei Province launched a pilot program in 2014 to regulate groundwater over-abstraction. Through an integrated approach including water saving, price levers and development of new water sources, the groundwater levels of unconfined and confined aquifers have increased by 0.58 and 0.70 meters between 2014 and 2016 respectively. The overexploitation of groundwater has induced serious environmental and ecological issues including land subsidence, sea water intrusion, and the drying up of surface water bodies and significant economic impacts.

Improving water quality remains a serious issue that requires long-term investment. Industrial, agricultural, and organic pollutant discharges pose significant risks to human health. The annual environmental census in 2015 indicated that the nationwide chemical oxygen demand – depleting pollution discharge volume had reached 22 million tons, and the $\text{NH}_3\text{-N}$ (ammonia) discharge volume was 2.3 million tons, greatly exceeding natural absorption capacity. In 2017, 8.3 percent of tested water received the lowest rating for water quality based on China's five-tiered rating system, the quality of water in 32.1 percent of monitored sections in major waterways were lower than Class IV, and 31 percent of monitored lakes and reservoirs were subject to eutrophication. Among 5,100 monitored groundwater sources, 66.6 percent were rated as poor or very poor. Six of nine major bays or coastal inlets likewise have poor or very poor water quality according to the 2017 Ecological and Environmental Status Report. In the absence of bold, sustained interventions the control of water pollution will only become more complex, as both water consumption and sewage discharge volume continue to increase, and there is growth in the contribution of agricultural and non-conventional pollutants. Without major policy interventions, water pollution will impose significant economic as well as health-related burdens. While these were estimated at 2.3 percent

of GDP in 2007 (Xie et al., 2008), the Government has introduced a series of stringent measures in recent years to try and control water pollution and improve water quality.

Ecosystem services are under severe pressure from urbanization and growing water use. Traditionally, urbanization has come at the expense of natural habitats and has severely damaged ecosystems. Natural ecological systems such as wetlands, coastlines, and the banks of lakes and rivers keep decreasing, reducing the conservancy capacity of water sources. Major wetlands in the Haihe Basin have decreased by approximately 83 percent according to background documents in support of the Action Plan for the Prevention and Control of Water Pollution. With significantly reduced coastal wetland areas, biodiversity in off-shore coastal areas has decreased precipitously, and offshore fisheries have been harmed considerably. The stock of natural coastline now accounts for less than 35 percent of the total. The area affected by soil and water erosion has moreover reached 2.95 million square kilometers, accounting for 31.1 percent of China's total land area (China's Ecological and Environmental Status Report 2017; World Bank/DRC 2017j). The upper bound of water resources development rate should not exceed 40 percent for ecosystem protection, but in some places exceeds the renewable capacity. For example, the development rates in the Hai River, Yellow River and Liao River basins are as high as 106 percent, 82 percent and 76 percent, respectively; significantly more than the 40 percent required for ecosystem protection and sustaining environmental services and ecological flows.

Drought and local water scarcity plague large parts of the country. China's water resources are unevenly distributed across place and time, with the south and southwest featuring the most abundant reserves of water. Rainfall is also highly variable in many regions. Shortages of water are especially acute in China's energy-producing regions, where the high water requirements of energy and chemical industry may exceed local water supplies (Qin et al. 2015). Producing a single ton of coal for example requires 5 to 6 cubic meters of water, while it is estimated that nearly 10 cubic meters are required for a ton of oil. Specific regulations of water consumption within the energy and chemical production sectors under the Three Red Lines are improving efficiency and reducing withdrawals within projected limits. Though it is well understood that water scarcity is an issue for the northern and northwestern parts of the country, the eastern and southern central parts of the country also face potential water constraints with growth in demand anticipated to rapidly surpass supply due to urbanization and industrial growth.

As China's energy demand continues to increase rapidly in water scarce areas, the energy sector will increasingly need to plan with full consideration of water requirements, including an understanding of potential future constraints because of other competing uses and possible climate change (World Bank, 2018b). Other previous World Bank reports have examined China's growing water scarcity and provided a number of recommendations to address these issues (see box 1.1) (World Bank/DRC 2014).

Gaps remain in water supply, sanitation, and flood protection. China's small and medium sized cities and rural areas remain unevenly served by water supply, sanitation, and flood protection infrastructure. China has made significant progress over the last 40 years in improving access to water supply, with the JMP data³ indicating 95 percent of the population estimated has access to an improved source of drinking water on their premises. However, the remaining 5 percent is equivalent

to roughly 70 million people and there are a number of significant challenges in closing the service gap for these segments of the population. According to data from the Ministry of Water Resources, only 76 percent of rural households had access to tap water in 2015 and wastewater management, water supply and sanitation services in rural areas often lag behind those in urban areas. Quality is also a concern, with about 9.5 percent of the monitoring points for the centralized drinking water sources in prefecture-level cities and above recording values below the national quality standard in 2017. In addition, some small and medium sized cities rely on a single source of water, making them vulnerable to pollution and undermining the security of supply. Securing supplies for the large mega-cities and keeping up with increasing demands also remains a challenge. Surveys carried out by the Ministry of Water Resources also show that there are still many small and medium sized cities located along a large number of small waterways without adequate flood protection structures.

Box 1.1 Addressing China's Water Scarcity

The World Bank Report *Addressing China's Water Scarcity* (2007) focuses on the impact of water scarcity, aggravated by water pollution, and its implications on the environment, humans, and the economy. To address this challenge, the report makes several recommendations. These include the following:

- *Improving water governance.* This includes amending and improving existing water-related laws and regulations; improving law enforcement; establishing a national organization for integrated water management; converting river basin management commissions into inter-sectoral commissions; making public information disclosure a compulsory obligation of the government, companies, and relevant entities; and building a strong legal foundation for public participation.
- *Strengthening water rights administration and creating water markets.* This includes recognizing ecological limits of water resources, clearly specifying and implementing water withdrawal permits, strengthening water rights administration and providing certainty and security for holders of water rights, promoting evapotranspiration-based water resource management, and adopting a stepwise approach to water trading.
- *Improving efficiency and equity in water supply pricing.* This includes adopting a stepwise approach to tariff reform, raising water tariffs to fully reflect its scarcity value, addressing the social impact of tariff increases, and converting the water resource fee to a tax.
- *Protecting river basin ecosystems through market-oriented eco-compensation instruments.* This includes continuing to expand the application of ecological compensation mechanisms and promoting the piloting of payment for ecosystem services.
- *Controlling water pollution.* This includes improving pollution control planning, unifying and strengthening the pollution monitoring system, strengthening the wastewater discharge permit system, increasing reliance on market-based instruments, enabling litigation for public goods, controlling rural pollution, and increasing financing for market gap areas.
- *Improving emergency response and preventing pollution disasters.* This includes shifting from mitigation to prevention and planning, enhancing preparedness, establishing an environmental disaster fund through the implementation of the "polluter pays" principle, establishing a chemical management information system, and strengthening monitoring and public information.

Though this 2007 report focuses on the narrow issue of water scarcity, many of the recommendations also support broader improvements to the water resource management system. Thus, many of the recommendations are reflected in this report.

Climate change will exacerbate stresses on China's water resources. Even while shifting rainfall and tropical cyclone patterns increase the risk of flooding, warming in the Himalayan region is predicted to sharply decrease runoff from glaciers and the snowpack, which supply much of the water in China's major river systems, after 2050 (Lutz et al. 2014). Water availability in northern China is expected to decrease by up to 24 percent by 2050, placing additional strain on already overexploited groundwater and surface water resources (Mo et al. 2017). In southern China, temperature increases and increasing rainfall variability are expected to increase water demand for irrigation as water availability becomes less certain (Xia et al. 2017). These effects of climate change will only add to the existing water resource challenge.

Water resource management in China faces central-local and inter-jurisdictional coordination problems.

In addition to a constellation of actors at the central government level, most water resource management functions are in practice organized and implemented by provincial and local officials. Water Resource Bureaus typically exist at provincial, prefectural or municipal, county, and sometimes township levels, which, collectively, are typically responsible for planning, allocating and regulating local water use and conservation measures, water saving and flood control as well as developing and providing water infrastructure services. These should be implemented in accordance with the master plans for water resources development and utilization for each of the river basins. Similar entities, usually called "Environmental Protection Bureaus," are responsible for monitoring and enforcing compliance with pollution regulations. These two agencies have some overlapping responsibilities in water environment protection. In addition to these hierarchically-organized bodies, river basin commissions exercise many management functions, including water use planning, environmental protection of water resources and flood risk mapping at a basin scale. Despite these many institutions, implementation of national water resource management policies and regulations is uneven at local levels, and in some cases local officials are hesitant to cooperate with neighboring jurisdictions to address issues such as pollution and flood management (Moore 2014).

State-owned and private enterprises play an increasingly important role. In addition to formal governmental actors, both private and state-owned enterprises (SOEs) play an important role in China's water governance landscape. SOEs represent some of the largest industrial water users, being active in many of the most water-intensive industries as well as those sectors and industries that make significant contributions to water pollution. Many municipal water service

providers, including water supply and wastewater treatment operators, are also municipally owned. The relationship between SOEs and government regulators in any context creates the potential for a conflict of interest, as the state that is responsible for the regulation of activities is also the shareholder of the entity it is overseeing. This can create challenges in strictly enforcing both water quality and quantity restrictions. In recent years, SOEs have been joined by a large number of private water users as well as individual water users, most of whom pay tariffs for water supply and wastewater services (GWI 2015). Increasingly, the growth and pluralization of the Chinese water sector have created supervision, management, and governance challenges: it has become increasingly difficult to monitor water use and balance water demands between sectors and industries.

Progress to Date in China's Water Governance Reform

In recent decades, China has established a comprehensive legislative and regulatory framework for water resource management covering water pollution, water-related disaster control, water conservation, water pricing, water management and water infrastructure. The most important element of this framework is the 1988 Water Law, which was substantially updated in 2002 to strengthen provisions for river basin management, allocation, ecological protection, and enforcement. Other key legislative instruments include the Water Pollution Control Law, which was amended in 2017 to tighten enforcement, dramatically increase fines for non-compliance, set a national standard for one key pollution metric (chemical oxygen demand), and, most importantly, incorporated water quality standards into China's cadre evaluation system (*kaohe*). China's 1997 Flood Control Law, meanwhile, incorporates a progressive approach to flood management in which flood planning is undertaken at a basin and watershed level, and land use is controlled according to flood risk. Apart from legislation, a wide range of regulations, such as the State Council's 1993 decision establishing a water withdrawal permit system, and inclusion of specific provisions in each Five-Year Plan since 2005, have further strengthened China's water resource management framework.

Most notably, China has adopted perhaps the world's most ambitious set of water policy objectives. In 2011, the Government passed the No. 1 Central Government Document on "Accelerating Reform and Development for the Water Sector" with a focus on the key water resources issues and targets to be achieved within the next 10 years. The central vision

of this new agenda is to develop a “*system for rational allocation and efficient utilization of water resources*” and “*a system for governance of water resources.*” The document also clearly defines the guiding ideologies, objectives, and basic principles of water resource development and sets down a series of new policies and measures for water resource management. These objectives and principles are in turn reflected in the Three Red Lines designed to establish specific targets for water use, water use efficiency, and water quality, including at the provincial level (see box 1.2 and figure 1.2). In 2012, guidelines were issued to support implementing a Most Stringent Water Resources Management System to achieve the Three Red Lines targets based on four accompanying “systems” for total water use withdrawal control, water efficiency control, and pollutant discharge control, coupled with a responsibility and performance system. A more detailed work plan was prepared to implement this in 2014. In combination, the Three Red Lines and its accompanying regulatory infrastructure form the foundation of China’s current water policy, and represent perhaps the world’s most ambitious attempt to define strategic water policy objectives.

These policies have significant implications for national and regional growth that are critical to understand. Establishment of the Three Red Lines, with its emphasis on water demand management as opposed to a more traditional supply-augmentation approach, has helped to reduce both total water use and improve water use intensity across all economic sectors (see figure 1.3). The overall water intensity

per RMB 10,000 of GDP has improved from 552 cubic meters in 2000 to 153 cubic meters in 2015. Water quality, too, has substantially improved over the past decade (see figure 1.4). Moreover, it is predicted that the total accumulated amount of water pollutants will peak between 2016 and 2020 with ecological water requirements beginning to be included in regional water allocation. To understand further the future impacts of the Three Red Lines targets, which will increase in stringency over time, this study has developed an integrated modeling tool to estimate how different policies related to total water use, water use efficiency, and water quality might affect national and regional GDP (see box 1.3). Under certain assumptions (e.g., labor and capital mobility), the Three Red Lines policy is estimated to have little detrimental impact to the overall economy and economic growth, though this masks important regional differences (World Bank/DRC 2017k). For instance, though it is well understood that water scarcity is an issue for the northern and northwestern parts of the country, the east and south central parts also face constraints because demands are anticipated to rapidly surpass supply. This growth in demand is primarily driven by strong industrial growth. This analysis highlights the importance of implementing all of the targets for the Three Red Lines in tandem (especially the implementation of industrial water efficiency targets) to help cope with future water shortages.

Recent reforms highlight the importance of better institutional cooperation. In recognition of the need for institutional reform to implement policies such as the Three Red Lines, the government has also greatly strengthened the legislative and regulatory framework for water resource management, assigning existing institutions generally greater powers and responsibilities, and deployed new tools, like water rights trading, with increasing scale and sophistication. Notably, the State Council announced a series of institutional reforms in March 2018 to substantially redefine the responsibilities for water resource management. Highlighting the Chinese government’s determination to address institutional barriers to effective water resource governance these institutional reforms include the establishment of the Ministry of Ecology and Environment (MEE) and the Ministry of Natural Resources (MNR), along with consolidation of responsibilities within the Ministry of Water Resources. Moreover, in announcing these changes, the government cited a renewed commitment to environmental protection and sustainable use of natural resources.

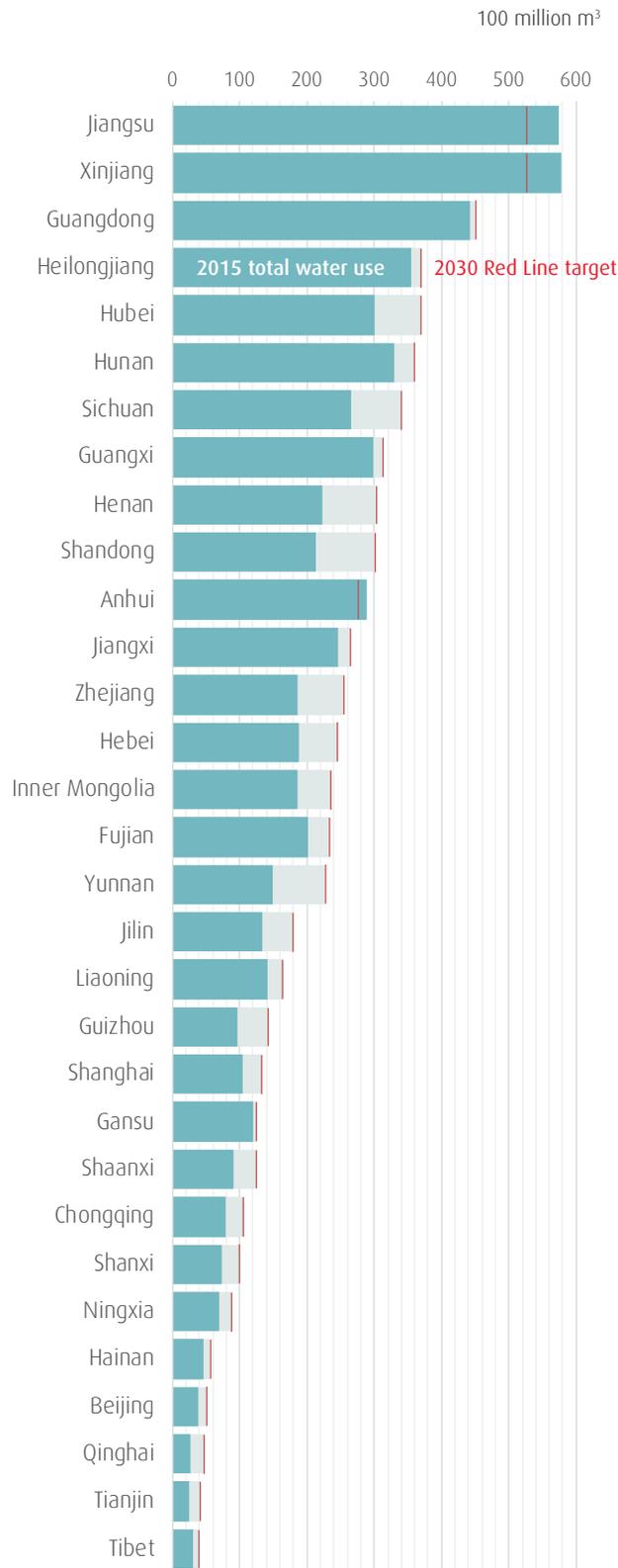
Despite reforms, China’s water policy objectives require greater institutional coordination and capacity. While these reforms indeed hold great

Box 1.2 The Three Red Lines

The Three Red Lines as given in the No. 1 Central Government Document on Accelerating Reform and Development for the Water Sector are as follows:

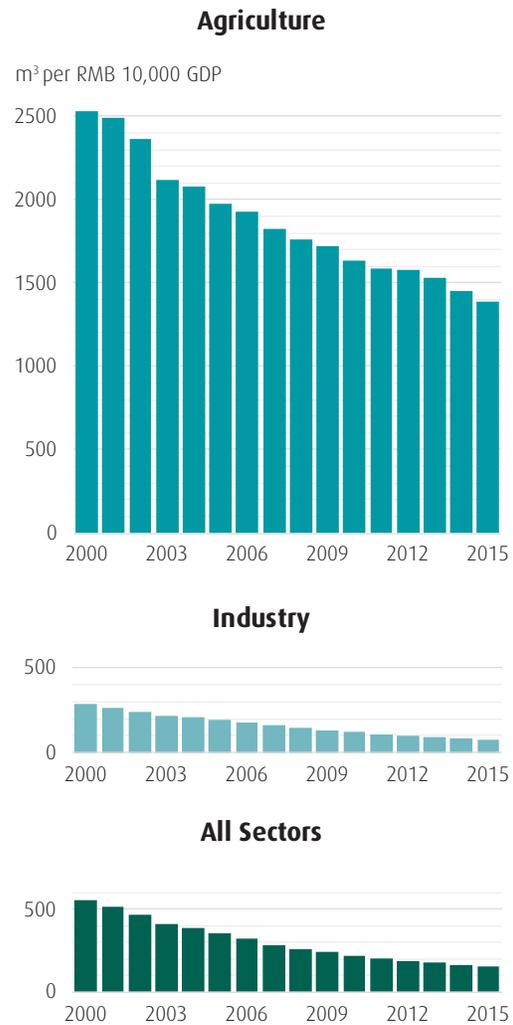
- **Water quantity:** By 2030, total water use must not exceed 700 billion cubic meters.
- **Water use efficiency:** By 2030, industries will reduce their water use per US\$1600 (RMB 10,000) of industrial added value to 40 cubic meters. In addition, by 2030, irrigation efficiency must exceed 60 percent.
- **Water quality:** By 2030, 95 percent of water function zones must comply with water quality standards. In addition, by 2030 all sources of drinking water will meet set standards for both rural and urban areas and all water function zones will comply with water quality standards

Figure 1.2 Current Water Use and Future Red Line Water Quantity Targets by Province



Source: World Bank/DRC 2017k.

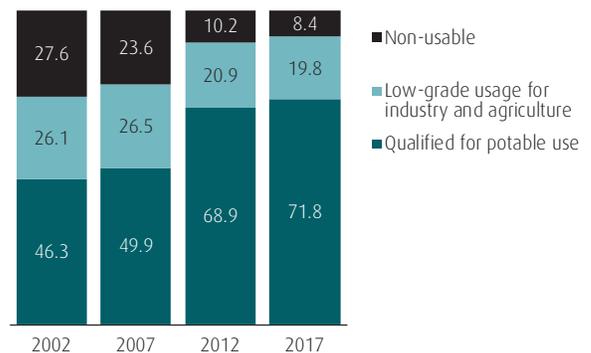
Figure 1.3 China's Water Use Intensity across Sectors, 2000–15 at 2000 constant prices



Source: World Bank/DRC 2017k.

Note: GDP = gross domestic product.

Figure 1.4 Proportion (%) by the Quality Level of Rivers, 2002, 2007, 2012, 2017



Source: Source: Data from Ministry of Ecology and Environment.

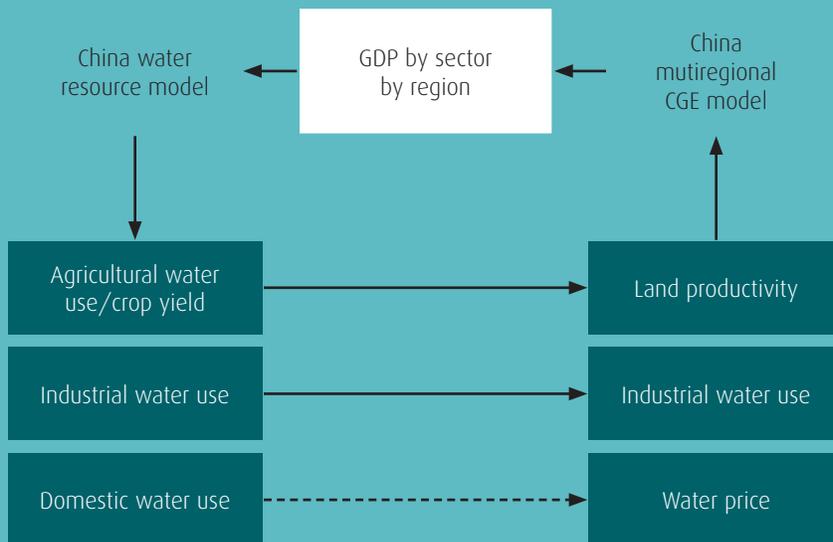
Box 1.3 Using Integrated Modeling Tools to Assess Policy Instruments

To better understand the linkages between water policy instruments and their impact on economic growth and household income, water resource models can be linked to multiregional computable general equilibrium (CGE) models (see figure BI.3.1). For this report, a separate study was undertaken linking a basin-provincial water model with an existing China multi-regional CGE. These integrated models can capture regional heterogeneity both in terms of water resources and economic development and are suited for simulating the impacts of water allocation across broad water use sectors (e.g., agriculture, industry, and municipal) to the regional

economy. By extension, the effects of water resource management policies can also be tested (e.g., Three Red Lines pricing policies). It should be noted that as with any such modeling framework, uncertainty with parameters exist and many assumptions will need to be made (e.g., substitutability of factors of production across sectors). Nonetheless, as a tool to identify broad and relative directions in policy and planning, such approaches can be useful and illustrative. This approach has been adopted in numerous studies worldwide (e.g., in Pakistan, Bangladesh, South Africa, the Arab Republic of Egypt, and Ethiopia).

Figure BI.3.1 Schematic of China Water Governance Study Computable General Equilibrium Model

(from World Bank/DRC 2017k).



Note: CGE = computable general equilibrium; GDP = gross domestic product.

promise to improve water resource management, as the remainder of this Synthesis Report details, for the foreseeable future institutional challenges continue to hinder China's ability to achieve its ambitious water resource policy objectives. Broadly speaking, these fall into three categories. First, communication and coordination between agencies responsible for different aspects of water resource management is often minimal. Tackling issues like nonpoint source (NPS) pollution nonetheless call for close coordination between authorities responsible for agriculture, urban, environmental and

water resource issues. Second, China's institutional structures, which are often organized on a hierarchical basis, provide few incentives for officials in neighboring jurisdictions to cooperate, even though many water resource management challenges are inherently inter-jurisdictional. Third, decision-making protocols and procedures are not sufficiently comprehensive or agile to deal with increasingly complex and evolving, multi-stakeholder issues like inter-sectoral water use allocation or public-private financing of water projects. While this Synthesis Report outlines many priority areas for further reform of

China's water governance system, in many ways these institutional issues remain at the heart of the challenge.

A novel water governance approach is needed to build on these achievements and promote China's economic transformation. This includes the New Development Model, Building an Ecological Civilization, propelling the Decisive Move to the Market envisioned in the 12th Five Year Plan, and supporting clean technologies called for in the 13th Five Year Plan. Each of these major initiatives relies on improving water governance. Chinese economic development has entered a new stage characterized by rapid growth and structural change. Moving to a more service-oriented, higher value added, and less pollution-intensive economic model, as each of these strategic initiatives envisions, will require more water to be made available to new urban and industrial uses. Moreover, many of the "magic seven" Strategic Economic Industries identified in the 12th Five Year Plan require dependable access to high-quality water (see table 1.1). A traditional supply augmentation approach to address these new demands will be too costly (2030 Water Resources Group 2009). China must recognize that water scarcity may impose a fundamental constraint on its development path unless significant changes are made. China must ensure that water resource issues inform its strategic policies, including the planned development of mega-urban regions in northeast and southern China. China must ensure that these initiatives do not exceed the ecological limits enforced by limited water availability in the affected regions. A new water governance strategy is needed to ensure that water-related challenges do not constrain China's future development.

Essential Principles of a Water Governance Strategy

China's sustainable growth goals require new approaches to water governance. Ambitious water policies such as the Three Red Lines set the right foundation to achieve sustainable growth that balances economic development and environmental protection. But these policies need to be supported by a water governance approach that addresses all aspects of China's complex water challenges and engages all stakeholders to solve them. A water governance approach is built on three pillars: (i) a sound legal framework that establishes clear accountability between actors and levels of governance, (ii) strong institutional arrangements, and (iii) full participation of all water user groups (Xie et al. 2008).

Different kinds of approaches to water governance will be needed for a country as geographically and economically diverse as China. China's water challenges are complex and multi-faceted, spanning pollution and scarcity, flooding and drought, and important regional differences. Such challenges cannot be addressed using any one policy measure, or by any one agency or organization. Figure 1.5 shows how current water use patterns across the major sectors differ for each of the provinces. These important differences, which themselves are dramatically evolving over time, require region-specific responses. This may not necessarily be at odds with the national vision set by the Three Red Lines and other legislation, but highlights the challenges with only centralized approaches. A new approach to water governance should fill remaining

Table 1.1 Key Industrial Sectors in China's Past and Planned New Economic Structure

Old pillar industries	Magic seven strategic emerging industries ^a
National defense	Energy saving and environment protection
Telecom	Next generation Information Technology
Electricity	Biotechnology
Oil	High-end manufacturing
Coal	New energy
Airlines	New materials
Marine shipping	Clean energy vehicles

a. These are the new components of China's industrial strategy (12th *Five Year Plan*).

gaps in the overall architecture for water resource management in China, and balance better coordination with developing locally appropriate solutions.

A new water governance strategy for China should be built on several key principles: integration, balance, participation, innovation, accountability, and gradualism. Water governance is fundamentally about taking water out of its sectoral silo and managing it in a way that reflects its crucial importance to all parts of the economy and society. An ideal water governance system spans multiple issue areas, institutional frameworks, and mechanisms, and employs a variety of tools and methods. This approach should be built on several key principles. First, water policy must be integrated, both horizontally and vertically; it cannot be made in isolation from food, energy, or land management policy. Second, it should balance multiple, sometimes competing objectives, setting standards that protect human health and preserve adequate water for the environment. Third, it should be focused on supporting participation at all levels, especially that of local communities. Fourth, roles and responsibilities of various entities should be clear to ensure accountability. Fifth, a water governance approach must embrace innovation and experimentation, especially the use of advanced technologies, big data, and integrated

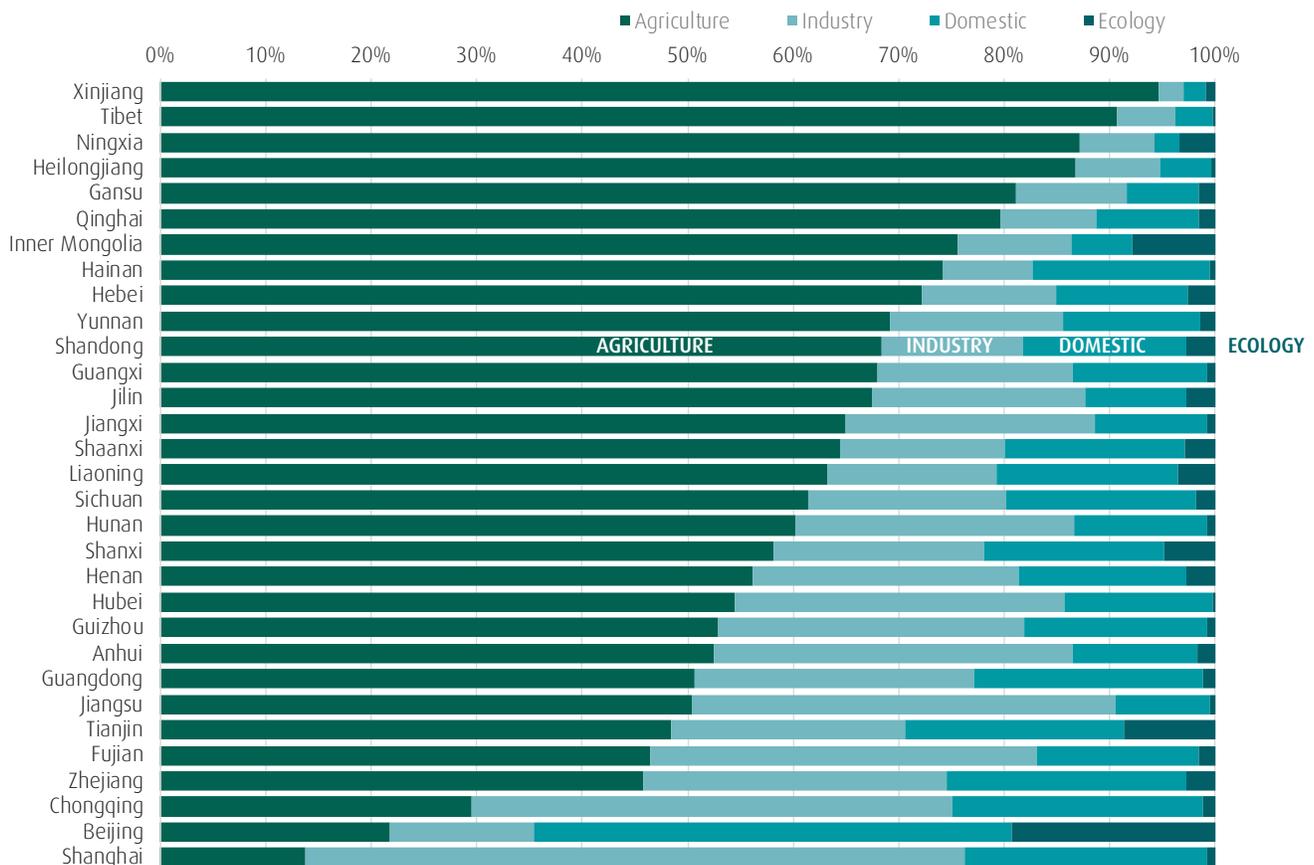
information-sharing platforms. Finally, new reforms will take time to evolve gradually, and will require flexibility and iteration.

China has an opportunity to think big and develop bold, innovative solutions to water challenges.

Developing and implementing a new water governance strategy requires significant effort and investment, but it also provides the opportunity for China to become a global leader in responding to water-related development challenges. Facing environmental challenges and rapid growth, China has needed to innovate and pilot various approaches to address these common global problems. This includes adopting visionary development concepts (e.g., “Ecological Civilization” which puts nature at the center of development), developing innovative technologies like highly efficient water purification and desalination technologies, institutional reform experiments such as the River and Lake Chief (*hezhang*) system, piloting innovative ideas such as the sponge city, and an evapotranspiration-based⁴ water rights trading systems. China can lead the way in demonstrating how to solve the world’s growing water challenges.

China’s water governance system should be inclusive and adaptable. Recognizing the important contributions of institutions to economic and social

Figure 1.5 Water Use Structure by Province (100 million m³), 2015



development, the realization of a new era of water governance in China should be cognizant of and contribute to the following:

(1) the state governance system and the establishment of its regulation system. From ancient times the management of water has been central to considering the ability and achievements of state officials. Among others, this is reflected in the philosophies of the famous official Guan Zhong. While the state has continued to reiterate and elevate the importance of water governance, there remains significant challenges in adjusting with the changing context and development needs;

(2) ecological civilization and development of a system for implementation. Water governance is an important and integral part of realizing an ecological civilization. The design of a water governance system requires the establishment and improvement of corresponding systems related to water resources, such as water rights, planning, utilization and protection of water resources, control of the total water-volume, overall water conservation, user pays and ecological compensation, market based systems for environmental and ecological protection, market based systems, performance evaluation and accountability;

(3) enhancement of capacity to ensure national and regional water security. Focus on improving the security of water resources, including the water security for the environment, ecological services, development, water supplies, and contributing to international water security;

(4) improvements of the long-term livelihood well-being of the Chinese people. Increasing the resilience of human and environmental systems through reducing the impacts of disasters from floods and droughts, improving the level of service and quality of drinking water for urban and rural residents, and improving the aquatic environment and ecological services for urban and rural residents; and

(5) regional and global water governance. The Chinese experience in managing the development of water resources provides important lessons, models, concepts and capabilities to inform regional and global efforts to address water related risks to economic progress, poverty eradication, and sustainable development.

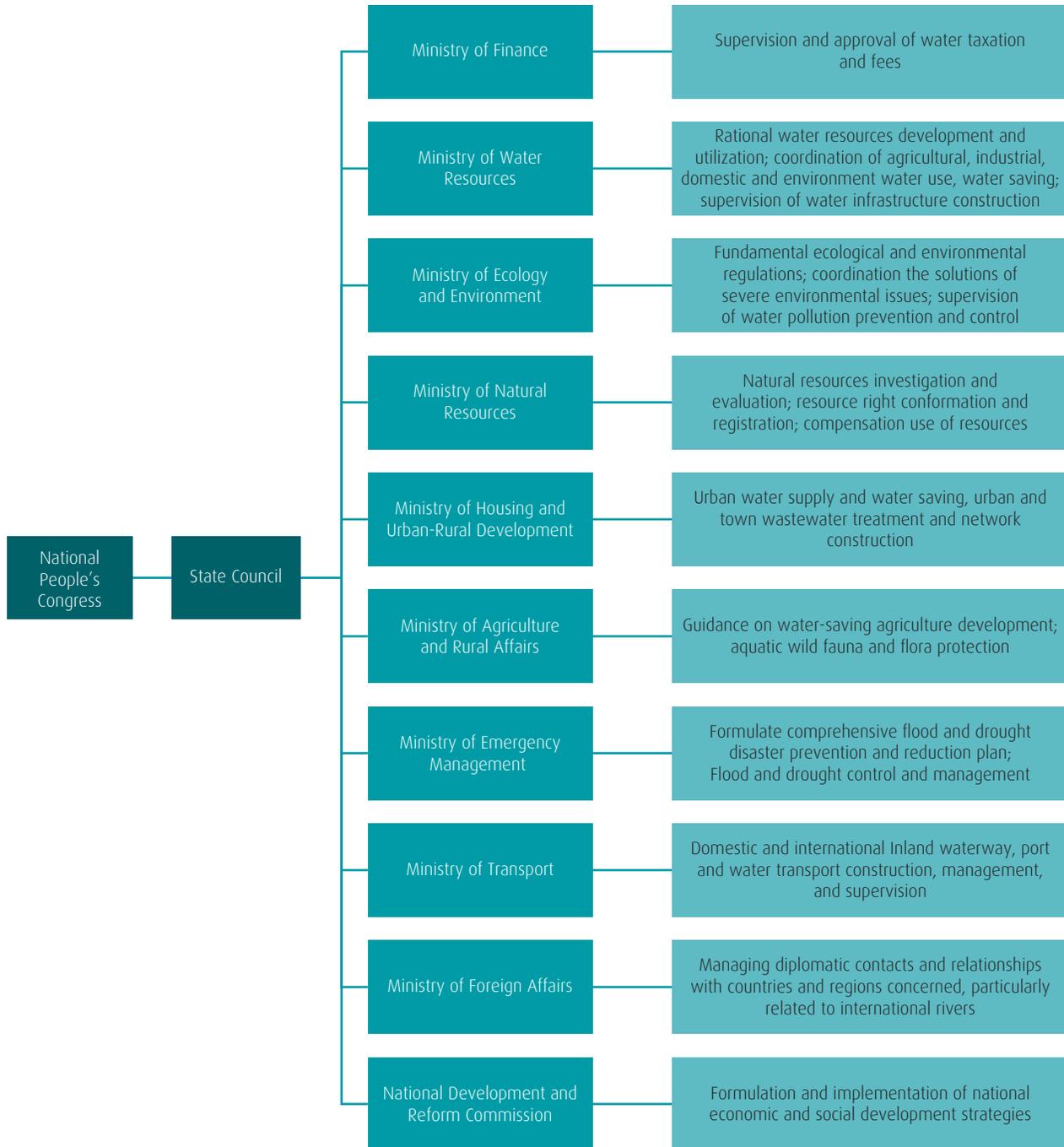
China's water governance system will be developed and implemented with Chinese characteristics. Based on current situation and demands, China's water governance system should integrate at least five parts that align with the broader cultural context, including: (1) water resources governance focused on the security of water resources through the development, utilization, conservation and protection of water resources; (2) environmental water governance

focused on ensuring safety and security of the aquatic environment by reducing pollutants, promoting rehabilitation and investing in restoration; (3) ecological water governance focused on achieving and maintaining a sustainable and safe freshwater ecosystem by strengthening the protection, restoration and allocation of water for ecological functions; (4) water engineering focused on promoting the construction and operation of infrastructure to ensure their safety, productivity and environmental sustainability; and (5) management of water affairs focused on establishing and implementing mechanisms to mediate water disputes so as to ensure harmonious, healthy and stable relations related to water affairs.

Priorities for Water Governance Reform

China should address five key water governance reform priorities. First, China needs to enhance the legislative foundation for water governance by revising water-related laws and regulations. Second, national and basin governance institutions should be strengthened and their role in ecosystem protection expanded. Focal points for policy coordination between different agencies, jurisdictions, and sectors need to be clarified. Third, existing piloted economic policy instruments should be improved upon and scaled-up where appropriate. Fourth, human and ecological systems need to be made more resilient to meet future threats and challenges. Fifth, data- and information-sharing need to be improved among agencies, jurisdictions, and water users. These priorities are described briefly in turn.

The legislative foundation for water governance must be enhanced. The legal basis for China's water governance system is incomplete. Some legislation remains in contradiction, while other provisions are incomplete or inflexible. Due to the competing priorities of different bureaucratic units, legal and regulatory authorities are often inconsistent. The Water Pollution Prevention and Control Law and the Water Law, for example, feature different water quality standards and provisions, and fail to sufficiently clarify responsibilities of different departments. The importance of doing so is even greater given the ministerial reorganization announced in March 2018. At the same time, provisions to support enhanced enforcement of regulations on water pollution remain weak and should be strengthened. Several modalities could be employed to achieve this objective, including the use of regulations and State Council opinions and directives, in addition to new and revised legislation. Given its importance to China's overall system of water governance, legislative reform should include revisions to China's current Water Law to

Figure 1.6 Institutional Structure and Main Water-Related Functions for Water Management in China

Note: Representation of the different institutions is in no particular order. The description of the main water-related functions is not considered exhaustive and the respective institutions have a broader range of related functions that are not detailed here. For a comprehensive consideration readers are referred to the respective institutions.

reflect new principles and challenges that have emerged recently for water resource management in China.

Improved coordination and integration across sectors and administrative levels is needed to address China's emerging challenges. To achieve policy objectives such as the Three Red Lines, better integration across policy areas is needed. Achieving

water quality standards, for example, depends in part on erosion control and rangeland management far upstream—responsibilities that fall outside the traditional water resource management system. Given the need to strictly control water use and water pollution from all economic sectors, more inter-sectoral strategies and more inter-agency cooperation (see figure 1.6) is needed to achieve these policy goals. Many economic

policies regarding, for instance, urban planning, industrial development, and agricultural policy, can have indirect effects on water resources. Strengthening river basin commissions can help in this integration horizontally (e.g., across sectors) and vertically (i.e., across administrative levels). River and lake chiefs can also play an enhanced role in these institutions.

Economic policy instruments can be improved upon and optimized. While the Three Red Lines policy establishes sound overall targets for water quantity and quality, economic policy tools to achieve these goals can be made more effective. Embracing the Decisive Move to the Market entails reducing the government's role in regulating water use, and instead promoting market-based mechanisms to improve water allocation and water quality. Water rights trading and water price reforms are showing great promise in pilot programs, but these need to be expanded in order to achieve Three Red Lines targets. Continued progress toward water pricing reform is needed to encourage both conservation and cost recovery. For example, agricultural water prices remain too low to encourage real conservation. In 2010, irrigation water prices only ranged from RMB 0.01 to 0.35 per cubic meter. Further empirical analysis is needed to determine whether current pricing structures and policies are having their intended effects.

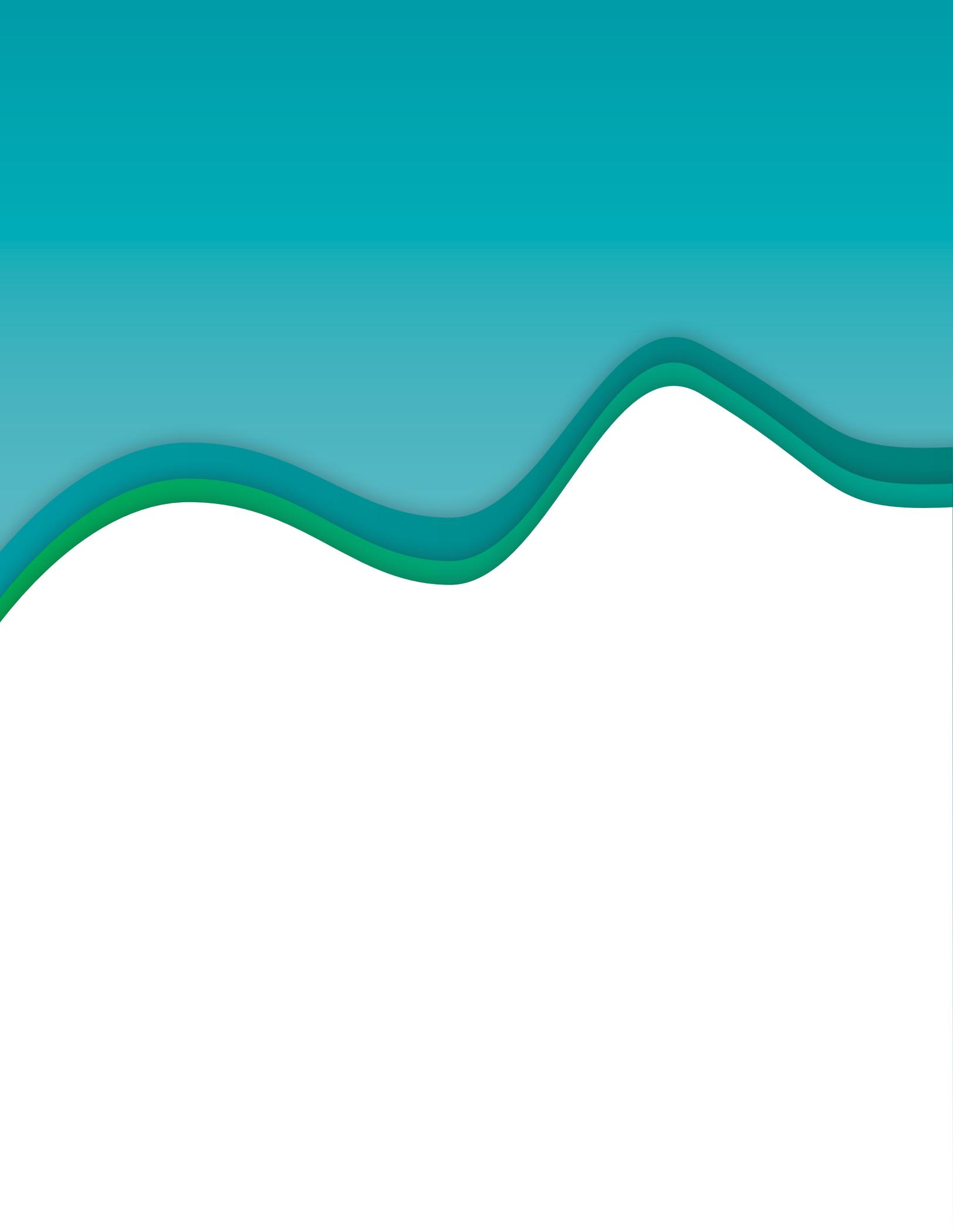
China needs to continue to strengthen adaptive capacity to climate and environmental change. This includes strengthening resilience to floods, exploring a Red Line target to ensure water availability for ecological services, and by addressing NPS pollution, especially from agricultural sources. Water ecosystems, including streams, rivers, wetlands, and lakes, provide many economically valuable services, including flood and water retention, purification, and recreation. Yet, urbanization and the attendant destruction and modification of wetlands and water bodies have substantially reduced the functioning of

these ecosystem services. A robust river and lake health index could be used to assess and monitor whether environmental water requirements are being met and added to the Three Red Lines. China also has an opportunity to develop further a national flood insurance system.

Finally, local leaders and decision makers need more and better data and information to support policy implementation. In many cases, local authorities need to improve the capacity to collect and analyze high quality, timely data on water availability, consumption, and other key metrics to effectively manage water resources and properly implement policies such as the Three Red Lines. New technologies, including remote sensing, show great promise in enhancing the capacity of local leaders to ensure compliance with water consumption and quality standards. At the same time, building data- and information-sharing platforms can help officials across all agencies better coordinate efforts and monitor progress toward implementation and understand challenges encountered at local levels. Public participation must also be strengthened, especially to aid local authorities in better enforcing water pollution regulations.

Notes

1. <http://www.gov.cn/guowuyuan/zuzhi.html>
2. Ministry of Ecology and Environment, Background for the Launch of the Action Plan for Prevention and Control of Water Pollution: http://www.mee.gov.cn/home/ztbd/rdzl/swrfzjh/ctbj/201505/t20150529_302579.shtml
3. <https://washdata.org>
4. Evapotranspiration refers to the process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.



PRIORITY 1

Enhance the Legislative Foundation for Water Governance

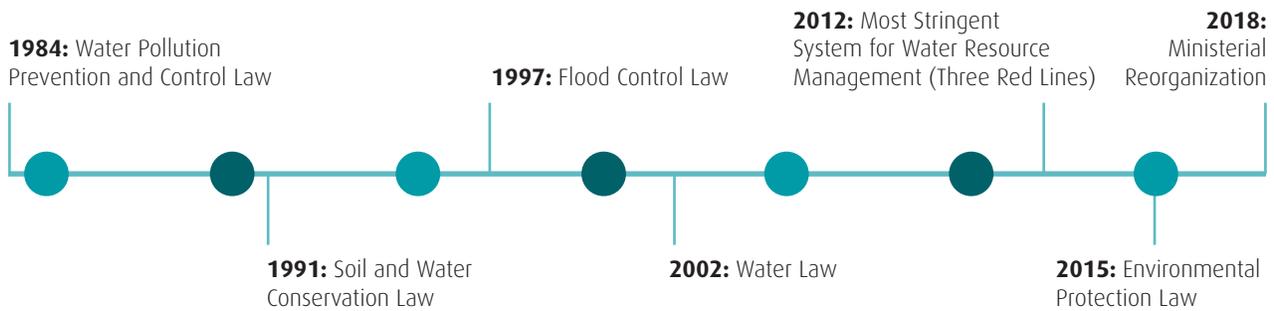
It is essential that China codify recent major existing principles and reforms into laws to send strong policy signals to local officials and enterprises that compliance will be taken seriously. China should take several steps to enhance the legislative foundation for water governance. First, the 2002 Water Law requires an update to reflect the current legislative environment and the new administrative landscape, including the new ministries announced in the 2018 reform. Second, approaches to enforcement of existing pollution legislation needs to be expanded. Third, legislative adjustments can be made to encourage greater public-private partnerships (PPPs), which will be critical for mobilizing financing to support water management.

Update the 2002 Water Law

In many countries, legislation serves as the foundation for water governance. The challenges of sharing water between different uses and between upstream and downstream users have in many parts of the world given rise to a complex body of water law that determines, among other things, basic principles for how water is allocated, as well as through what means or institutions. While some countries, such as the United States, and many common law legal systems have established these principles through individual legislative provisions and judicial decisions, others

seek to outline them in specific water laws intended to codify, in a single legislative instrument, the framework for water resource management. This approach is recommended by many water law experts (Wouters 2000), but it is also widely recognized that framework water legislation should seek primarily to enumerate basic principles for water governance, while clarifying specific provisions through subsidiary regulations. According to one prominent water law expert, for example, *“A basic water law, act, or code should not be too detailed, but should contain the basic principles which create the instrumentalities which ensure the attainment of its objectives.”* (Caponera 1992, 133). In approaching the broader issue of water governance reform, it is therefore necessary to first consider such basic legal foundations.

Legislative reform has been one of the most important elements of China’s first generation of water governance reforms. As with that of several countries, China’s Constitution specifies that water resources are, with minor exceptions, the property of the state, and therefore subject to near total regulation. Several laws pertaining to water resources have been promulgated under this general authority, including the Soil and Water Conservation Law of 1991, the Water Pollution Prevention and Control Law, first passed in 1984 and most recently amended in 2017, and the Flood Control

Figure 2.1 Selected Key Water Governance Laws and Policies, 1984 to Present

Law, first passed in 1997 and most recently amended in 2016. The most significant and comprehensive legislative instrument for water governance, however, is the Water Law. This was first promulgated in 1988 and was significantly revised in 2002, with a further amendment in 2016 to emphasize the need for water infrastructure construction to align with integrated basin planning, and for any construction in designated important rivers and lakes, and sub-national transboundary rivers and lakes requiring letters of authorization signed by basin management institutions. The Water Law forms the legislative foundation for China's current water governance system. Accordingly, as is the practice for similar basic legislation in other countries, the Water Law should be periodically updated to take account of new developments and challenges (Caponera 1992).

Since the last major revision of China's Water Law in 2002, many important laws and policies have been promulgated that have reshaped the landscape for water governance in China (see figure 2.1). Accordingly, the Water Law should be revised to reflect new principles and challenges that have emerged for water resource management in China. The Water Law should be updated to: (i) establish a clear institutional mechanism for addressing inter-jurisdictional water pollution, including through the *River and Lake Chief System*; (ii) strengthen provisions related to water quality enforcement and environmental impact assessment; (iii) clarify the allocation of powers and responsibilities for implementing key water resource management policies among the ministries of Ecology and Environment, Natural Resources, Water Resources and other entities, including the Action Plan for Prevention and Control of Water Pollution, the Most Stringent System for Water Resources Management, and the Ecological Civilization Construction pilot. While there is a clear need to undertake a significant update of the Water Law, there are many options for how these updates can be undertaken, and supporting regulations should be amended accordingly.

Perhaps the most significant gap in the present Water Law is that it does not sufficiently regulate interjurisdictional water pollution. China's current water governance system often encourages the setting of water quality regulations on a jurisdictional rather than regional scale (Li, Liu, and Huang 2010). Since many courts are ill-prepared, and in some cases unauthorized, to hear cases of inter-jurisdictional infractions, enforcement of inter-jurisdictional pollution issues is very difficult (Moore 2017). Similarly, while effective water management requires multiple government agencies and jurisdictions to work together, at present, there are few institutional forums to facilitate or encourage such inter-jurisdictional and inter-sectoral coordination (World Bank/DRC 2017e). These gaps need to be addressed in the Water Law to better address pollution and other issues that cross provincial and local government boundaries.

Moreover, several significant legislative and regulatory developments have taken place in the last 15 years that are not directly addressed by the Water Law. At least three major pieces of legislation with implications for water resource management, namely the Environmental Impact Assessment (EIA) Law, the Water Pollution Prevention and Control (WPC) Law, and the Environmental Protection Law (EPL), have come into force or been revised since the Water Law's most recent 2002 revision. The EIA Law establishes a detailed process that must be undertaken prior to construction of water conservancy projects, including large dams, part of which consists of public consultation and review. The WPC Law builds on many of the environmental provisions of the water Law, directing local officials to maintain and improve environmental conditions, prevent and control water pollution, protect aquatic ecosystems, and ensure safe water supplies. The EPL, meanwhile, includes provisions authorizing and encouraging the use of eco-compensation mechanisms for water pollution, and directs local authorities to establish "ecological red lines" for areas including

source water regions. Some of these provisions appear to supersede elements of the 2002 Water Law.

Finally, the Water Law does not reflect several critical environmental and water policy initiatives, and does not define how the responsibilities for achieving them might be allocated among various ministries and agencies. First, it does not include the core concept of “ecological civilization” that currently underpins much of China’s environmental policy. The concept, promulgated by the government in 2015, integrates environmental quality metrics into the set of criteria used to evaluate the performance of government officials, and encourages public and non-governmental participation in pollution monitoring and environmental protection (Geall 2015). Second, the Water Law does not codify the Most Stringent Water Resource Management System, also known as the Three Red Lines in reference to its three main elements, which include a cap on total national water use (World Bank/DRC 2017g). Yet despite their importance, the Three Red Lines lack explicit legislative authorization and a clear designation of administrative responsibility for achieving them. There is, for example, no explicit linkage between the 2002 Water Law’s river basin planning and allocation provisions and the Three Red Lines water quantity allocations (World Bank/DRC 2017g). Codifying the Three Red Lines through revision of the Water Law would help reflect the importance of these allocations to China’s overall system of water governance.

Strengthen Enforcement of Existing Water Quality Standards

In China, as in many countries, the most important means of addressing water pollution is a set of legislative and regulatory provisions that establish water quality standards and penalties for those responsible for violating them. These regulations are an especially important means of controlling pollution from point sources such as factories and enterprises. China has established water quality standards, including approximately 25 water quality criteria for surface waters, including temperature, nitrogen, and chemical oxygen demand; 69 criteria in wastewater; and specific discharge and effluent standards for various industries, including iron and steel manufacturing, rare earths mining, and so on. Policies such as the Action Plan for Prevention and Control of Water Pollution and the Most Stringent System for Water Resources Management have moreover established a framework to enforce these standards through water quality monitoring and reporting, fines, and, in some cases, criminal penalties.

Despite the existence of this framework, enforcement of existing water quality standards remains a challenge, and several options should be considered to strengthen

enforcement of existing water quality standards. In a recent survey of textile plant operators, for example, only 25 percent of respondents indicate that their operations have been impacted by the Water Pollution and Prevention Control Action Plan, despite the Plan’s specific targeting of the textile industry (McGregor 2017). Current methods of enforcement include the increased use of fines, public identification of cities and enterprises that violate pollution regulations, and tying the promotion of local officials to meeting water quality standards. Each of these methods should be considered as part of a holistic strategy to strengthen enforcement, because research suggests that combining enforcement mechanisms is more likely to be effective than relying solely on such measures such as increasing inspections (Lin 2013). Among this range of options, one promising method is to expand the use of citizen suits to seek redress for environmental harms, and this should be carefully considered as part of a holistic strategy.

Environmental law cases have been rare in the Chinese legal system, primarily because it has been unclear whether individuals or entities have the legal standing to bring lawsuits for environmental harms. China’s Water Pollution Control and Prevention Law of 1996 provides for lawsuits related to harms caused by water pollution, but only if arbitration initiated by the local environmental protection department were to fail. Over the past decade, however, China has enacted several important reforms to enable citizen suits to enforce environmental regulations. In the late 2000s, several specialized environmental courts were established to help redress the fact that many judges were unfamiliar with the concept of environmental litigation or enforcement (Stern 2014). In 2012, China’s Civil Procedure Law was amended to provide that “*relevant bodies and organizations ... may bring a suit to the people’s court against such acts as environmental pollution.*” The most recently amended version of the Environmental Protection Law, which took effect in 2015, further clarifies that any properly registered organization that has “*specialized in environmental protection public interest activities for five consecutive years and have no law violations*” is entitled to bring environmental lawsuits (Zhang 2014). In 2017, the China National People’s Congress also approved the amendment of the Civil Procedure and Administrative Procedure Laws to formally allow procuratorates, which prosecute cases in the public interest, to file civil lawsuits in cases relating to environmental protection, including water pollution (Zhang 2017a). This reform is especially promising because the procuratorates are powerful entities with substantial legal and investigatory resources that outstrip those available to nearly all non-governmental organizations (NGOs) (Wilson 2015). However, the experience of other countries suggests that allowing

individual citizens to litigate for water-related environmental harms can be a powerful tool for improving enforcement of pollution control legislation.

In some countries, most notably the United States, litigation is an important method for enforcing environmental regulations, particularly those concerning pollution. In the United States, environmental regulations can be enforced by three primary avenues: administrative agencies acting to fulfill a legal mandate, lawsuits filed against government agencies by NGOs, usually seeking to compel administrative agencies to act against polluters, and by individual citizens and organizations acting as “private attorneys-general” by suing to prevent environmental harms (see box 2.1). This last avenue, which effectively deputizes individual citizens and organizations in enforcing environmental regulations, creates an additional incentive for polluters to minimize the impact of their activities on neighboring entities, which might otherwise sue them, and promises to thereby increase enforcement capacity at little cost to the government (Daggett 2002). The two keystone pieces of environmental legislation in the United States, the Clean Air and Clean Water Acts, offer two different examples of how these “citizen suits” have been enabled. The Clean Air Act includes a specific citizen suit provision explicitly intended to enhance federal air pollution enforcement capacity, and allows any person to bring suit under the act for breach of air quality standards, or failure to enforce them (Alpert 1988). The Clean Water Act, meanwhile, includes a similar provision, but more narrowly defines which entities possess standing to sue for alleged water pollution violations (Campbell 2000).

While China has embraced the basic principle of non-governmental standing to sue, the U.S. experience in environmental law offers several lessons to improve China’s potential to control water pollution. In addition to allowing specified organizations standing to sue for water-related environmental harms, China should consider granting individual citizens the same standing, at least under specific circumstances. By expanding the number of potential lawsuits, this reform would create an even stronger economic incentive for industries to prevent and control water pollution. The amended Water Pollution Prevention and Control Law permits citizens to sue for the disputes of costs, damages and compensations due to the water pollution issues. This standing to sue could be extended to allow citizens to sue for a broader range of harms, including those associated with long-term chemical exposure. This amendment should be accompanied by other regulatory changes to further increase fines and strengthen incentives for local officials to ensure compliance with water quality standards.

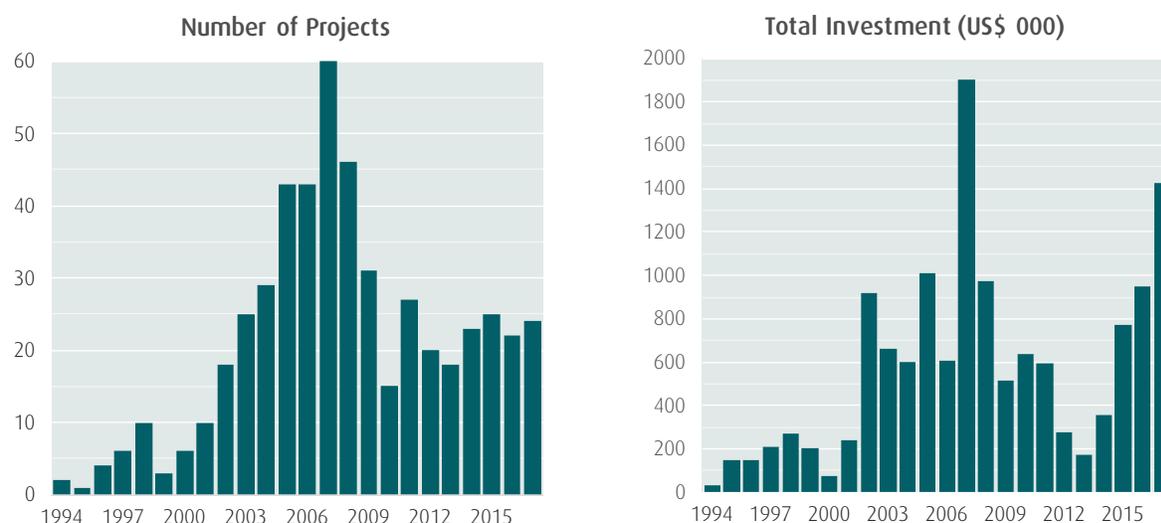
Box 2.1 Role of Environmental Litigation in U.S. Environmental Enforcement

The United States has adopted a highly litigious approach to environmental enforcement, but one that effectively enlists non-governmental entities in enforcing regulations. Broadly speaking, the U.S. system provides two avenues for non-governmental engagement in environmental enforcement. First, several key pieces of legislation, notably the Clean Air and Clean Water Acts, specifically authorize individuals to sue entities in violation of environmental quality standards. Second, individuals can sue governmental entities for not enforcing such standards, or for doing so in a way that does not satisfy other legal requirements. This two-part approach allows non-governmental entities to both help police polluters as well as to hold regulators to account.

The Clean Water Act, for example, specifies that “any citizen may commence a civil action on his own behalf against any person, including the United States ... who is alleged to be in violation of an effluent standard or limitation” as well as “against the Administrator [of the Environmental Protection Agency] where there is alleged a failure of the Administrator to perform any act or duty.” The Act also gives district courts the authority to themselves “enforce such an effluent standard or limitation,” and to “apply any appropriate civil penalties.”

Codify and Strengthen the Role of Public-Private Partnerships

China has become one of the world’s most important and active markets for public-private partnerships (PPPs) in the water sector. PPPs have long held an attraction for governments (especially in the low- and middle-income countries [LMICs]) that seek to expand infrastructure coverage while minimizing pressure on public budgets. There are many approaches to PPPs, but most rely on private sources of capital to finance most of the initial capital cost of building infrastructure, which is then recouped through long-term concessions, user fees and charges, or other mechanisms. Roughly 511 water sector PPP projects were initiated in China between 1994 and 2017. Many of these projects focused on wastewater treatment, as well as urban water supply. The development of PPP investments in the water sector in China has gone through four distinct stages. The initiation stage was from the middle of 1990s to 2001 when PPP started to invest urban water supply systems in several cities. From 2002 to 2008, PPP investments in the water sector

Figure 2.2 PPP Water Sector Projects and Investment in China, 1994–2017

Source: World Bank data.

Box 2.2 Summary of Water Sector PPPs in China

Various forms of PPPs have played a critical role in China's water sector development over the past 20 years. Since China opened its water sector to private sector participation in 1995, international and domestic private sector companies, as well as state-owned enterprises (SOEs), have powered a dramatic expansion in water and wastewater provision, from serving less than 1 percent of the population in 1990 to approximately 40 percent in 2015. These partnerships, which include operation and maintenance (O&M) contracts, Build-Operate-Transfer arrangements, and Joint Venture mechanisms, were initially dominated by multi-national companies. However, the market has become indigenized: local private companies and SOEs now constitute nine of the 10 largest players. PPPs in the water sector have increasingly become attractive due to general trends with increasing tariffs, infrastructure subsidies, and alternative payment methods, including from land development.

In several cases, PPPs have helped to introduce new technologies and practices. Shanghai's Nanxiang Wastewater Treatment Plant, for example, financed in part through a PPP agreement with China Water Environment Group, a private investment company, uses an advanced anaerobic-anoxic-oxic treatment technology to meet discharge standards. The municipal government invited the private sector to improve the management of the plant and test these new approaches. A 2016 Asian Development Bank study surveyed about 300 state-run and PPP utilities in China; the results show that PPPs are significantly

Source: World Bank/DRC 2017f.

more efficient than state-run utilities. PPP-run utilities are more fiscally sustainable, featuring 5 percent to 16 percent higher total factor productivity, a 1 percent lower subsidy rate, and 6 percent lower labor costs. At the same time, PPP-run utilities feature generally better outcome indicators, including larger service areas, lower leakage rates, better bill collection rates, and lower energy consumption. But while such performance indicators are compelling, tariff rates remain generally below cost recovery rates, reducing the attractiveness of PPPs for private sector investors.

Another promising example is a PPP project in Chizhou City (Anhui Province), which aims to model the sponge city pilot program to improve resilience to extreme weather and simultaneously improve the Qingxi River Basin catchment. This very successful PPP is often referred to as the "Chizhou model." The PPP started in 2014, when the Chizhou municipal government signed a cooperation agreement with Shenzhen Water (Group) Co., Ltd., an SEO, for the provision of urban sewage treatment and municipal drainage. The city's financial resources were insufficient to cover the total costs of the project. Therefore, the government decided to split the project into three separate components financed from different sources: sewage and municipal drainage, the restoration of Qingxi River, and sponge city construction measures including public parks and natural recreation areas. These three components together leveraged RMB 2.28 billion, split among contributions from the central government, municipal government, and the private partners.

increased dramatically, driven by the adoption of policy regulations to marketize municipal services through public utilities. However, the PPP investment reached to the regulation stage with the decreasing trend from 2009 to 2013 partly due to the public criticism on the marketization of water supply services. In 2014, the central government announced several regulations which stimulated the development of PPP investment in water sector (figure 2.2). After encountering several regulatory and other hurdles, particularly with respect to foreign investment, the Chinese Government has substantially reformed the overall policy framework for PPPs (Wu, House, and Peri 2016). Nonetheless, this framework requires additional reform considering the prominent role that PPPs are expected to play in future water sector investment.

The 18th Party Congress's Third Plenum reforms, announced in 2013, envision a "Decisive Move to the Market," in which PPPs are expected to play an even more important role in water infrastructure provision and as a source of needed financing. The government has already identified water sector priorities for PPP investment (e.g., dams, urban water supply, and water pollution control). Several important regulations have been promulgated to establish a basic framework for PPPs. These include a set of guiding opinions issued by the State Council in 2014, as well as separate directives issued by the Ministry of Finance and People's Bank of China (World Bank 2017b). The Ministry of Finance also established a National PPP Center to provide policy research, advice, training, and inter-agency coordination. The regulatory framework makes clear that PPPs are expected not only to contribute to a stronger and more diversified revenue base but also to improve coordination between the public, private, and civil society sectors in furtherance of policy goals (see box 2.2) (GoC 2014). In order to fully realize this potential, existing regulations concerning PPPs need to be both codified and strengthened further.

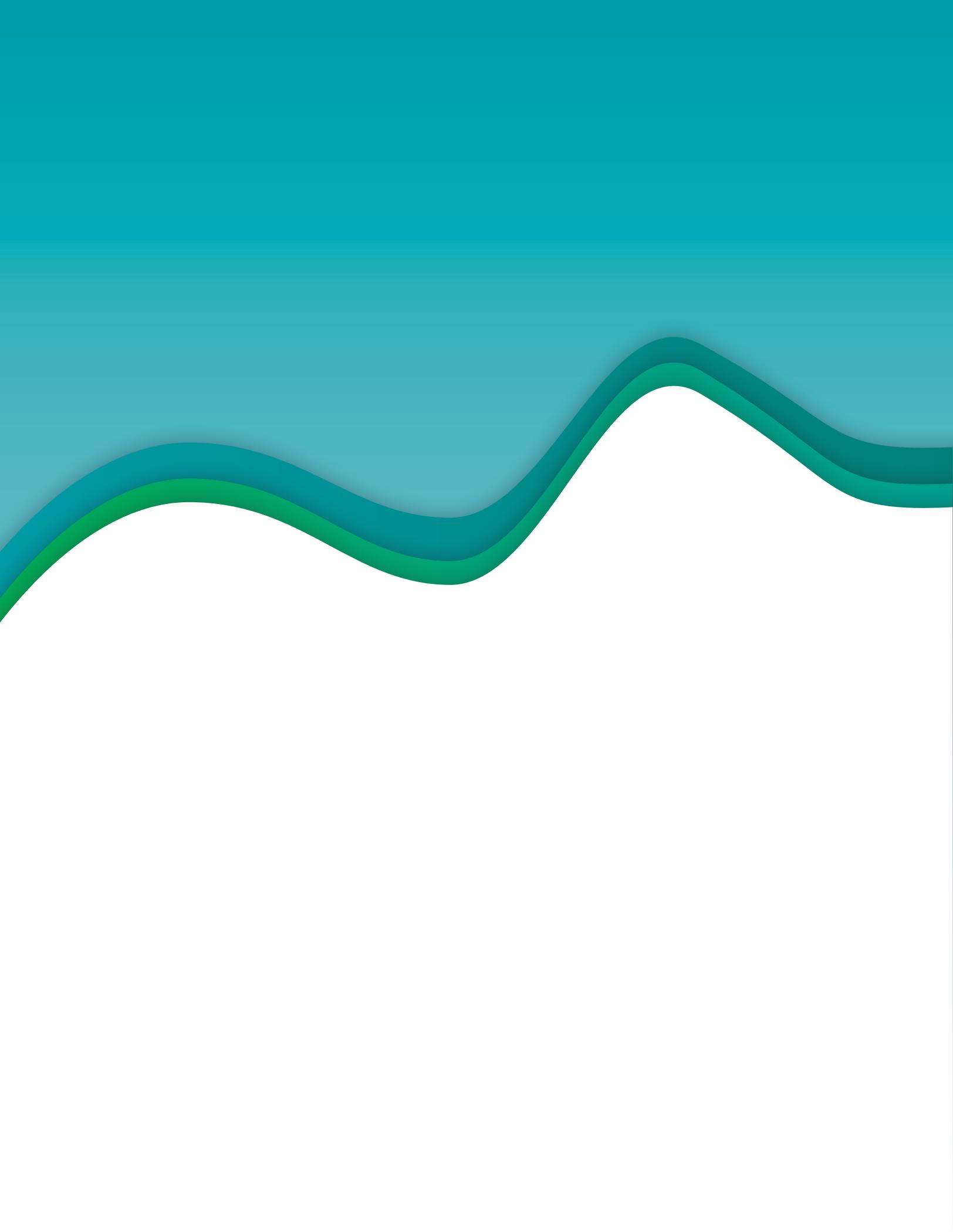
The current regulatory and policy framework for PPPs has several gaps. From a regulatory perspective, no specific methodologies have been developed to support key elements of the PPP preparation process, including economic analysis, financial viability and market assessment, and standardized contracts. Overall, according to the World Bank's PPP Benchmarking

Report (2016), China scores 80 out of 100 possible points on PPP procurement, and 75 on unsolicited proposals, but only 54 on PPP preparation and 58 on PPP contract management, suggesting that additional regulatory reform could help lower barriers to greater private investment at both the preparation and implementation stage. On a practical level, four primary barriers have historically hindered the expansion of PPPs. First, PPP regulations are not entirely consistent, creating significant uncertainty. Second, the slow pace of tariff reform in some sectors reduces the financial viability of some projects. Third, there is a lack of transparency in many PPP bidding processes. Fourth, the dominance of SOEs in PPPs to date risks crowding out local private sector firms as well as foreign participation (ADB 2010).

Codifying the existing regulatory framework, which includes the 2010 State Council guidance and the National Development and Reform Commission's (NDRC)'s 2014 Guidance on the Social Capital Cooperation Model, into a uniform set of regulations would help to fill these gaps. Enhanced provisions, such as inclusion of model dispute resolution systems as proposed by the World Bank International Center for the Settlement of Investment Disputes (ICSID),¹ can further encourage PPP expansion. Existing regulations should also establish common standards for key elements of PPPs, including conditions for asset ownership and transfer, and supervisory and approval mechanisms. These reforms could take the form of either additional revisions to the 2002 Water Law or as inclusion in a separate National Government and Social Capital Cooperation Law currently under formulation.

Note

1. ICSID has an administrative council and a secretariat. Each member country has a seat in the administrative council at the center. The council is not involved in the handling of individual cases, and its main task is to deal with issues such as the institutional framework of ICSID. ICSID has a secretariat consisting of about 70 professionals who are responsible for arbitration and mediation cases. This division of functions not only enhances the fairness and independence of the global dispute settlement mechanism but also ensures the efficiency of arbitration and mediation.



PRIORITY 2

Strengthen National- and Basin-Level Water Governance

A fundamental challenge for water resource management is that many issues, including pollution and allocation, are inherently inter-jurisdictional in nature. These issues are shaped more by the boundaries of watersheds than political and administrative jurisdictions. For this reason, it is not uncommon to find institutions at both the national and river basin scale rather than at the political or administrative scale. For river basin water governance, such institutions can take the form of centralized regional bodies (e.g., the U.S. Tennessee Valley Authority), inter-jurisdictional commissions in which the different states, provinces, and other jurisdictions that share a river basin are represented (e.g., the Mississippi River Commission), or more informal networks of water users from a basin that agree to work together to accomplish specific aims (e.g., Brazilian watershed committees). Roles and responsibilities of these entities may vary. More important than the design of these water governance institutions is what they achieve, namely integrated and cooperative management that accounts for different water uses and sources, including both groundwater and surface water; balances competing objectives, including economic development and environmental protection; and builds consensus on contentious management issues, including the allocation of water (Molle 2009).

While China has embraced the concept of river basin management, a variety of institutional barriers inhibit their effective function. To achieve policy objectives such as the Three Red Lines, better integration across policy areas is needed. Achieving the standards for pollution discharge and environmental water quality, for example, depends in part on erosion control, managing fertilizer use in the agriculture sector, and rangeland management far upstream. Such responsibilities fall outside the scope of any single ministry or jurisdiction. Thus, national and river basin entities need to be strengthened in ways to help ease coordination problems and promote necessary cooperation across agencies. Three specific actions are proposed.

Create a National Coordinating Mechanism for Water Governance

Like that of most countries, China's policy-making apparatus is sufficiently large and complex that implementation can be hindered by a lack of coordination and communication between different elements of its bureaucracy. For decades, China has employed a type of inter-governmental coordination mechanism, the "leading small group" (*lingdao xiaozu*), to spearhead policy reforms. The use of leading small groups has waxed and waned over time, but China's current President Xi Jinping has employed them extensively to

pursue top policy priorities, and has established new groups responsible for cyber security, military reform, and overall economic reform (MERICS 2016). The model of the small leading group is especially relevant for the water sector, which includes a wide range of stakeholders, and inherently requires close coordination between a number of ministries, agencies, and other entities.

China's water governance spans many central government Ministries as well as relevant agencies at provincial and local levels of government (see figure 1.6). Key agencies include the Ministries of Water Resources, Housing and Urban-Rural Development, Agriculture, the National Development and Reform Commission, as well as the Ministry of Ecology and Environment and Ministry of Natural Resources. Each has specific responsibilities that are not always harmonized. Historically, for example, the fragmented responsibility between the Ministry of Water Resources and former Ministry of Environmental Protection has hampered policy responses to water pollution. China's principal water-related legislative instruments, the Water Law and the Water Pollution Prevention and Control Law, do not clarify the division of responsibility between these two ministries, resulting in occasional conflicts of interest, management costs, and decreased management efficiency (MERICS 2016). The reported transfer of many responsibilities for water pollution to the Ministry of Ecology and Environment in March 2018 is expected to partly address this situation. Nonetheless, it is difficult to consolidate all powers and functions related to water resource management within a single ministry, as the experience of other countries suggests.

One response to the cross sectoral challenges associated with water is to establish a high-level inter-governmental coordination mechanism. Such mechanisms typically include representatives of relevant government agencies and departments, and are charged with setting high-level policy related to water resource management. Among countries with such mechanisms, Brazil has established the National Water Resources Council (Conselho Nacional de Recursos Hídricos, or CNRH). This is an apex body that is mandated with coordination among a complex water governance system consisting of river basin commissions, state-level councils, federal agencies, and sub-national entities. The CNRH is chaired by the federal Minister of the Environment and consists of 57 seats, of which 29 represent different federal ministries, 10 are filled by representatives of the State Water Councils, 12 represent water user groups, and six are reserved for civil society.¹ Federal ministries represented include those of Transportation, Health, Agriculture, Livestock and Food Supply, and Cities, as well as special representatives for small-holder farming and women. Water user groups represented include irrigators, utilities, hydropower

generators, and inland navigation transportation companies. Finally, civil society organizations represented on the CNRH include watershed committees, research institutions, and non-governmental organizations (NGOs). Although it has not completely solved the problem of inter-sectoral coordination, the CNRH provides a multi-stakeholder platform that includes most of the relevant stakeholders related to water governance in Brazil. In contrast to Brazil's highly inclusive model, the U.S. established a National Water Resource Council under the 1965 Water Resource Policy Act. This model focuses more on building consensus among senior-level policy makers at the federal government level and comprises cabinet-level officials from the departments of Interior, Agriculture, Army, Commerce, Housing and Urban Development, Transportation, Energy, and the Environmental Protection Council, along with a chairman appointed by the President (42 U.S. Code 1962a).

Any coordination mechanism needs to be developed and implemented within the appropriate country context. China's complex water governance system, with a number of central ministries as well as relevant agencies at provincial and local levels of government, would benefit from enhanced coordination among key central level ministries, such as Water Resources, Ecology and Environment, Housing and Urban-Rural Construction, Agriculture and Rural Affairs, and Natural Resources. While there are several possible modalities for establishing such mechanisms, from advisory to more executive models, any such mechanism should have the necessary stature to convene different stakeholders and the authority to formulate policy recommendations. Such a coordination body would be well positioned to guide the formulation of joint implementation plans and major policy initiatives. Implementation of measures to realize the Three Red Lines are already coordinated by a working group with members drawn from ten related ministries. Such coordination mechanisms can also ensure the coordinated implementation of main, cross cutting pieces of legislation, such as Water Law and the Water Pollution Prevention and Control Law. Regulatory and administrative functions would remain with the individual ministries. Finally, such a body should ideally be supported by technical experts in various aspects of water resource development and management.

Strengthen Basin Level Coordination

One of the longest-standing principles of water resource management has been, so far as is practical, to organize water governance institutions at least partly along the boundaries of river basins rather than political boundaries. This approach has been advocated at least since the 1930s as a solution to

the problem of concurrently addressing issues like pollution, flooding, and navigation, the extent of which is bounded primarily by hydrological rather than jurisdictional units (Barrow 1998). It is not so much the form of the organization that is important but that the functions required for ensuring river basin management are carried out in an integrated manner. In this context, a river basin organization can perform a wide range of functions that are largely dependent on the context and purpose for their creation (see box 3.1).

There are a wide range of possible institutional models for strengthened river basin governance, and these need not possess all possible functions (Lankford and Hepworth 2010). The functions and powers assigned to a river basin organization may include: (1) advisory functions that extend to consultative, coordinating, or policy-making functions; (2) executive functions, which may include carrying out of studies, exploration, investigation and surveys, preparation of feasibility reports, inspection and control, construction, operation, maintenance or financing; (3) regulatory functions, which may include the implementation of the decisions of the administration, as well as law making, in which decisions may take effect directly or after acceptance by a higher authority; or, (4) judicial functions, which may include arbitration, mediation, fact-finding or dispute settlement.

The decision on the organizational form and character creates a framework that determines the manner in which political and economic factors relate to technical issues around water resources. Any water resources organization should consider the form, territorial competence, constitution and duration, objectives and purposes, functions and powers procedures for decision-making, legal status, as well as financial and economic matters along with dispute settlement mechanisms. Subsequent experience and research have shown that while there is often value in creating institutions that encompass whole river basins, they often face practical obstacles in terms of authority, autonomy, resources, and legitimacy.

Many accounts stress the need for such institutions to serve a “convening” function by incorporating diverse stakeholder groups, as well as the need to forge links between river basin management organizations, central and sub-national governments, and smaller-scale organizations at the sub-basin level (Jaspers 2003; Lankford and Hepworth 2010). In general, the consensus among water resource management professionals holds that *“it is considered best practice ... to integrate water quantity and quality management for both groundwater and surface water, while incorporating a full understanding of how the natural resources and the people of a basin are impacted”*

(World Bank 2006, 3). This is at the heart of integrated water resource management.

China established river basin commissions, also called water conservancy commissions, during the 1950s and 1960s for most of its major river basins, as well as for Lake Tai. Legislation has established the river basin as the unit for planning. The primary purpose of these commissions has changed in response to the prevailing needs and context. Over time, the commissions have gained more important water resource management functions. According to the Water Law amended in 2016, the responsibilities of the river basin commissions include water resources management and supervision as stipulated by laws and administrative regulations and the State Council. Despite their name, the river basin commissions do not have official representatives from local governments and other related organizations. Following the institutional reforms, China is also implementing a pilot scheme to establish basin-based agencies for environmental supervision and administrative law enforcement.

The river basin commissions suffer from several limitations. First, they lack authority to supervise or direct provincial or local government officials, and are sometimes ignored by them (World Bank/DRC 2017b). Without direct participation and cooperation of local government bodies, the river basin institutions are

Box 3.1 Functions of a River Basin Organization

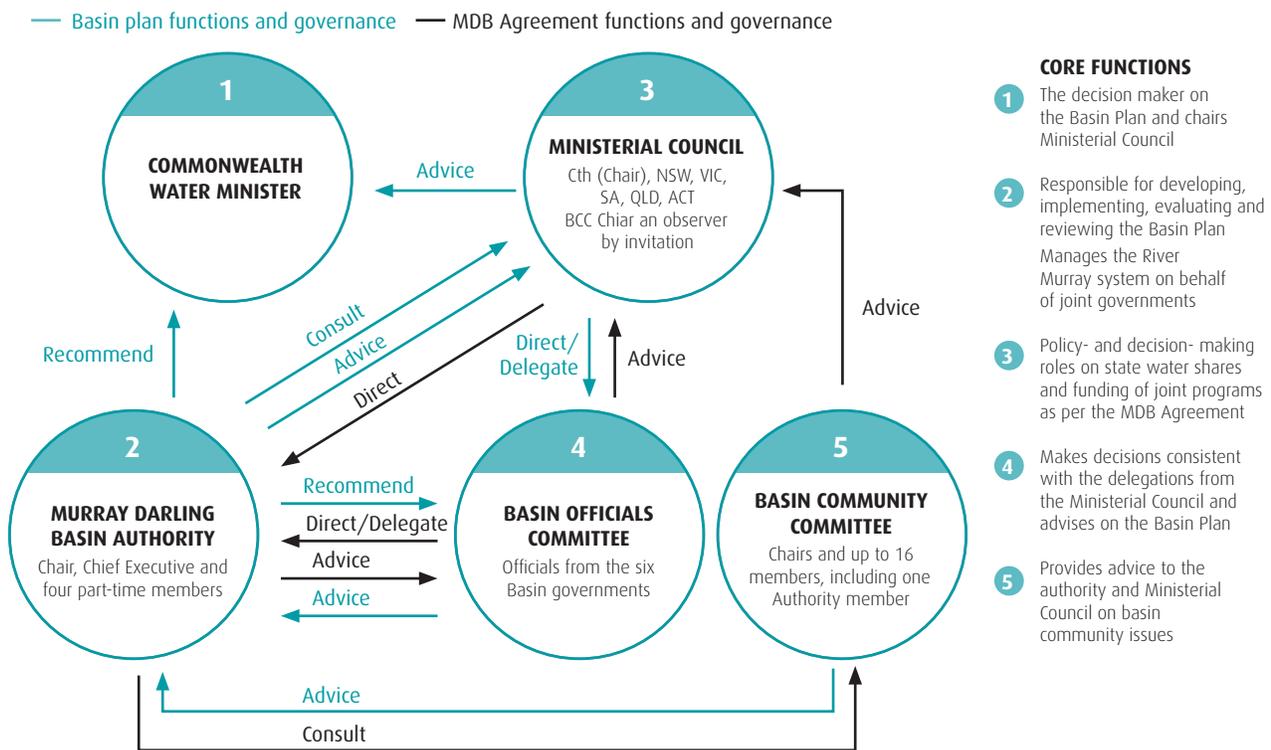
- Acquisition, exchange and monitoring of hydrological, technical and other data
- Advisory and technical (e.g., modeling, environmental, and social assessment)
- Implementation of inter-jurisdictional agreements and arrangements
- Policy coordination, integrated planning, and development of the river basin
- Maintenance, management, and operations of water-related infrastructure
- Water allocation and water rights administration
- Conflict management and mediation
- Mobilize financing resources, levy charges, and collection of fees
- Forecasting, warning, and emergency preparedness
- Convening entity for interjurisdictional water-related issues
- Stakeholder consultation

unable to address inter-jurisdictional and inter-sectoral issues such as water resource allocation and pollution. Second, they have not been given the mandate nor the authority to simultaneously manage water quantity alongside water quality and the environmental and ecological health of the basin. Finally, the commissions lack sufficient authority to arbitrate or resolve disputes among jurisdictions within each river basin (World Bank/DRC 2017b). To address these issues, the river basin commissions should be given enhanced authority and clarity in the key areas of planning, coordination, implementation, enforcement, and financing. This enhanced authority is not intended to diminish or duplicate powers currently exercised by other existing entities, but would rather create the sorts of “cross-scale linkages” necessary to effectively govern resources that are shared between users in multiple political jurisdictions.² For China, it is especially critical to establish stronger cooperation between the river

basin commissions and local governments, especially at the provincial level. Moreover, the re-organized river basin commissions should have sufficient budgetary resources to match their increased administrative responsibilities.

International models (e.g., in France, the United States, Spain, Australia, South Africa, Brazil, and the European Union [EU]) can provide useful guidance on how China’s existing river basin commissions might be reformed or reorganized along these lines. A key element of most river basin management institutions is that they feature mandated representation from multiple sectors, and often leaders from different jurisdictions within a river basin (Jaspers 2003). For example, the Brazil Water Law (1997) prescribes the river basin as the territorial unit for management, and that river basin committees comprise representatives of the union, states, and federal government; municipalities; water users; and civil entities located in the basin.

Figure 3.1 Governance of the Murray-Darling Basin Authority, Australia



Source: Murray-Darling Basin Authority.

Note: MDB = Murray-Darling Basin Authority; Cth = Commonwealth Government; NSW = New South Wales; VIC = Victoria; QLD = Queensland; ACT = Australian Capital Territory; BCC = Basin Consultative Committee.

Thus, it is legislatively clear that participation is extended widely both horizontally (i.e., sector) and vertically (i.e., administrative). Similarly, the Murray-Darling Basin Authority is responsible for developing and overseeing basin-wide sustainable water resource planning, while a preexisting multi-jurisdictional ministerial council continues to guide policy and decision making relating to long-standing inter-state sharing arrangements and joint funding programs (see figure 3.1).³ These governance arrangements for different functions are given in the Federal Water Act (2007). While complex, these provisions provide full clarity of roles and responsibilities of different levels of government and different institutions across the spectrum of water planning, management, and operations. Where several political jurisdictions share a river basin, a representational governance model can provide a platform for consensus building (World Bank/DRC 2017b). This model differs from the current setup of China's river basin commissions in that China's institutions do not explicitly represent different provinces and local governments; instead, all members of the commission are at least nominally affiliated with China's central government. This arrangement tends to result in the interests of individual provinces receiving more attention than the broader basin (World Bank/DRC 2017b).

Some legislation is explicit in mandating water quantity and quality be handled jointly. For example, the EU Water Framework Directive (WFD), and the EU Directive 2000/60/EC of the European Parliament and of the Council (23 October 2000) identifies the river basin district as the main unit for management of river basins.⁴ The rationale for choosing this level is stated in the preamble *"The objective of achieving good water status should be pursued for each river basin, so that measures in respect of surface water and ground waters belonging to the same ecological, hydrological and hydrogeological system are coordinated."* Though the WFD does not prescribe the creation of new authorities, entities, or commissions on the river basin level, it does require all member states to produce a river basin management plan for each river basin district lying within their territory. These plans lay out how the objectives set for the river basin (ecological status, quantitative status, chemical status, and protected area objectives) are to be reached.⁵ Finally, the WFD states: *"for the purposes of environmental protection there is a need for a greater integration of qualitative and quantitative aspects of both surface waters and ground waters."* Thus, both the water quantity and water quality perspectives are expected to be considered in the planning process.

These examples illustrate that it is essential that river basin commissions have clear responsibility for integrated management of water quantity, water quality,

and environmental health. This includes clear responsibility for taking the lead in developing master plans for the basin (which will take both a quantity and quality perspective), implementing the plan, and monitoring implementation progress. This monitoring should also include environmental and ecological monitoring. Thus, it is important under a newly re-organized commission that the participation, roles, and responsibilities of relevant ministries, local governments, and local stakeholders are clear. This is especially relevant with the establishment of the Ministry of Ecology and Environment and the Ministry of Natural Resources. These commissions will under any institutional scenario serve as important forums to improve policy coordination and cooperative action both horizontally and vertically to achieve common basin objectives and targets.

Finally, given the size of some of the basins in China, the commissions should themselves establish sub-basin level councils, committees, or other decision-making structures as needed to ensure that water resource management policies are implemented at the lowest levels. The Upper Mississippi River Basin Association (UMRBA) provides an example of a sub-basin entity (sitting in the larger Mississippi River Commission) designed to provide greater local level participation. This was formed in 1981 to facilitate dialogue and cooperative action regarding water and related land resource issues specific to the upper portions of the Mississippi River Basin. It serves as a regional forum for the cooperative planning and management of river-related issues of common concern to the states of the Upper Mississippi River Basin. The Association also provides a forum to develop regional positions on river resource issues and serve as an advocate of the basin states' collective interests before federal agencies. Over the years, the Association has addressed a wide range of issues including: nonpoint source (NPS) pollution, water quality planning and management, inter-basin diversions, cost-sharing strategies, water project financing, sediment and erosion, hazardous spills, toxic pollution, habitat restoration, navigation capacity, channel maintenance, flood response and recovery, floodplain management, wetland protection, hydropower development and licensing, and drought planning.

Several approaches could be taken with respect to strengthening and establishing river basin commissions. Each of these options has advantages and disadvantages. Given the large size of China's river basins, different institutional models may be more appropriate in some basins than others, and different models could be tested through pilot reforms instituted in one or more river basins before being refined and replicated nationwide. At the same time, it is important that the commissions be fully integrated into water policy making at the national level. The reformed

river basin commissions should also enjoy a formal relationship to the national coordinating mechanism. Ideally, this relationship should be structured such that the coordinating mechanism provides strategic direction in the form of policy guidance that informs the operation of the commissions. One approach could be to establish sub-committees for specific issues such as flood control, pollution, and allocation under the coordinating mechanism that would comprise representatives of relevant ministries and agencies charged with developing policy guidelines on these specific issues. Unlike the national coordinating mechanism, these sub-committees could meet on a regular basis, seeking guidance from the national body as needed. This approach would encourage the commissions to function in a more inter-agency manner, and allow them to better arbitrate and navigate inter-agency or inter-jurisdictional issues. Codification of these reforms could take the form either of additional revisions to the 2002 Water Law, as proposed previously, or a separate National River Basin Management Law.

Establish Clear Coordination between the Provincial River and Lake Chief System and River Basin Commissions

In addition to creating river basin commissions, China has also adopted a unique solution to the inherent nature of water as a boundary-spanning resource. In December 2016, the Chinese government created a system of River and Lake Chiefs (*hezhang*) for the country's major waterways, one that was later extended to include major lakes and other water bodies. This system names a single person, typically a senior official at local, county, and provincial levels, to be responsible for each stretch or section of every major lake and waterway within their respective jurisdiction. The primary purpose of the River and Lake Chief System is intended to strengthen enforcement and accountability concerning key water policy measures including water use control, water quality protection, and restoration of degraded waterways (see box 3.2).⁶ It is also intended to address the fact that in some cases, local officials lack the incentives to tackle fundamentally inter-jurisdictional issues such as pollution and ecosystem protection.² These officials are responsible for meeting environmental protection and water quality targets in their respective jurisdictions, even if they are subsequently rotated to another jurisdiction. River and lake chiefs at the provincial level are responsible for ensuring that water policies, especially those related to water quality, are properly implemented within their individual jurisdictions (Xu 2017). The river and lake chief system effectively makes the leaders of each province, city,

Box 3.2 The Wuxi River Chief System

Wuxi City, located on Lake Tai in populous, rapidly developing Jiangsu Province, has long struggled to control water pollution. In cooperation with the central and provincial governments, Wuxi was one of the first local governments to establish a river chief system. In 2007, the city introduced water quality metrics into the evaluation system of local officials, ensuring that the issue would be taken seriously by local leaders. The effort was widely judged to be a success, with the percentage of tested water quality reaching acceptable standards increasing from less than 25 percent before the reform to almost 75 percent by the end of 2008. Subsequently, the municipal chief of the Chinese Communist Party has taken the position of river chief, indicating the municipal leadership's commitment to addressing the issue.

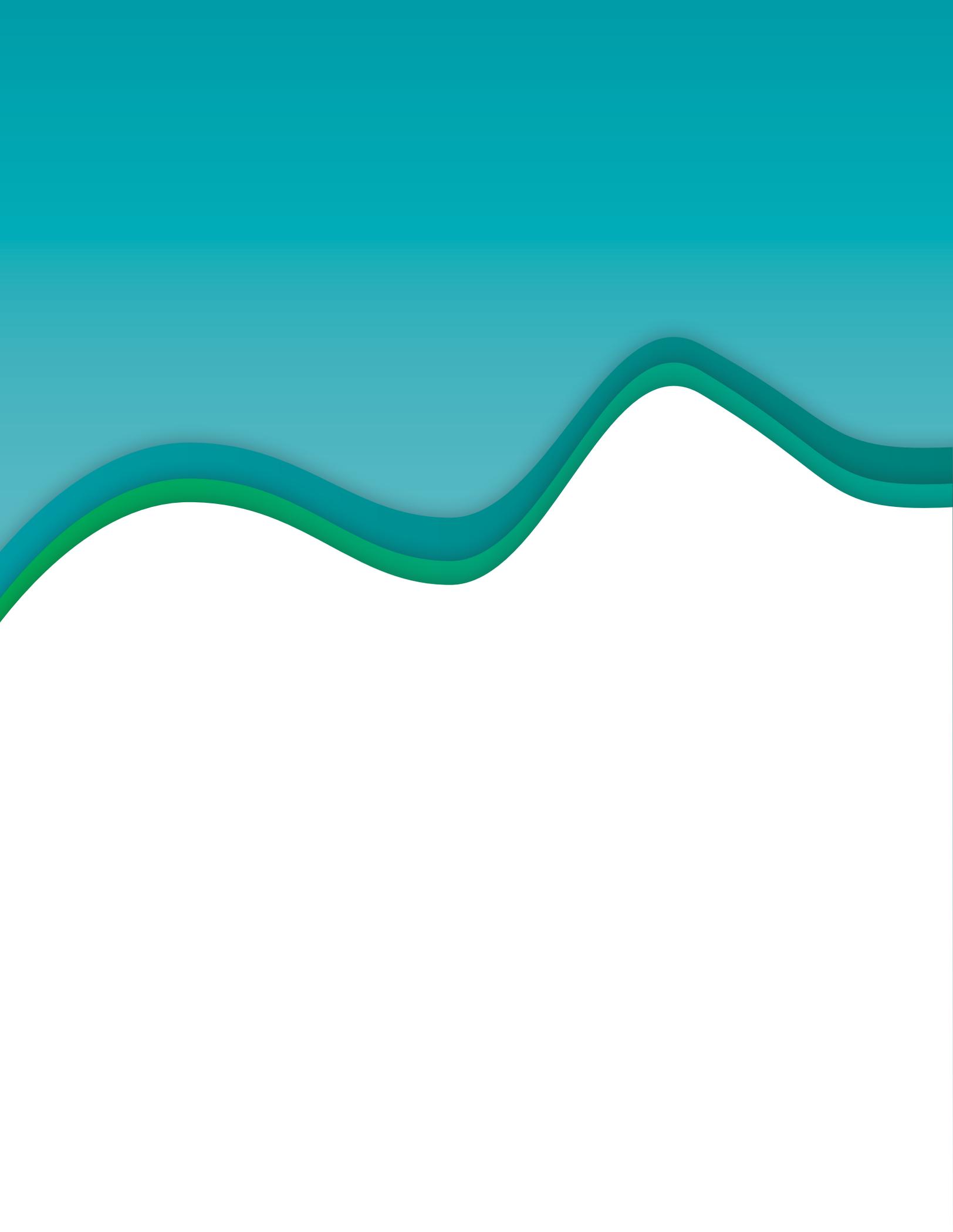
county, and township responsible for core water management functions. The creation of these positions reflects the fact that these policy priorities were in the past often hindered by inter-governmental coordination problems. The river and lake chiefs are expected to ensure that officials of various departments under their control work together to achieve key water policy objectives. Despite the wide range of tasks assigned to river and lake chiefs, it is clear that water quality is a special area of emphasis. A revision of the 2008 Water Pollution Prevention and Control Law, completed in January 2018, codifies the responsibility of river and lake chiefs to supervise water quality, enforce pollution regulations, and oversee ecological restoration efforts (China Water Risk 2017b).

The river and lake chief system therefore represents a distinctive response to the unique challenges that China faces in water resource management. At present it is too early to determine how effective the river and lake chiefs will be in carrying out their duties and the monitoring system to measure their performance. The central Government has proposed a range of mechanisms to do so, such as conducting an environmental performance audit before officials are rotated to posts in other jurisdictions, and establishing a lifetime accountability mechanism for environmental damage that occurs because of decisions made during an officials' tenure (World Bank/DRC 2017b). The relationship that the River and Lake Chief System has with China's existing river basin commissions is also yet to be determined. One option could be to include provincial River and Lake Chief members in the river basin commissions that include their jurisdictions. Alternatively, liaisons could be appointed between

each provincial River and Lake Chief and relevant river basin commissions that would ensure communication and coordination between the two bodies. The use of this model may also be expanded to include “head” river and lake chiefs for specific large river basins (e.g., the Yellow and Yangtze rivers) or river and lake chiefs at various administrative levels (e.g., central, provincial, city, county, and township). A further mechanism could include creation of data- and information-sharing platforms accessible to both river basin commissions and river and lake chiefs, replicating a successful such mechanism established for Lake Tai (Huanbaobu 2009). Regardless of the specific approach employed, it is essential that a clear channel of communication and coordination be established between the new river and lake chiefs and the existing river basin commissions.

Notes

1. See the CNRH website, “Composicao CNRH” [Composition of the CNRH], accessed October 28, 2018, http://www.cnrh.gov.br/index.php?option=com_content&view=article&id=99:composicao-cnrh&catid=1:0-conselho-nacional-de-recursos-hidricos-cnrh.
2. This concept arises from collective action theory. See, for example, Adger, Brown, and Tompkins (2005) and Heikkila, Schlager, and Davis (2011).
3. See the Murray-Darling Basin Authority’s website, accessed July 19, 2017, <https://www.mdba.gov.au/about-us/governance/authority>.
4. The WFD defines river basin as “the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta” (definition 13); and subbasin means “the area of land from which all surface run-off flows through a series of streams, rivers and, possibly, lakes to a particular point in a water course (normally a lake or a river confluence)” (definition 14). River basin district means “the area of land and sea, made up of one or more neighboring river basins together with their associated ground waters and coastal waters, which is identified under Article 3(1) as the main unit for management of river basins” (definition 15).
5. See the EC website “Introduction to the EU Water Framework Directive,” accessed on July 3, 2017, http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm.
6. The Wuxi example is described in Huanbaobu [Ministry of Environmental Protection], “Wuxi: faqi ‘Hezhangzhi’ qianghua hedao zhengzhi.” See the Ministry of Environmental Protection’s website, accessed on May 26, 2009, http://www.mep.gov.cn/home/ztbd/rdzl/hzhzh/gdsj/200905/t20090526_152010.shtml.
7. See the Ministry of Environmental Protection’s website, accessed on May 26, 2009, http://www.mep.gov.cn/home/ztbd/rdzl/hzhzh/gdsj/200905/t20090526_152010.shtml.



PRIORITY 3

Improve and Optimize Economic Policy Instruments

China's ambitious policy reform agenda has created multiple (and at times overlapping) sets of policy tools, especially economic mechanisms, whose use and application need to be better coordinated for maximum effect. Different prices, taxes, and fees are levied on water users to encourage conservation, capture externalities, and move closer toward cost recovery. Some policies currently being piloted (e.g., tiered pricing and water rights trading) can be expanded and represent global models. Further empirical research is needed to assess the effectiveness of these instruments to optimize their impact. These successful economic mechanisms can be better leveraged to advance national goals like those captured in the Three Red Lines.

Expand Use of Economic Policy Instruments to Promote Sustainable Water Use

Of the possible tools to promote sustainable water use, perhaps none is as important as water pricing and other economic policy instruments. The crucial role that water pricing plays in water resource management was recognized by the High Level Panel on Water (HLPW), whose 2018 final report notes that *"valuing water appropriately is a cornerstone for better water management"* and that *"appropriate pricing of water, or water*

services is a critically important way of recognizing part of the value of water" (HLPW 2018). The power of pricing arises from its ability to send a clear signal to water users about the scarcity value of the resource, and the importance of conserving it (Shore 2015). Proper water pricing can also help to re-allocate water from lower- to higher-value uses, such as from irrigation to industry, and be an important source of revenue for cost recovery (for both infrastructure capital costs and operation and maintenance). Globally, however, water prices remain generally too low to achieve these objectives. In 2017, a group of water executives concluded, for example, that water tariff rates in the United States would have to double to finance infrastructure upgrades and encourage conservation (GWI 2017).

China has enjoyed considerable success in leveraging economic policy instruments to pursue various water policy objectives. The Third Plenum decision on deepening the "move to the market," announced in 2013, envisions a much greater role for the use of market-based policy instruments (Moore 2013). China has piloted water pricing reforms to promote conservation and piloted water rights trading to facilitate the re-allocation of water to its highest-value uses (Moore 2015). These reforms are broadly on the right track, but require further analysis of their effectiveness before being expanded. This includes detailed empirical

analysis on whether current pricing structures and policies are having their intended effects (e.g., reducing water use, curbing groundwater over-extraction, and moving closer to cost recovery and financial sustainability).

The price water users pay for drinking water service should consider the scarcity and cost of various conventional and non-conventional water sources in an attempt to promote efficiency and conservation in line with the vision of a “water-saving society”. In addition to pricing, various taxes and fees are used to both encourage water conservation and finance water infrastructure. In general, water resource fees (*shuiziyuanfei*) are levied to cover capital, operation and maintenance costs associated with bulk water supply and delivery infrastructure. Water resource taxes (*shuiziyuanshui*), on the other hand, are intended to capture environmental externalities associated with particular water uses, and are often levied on groundwater withdrawals. Wastewater treatment fees (*wushuichulifei*) support capital, operation and maintenance costs associated with wastewater treatment plants. These taxes and fees are often collected by different governmental entities, creating a complex and confusing system that does little to promote sustainable water use. They are also generally below plausible estimates of the true scarcity value of water. For example, while the water resource fee in 2015 ranged from RMB 0.1 to 0.6 per

Box 4.1 Estimating Price Elasticity of Demand for Water in China

As in the case of many countries, there is relatively little research to support definitive estimates of price elasticities in China, especially in the agricultural sector, which accounts for most water consumption. Moreover, the estimates that do exist vary widely. For industry, Wang and Lall (2002) suggest an overall price elasticity of -1.0, while Zhou and Tol (2005) suggest -0.2 to -0.35, and Jia and Zhang (2004) provide an estimate of -0.5. Estimates for domestic water use, meanwhile, range from -0.35 to -0.55. Estimates of price elasticities for agricultural water use are generally considerably lower. Wang et al. (2000) suggest -0.35 to -.041, while Cai and Rosegrant (2004) estimate -0.11.

These crude elasticity estimates carry two implications for China’s water pricing reforms. First, they suggest that price increases will have to be, in general, very high to induce changes in behavior and reductions in water use, especially in the agricultural sector. Second, these estimates suggest that there is scope to increase water prices for domestic, industrial, and agricultural water users to move closer toward full cost recovery for O&M of water service provision.

cubic meter for surface water and RMB 0.2 to 3.0 per cubic meter for groundwater in major coal-producing regions, the estimated shadow price of water ranged from RMB 11 to 81 per cubic meter (Thieriot and Tan 2016).

Some localities in China have made good progress in reforming water prices to promote sustainable water use. Beijing, for example, (table 4.1) has instituted a tiered pricing structure that charges users a progressively higher price, with the aim of encouraging water conservation. At the same time, different prices are established for different water uses, including special uses like golf courses. This structure can help to direct water use to its highest-value uses. Urban and rural water users are charged at different rates, helping to ease the financial burden on poorer farmers and rural residents. In recent years, some cities have introduced preferential pricing for reclaimed water to encourage its use. As of 2010, 37 cities and counties in 18 provinces have introduced a preferential price for reclaimed water (World Bank/DRC 2017h). Special consideration must also be given to how these tiered rates are structured to maximize conservation impact. A recent study of the use of increasing block rate structures (comparing 28 cities with increasing block rate structures and 110 cities without) from 2002–09 demonstrates reductions of annual residential water demand around 3 percent to 4 percent in the short run and 5 percent in the longer run (Zhang, Fang, and Baerenklau 2017). These are modest impacts suggesting room for improvement in the pricing structure and the need to determine the price elasticity (see box 4.1) (Wang, Huang, and Rozelle 2000; Wang and Lall 2002; and Webber et al. 2008).

Table 4.1 Water Pricing Rates and Structure in Beijing municipality, 2017

Pricing category	Prices (RMB per m ³)
Residential	Tier 1: 5.0 Tier 2: 7.0 Tier 3: 9.0
Administrative / state-owned	Urban: 9.5 Rural: 9
Industrial	Urban: 9.5 Rural: 9
Service	Urban: 9.5 Rural: 9
Special Use	160

Source: Beijing Government-Services (<http://www.beijing.gov.cn/bmfw/jmsh/jmshshjf/shjfs/sj/t1492197.html>)

Note: Many jurisdictions establish a range for each use; for simplicity the table lists the maximum rate for each user type and water source category.

Pricing signals could be made clearer to further encourage conservation. For example, by clearly indicating on each water user’s bill the breakdown across services (e.g., supply, sewerage, and resource abstraction), water providers can send a stronger signal to users about the importance of conservation (Xie et al. 2008). In the United States, for example, some water utilities provide each customer with a clear breakdown of usage within each pricing tier, along with a comparison of how much a customer pays relative to a “highly efficient” water user (World Bank/DRC 2017k). Highly water-stressed jurisdictions in China, especially in the northwest, could consider adding additional special use categories, such as for power plant cooling, to encourage the adoption of water-saving technologies (Tan 2017).

The differences in fee and tax structures across users and jurisdictions is demonstrated in Table 4.2. However, also of note is the fact that the water resource tax is not progressive, but is based on fixed volumes instead of a marginal pricing basis. Such an approach does not provide as strong a signal as marginal cost pricing to water users to reduce groundwater use in favor of alternatives, and therefore may not fully capture the environmental externalities associated with excessive groundwater abstraction (World Bank/DRC 2017h). Jurisdictions seeking to shift water use away from groundwater should therefore consider marginal cost pricing.

In 2016, China launched a pilot scheme in Hebei Province to replace water resource fees with a single water resource tax based on the quantity of water

used, and with a higher rate for groundwater to discourage over-use of the province’s already depleted aquifers. Surface water resource taxes have been set at RMB 0.4 per cubic meter, while groundwater resource taxes are much higher at RMB 1.5 per cubic meter (World Bank/DRC 2017h). It remains to be seen if this approach will curb excessive groundwater abstractions. A single tax is easier to administer and for water users to understand and pay. Simplifying water resource taxes can be an important tool for water scarce regions to encourage conservation and support ecological functions. Tax reforms can also help to address water quality issues. While Hebei’s approach focuses on water quantity, in October 2017 the government announced that beginning in 2018, a tax of RMB 1.4 to 14 per unit volume of pollutant would be levied on water pollutants nationwide, rather than leaving such rates to the discretion of local authorities (Zhang 2017b). Such reforms, which aim to better capture the externalities associated with unsustainable water use and water pollution, should be both continued and enhanced.

Cost recovery is an especially important objective for the irrigation sector given the high cost of service delivery. The 2002 Water Law attempts to codify the principle of cost recovery for major water projects, stipulating that water supply providers should directly receive water fees collected by local governments and administrative units (World Bank/DRC 2017h). However, most agricultural water prices remain far below cost recovery levels, and are far too low to promote sustainable water use. According to a 2010 survey of 414 large-scale irrigation districts, the cost of agricultural water

Table 4.2 Water Tax and Fee Rates and Structure

RMB per m³

Water Use	Water Resource Tax - Beijing (2017)	Wastewater Treatment Fee - Beijing (2017)
Residential	1.57	1.36
Administrative / Governmental	n.a.	3.0
Industrial	Urban Surface Water: 2.3 Urban Groundwater: 4.3 Rural Surface Water: 1.8 Rural Groundwater: 3.8	3.0
Service	Urban Surface Water: 2.3 Urban Groundwater: 4.3 Rural Surface Water: 1.8 Rural Groundwater: 3.8	3.0
Special Use	153.0	3.0

Source: Beijing Government-Services (<http://www.beijing.gov.cn/bmfw/jmsh/jmshshjf/shjfs/sj/t1492197.html>)

Note: n.a. = not applicable.

supply was up to RMB 1.18 per cubic meter, but the maximum water price was RMB 0.35 per cubic meter, with prices in 90 percent of surveyed districts being even lower. Nationally, average agricultural bulk water supply prices are only RMB 0.0611 per cubic meter (World Bank/DRC 2017h). Further indication of this gap is provided in table 4.3, which displays agricultural water price data from several irrigation districts in the Tarim River Basin in Xinjiang, which has been the site of a long-running agricultural water price reform effort. This effort involves a three-phase price reform beginning in 2016, and for some districts extending to 2020. Nonetheless, in only a few cases do prices approach cost recovery levels. For arid and semi-arid Xinjiang in particular, such prices are moreover far too low to reflect the scarcity value of water (World Bank/DRC 2017h). The situation is similar in Ningxia, where despite an effort to charge farmers a higher rate for above quota water use, prices remain far below scarcity pricing levels (World Bank/DRC 2017h). Continued efforts toward full cost recovery are therefore needed.

In summary, deepening reform of economic policy instruments is critical for China to achieve its water policy goals. Existing attempts to modify water pricing structures and generally increase water prices also present an opportunity to better capture externalities associated with unsustainable water uses such as the over-abstraction of groundwater. It also provides an opportunity to move closer to full cost recovery for some water infrastructure, helping ensure the fiscal sustainability of China's water sector. However, adopting these reforms will also require institutional reform. Various water pricing mechanisms, such as taxes and fees, have in the past been employed by separate bureaucratic entities, and often represented an important revenue stream. Deepening reform will

require careful coordination between central and local governments to ensure that pricing mechanisms are fully leveraged to achieve such objectives as the Three Red Lines. Finally, though water pricing reforms are broadly on track, further analysis of their effectiveness is needed. This includes detailed empirical analysis on whether current pricing structures and policies are having their intended effects (e.g., reducing water use, curbing groundwater over-extraction, and moving closer to cost recovery and financial sustainability).

Strengthen the Effectiveness of the Three Red Lines

The most important element of China's current water governance system is the Most Stringent System for Water Resource Management, otherwise known as the Three Red Lines. The core of this system consists of targets that limit total national water use, specify minimum standards for water use efficiency, and establish clear limits on pollutant loads. The experience thus far has been largely positive with demonstrable results. Under China's hierarchical water management system, these targets are broken down by province and local jurisdictions according to a detailed, formulaic process. The target setting process relies on a comprehensive monitoring and evaluation system established in 2014 that measures progress on several key indicators: total water quantity use, industrial water productivity, agricultural water use efficiency, and water quality. In 2016, two additional indicators were added: domestic water use productivity and total pollutant loads (World Bank/DRC 2017g).

Detailed procedures have been developed to guide target setting for each major element of the Three Red Lines. For each jurisdiction, factors to be considered

Table 4.3 Irrigation Water Price Reforms in Xinjiang

RMB per m³

Region / Irrigation District	Water Supply Cost (2010)	Phase 1 Water Price Reform (2016)	Phase 2 Water Price Reform (2018)
Kaidouhe	0.0405	0.0324	0.0405
Sundonghe	0.0932	0.0746	0.0932
Akedonghe 1	0.0168	0.0118	0.0143
Akedonghe 2	0.0168	0.0084	n.a.
Akedonghe 3	0.0168	0.005	n.a.
Akedonghe 4	0.0168	0.0118	0.0143
Akedonghe 5	0.0328	0.023	0.0279
Kashgar	0.0149	0.0131	0.0153
Hetian	0.0076	0.0053	0.0065

Source: World Bank/DRC 2017h.

Note: n.a. = not applicable.

include local water resource conditions, planned construction and infrastructure projects, national economic and social development plans, and local development plans. Water use is to be controlled through the existing withdrawal permit system and economic instruments (e.g., prices, fees, and taxes) to encourage water conservation. Water efficiency target setting is conducted at the enterprise or production unit level. A water use quota based on the total water quantity usage limit is assigned to each production unit, which is then used as the basis for setting efficiency targets. Water use efficiency targets are meant to be implemented chiefly through a reward and punishment system that provides either recognition or financial penalties for production units depending on their adherence with the policy. Water pollution targets are set on a zone basis, meaning that they specify total pollutant loads for different waterways or water bodies, depending on whether they are zoned for source water protection, environmental protection, industrial, or other water uses. Implementation is conducted through expansion of sewage and effluent treatment, strict control of pollution discharge permits, and the imposition of differentiated fees depending on pollutant type (World Bank/DRC 2017g).

Four reforms would help to further enhance the Three Red Lines. First, the Three Red Lines water quantity control targets could also be based on actual consumption. The current targets are based on water withdrawals with the implicit assumption that reductions in withdrawals lead to “saved” water. However, in the agriculture sector, this water is not totally lost, nor are the savings real. This is because water may return to the system through run-off or recharge into the groundwater to be used elsewhere in the system. Thus, to achieve genuine savings, measures should be taken to reduce non-beneficial evapotranspiration.¹ The Three Red Lines target can be strengthened by including actual water *consumption* (evapotranspiration) amounts (and not simply withdrawal volumes) in water quantity permitting and control targets. This consumption-based control can be aided by advances in technologies such as satellite remote sensing. China already has experience with designing evapotranspiration-based water rights administration systems as part of the Xinjiang Turpan Conservation Project, which could be expanded to other regions of the country (see box 4.2) (World Bank 2013b).

Despite the consolidation of responsibility for water quality within the Ministry of Ecology and Environment, achieving targets related to pollution is likely to require cooperation between multiple agencies and sub-national governments. Target setting in the future should accordingly be formulated jointly. This is important also in setting shared responsibility toward these goals.

Broadly speaking, wider participation of stakeholders during the target setting process can ensure better integration of the physical and administrative. Third, the use of water intensity (cubic meter per RMB 10,000) metrics for the industry targets ensures that the most value is to be generated from the water usage. Similar metrics on water productivity could be applied to the irrigation sector. This would signal in the long run that water should be allocated to those crops that generate the most value for the country. Moreover, actual field-based irrigation efficiency measurements should be taken and more scientifically based approaches to determining efficiency be pursued.

Finally, once the water use targets are set at lower administrative levels, there is little flexibility for adjustments. Such flexibility, however, is needed because water availability and demands are constantly changing in space and time. One option is to consider these caps on withdrawal in the context of water rights trading. That is, local level targets can serve as established caps for which the holder can then be empowered to buy and sell with other local entities. There may be places for instance in which the effort and cost to reach compliance with these targets are more difficult than others. Thus, by allowing such trades, the cost of compliance to reaching the overall national level targets can be minimized. Such an approach would also help to better leverage China’s existing pilot efforts to institute water rights trading systems at the national scale.

China has experimented with water rights trading programs since the early 2000s (Moore 2015). In 2003, Ningxia and Inner Mongolia established the first compensated inter-provincial water transfer pilot project, which created a mechanism for irrigation districts to invest in water conservation and then sell the “saved” water to industrial enterprises. As of 2012, the pilot project had completed 39 such transfers. A further important step was taken in 2007, when Ningxia mandated that all new industrial enterprises purchase water rights from existing rights holders, thereby effectively capping localized water use. In 2014, the Ministry of Water Resources established seven provincial water rights pilot projects. These pilot projects attempted to tackle each of the three principle elements of water rights trading establishment, namely cap setting, water rights allocation, and water rights trading, and aimed to create the foundation for province-wide water rights trading. Progress has been slower than initially anticipated (World Bank/DRC 2017i). Further research is needed on the outcomes of these pilots. To date, of the seven provinces only Ningxia, Gansu, Jiangxi, and Hubei have begun verifying water rights allocations. In a few regions, this process has enabled relatively large-scale trades to take place. In Jiangxi, for example, a 25-year contract was concluded to transfer 62.05 million cubic

meters from Shankouyan Reservoir to Anyuan District and the Pingxiang economic and technological development zone at a total cost of RMB 2.55 million per year. In other provinces, such as Jiangsu, basin-level cap setting remains ongoing (World Bank/DRC 2017h).

A defining feature of these experiments with water rights trading has been the dominance of inter-jurisdictional trades rather than transfers between sectors

or individual water users. The China Water Exchange, a state-owned company founded in 2016, represents a promising innovation to expand water rights trading below the jurisdictional level. China Water Exchange was established with an initial investment of RMB 600 million with 12 investors and sponsors, including enterprises owned by the Ministry of Water Resources, China's seven river basin authorities, and the Beijing Municipal Government. This unique ownership structure

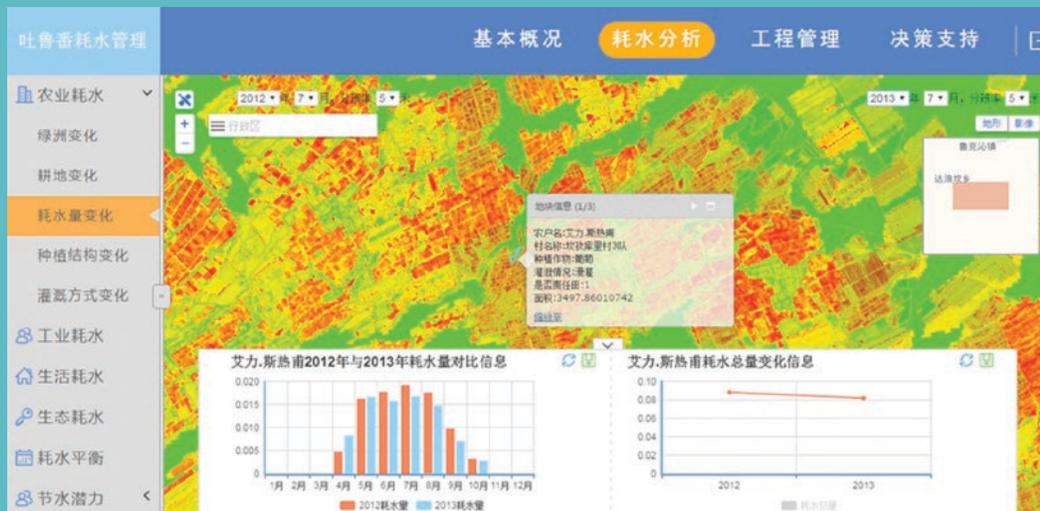
Box 4.2 Evapotranspiration-Based Water Allocation in China's Turpan Basin

The Turpan Basin, in Xinjiang Uygur Autonomous Region, is the hottest and driest area in China. With rapid economic growth in recent years, consumption of water is exceeding supply and has led to severe groundwater over-exploitation, threatening the livelihoods of many of the basin's farmers. In Turpan, as in many parts of China, farmers are given a specific quota for water withdrawals, creating an incentive to "use it or lose it," and driving increases in total water consumption throughout the basin.

To help remove this perverse incentive and promote more sustainable water use, the World Bank-financed Xinjiang Turpan Water Conservation Project created a new system to monitor and enforce restrictions on water use using satellite-based evapotranspiration measurements. Evapotranspiration measures how much water crops are consuming. More conventional measurements are based on water withdrawals from wells or canals, but do not accurately account for water that seeps back into the soil or evaporates.

In general terms, the evapotranspiration-based water rights administration system for the Turpan Prefecture consists of five key elements to help control total water use. First, evapotranspiration measurements throughout the basin are compiled to give an accurate measurement of the total water balance in the area, and the amount of water that can be sustainably consumed by crops. Second, each of the three counties that make up the Turpan Basin are given a total water consumption target based on the overall basin total. Third, these targets are disaggregated to individual farmers. Fourth, satellite-based evapotranspiration measurements are used to verify each farmer's compliance with water consumption caps, based on measurements of field-level crop water consumption. Fifth, these measurements are verified through periodic household and field surveys. Together, these elements provide a durable framework to control total water consumption throughout the Turpan Basin (World Bank 2013b).

Map B4.2.1 Sample Monitoring Platform for ET-Based Water Consumption Measurement in the Turpan Basin



Source: World Bank 2013b.

helps to give the exchange unusual national reach, and promises to help avoid some of the inter-governmental conflicts that have occasionally hindered other water resource management institutions. The China Water Exchange is intended to promote water rights transfers by identifying potential trades, serving as a resource for entities interested in engaging in transfers, and helping broker transfers between water users. Its organizational structure resembles that of a limited liability corporation, including a shareholders' conference, board of directors, and four divisions, including trading operations, development and information, and risk management.

In its one year of operation, the company has developed standards to promote water rights trading in the form of guidelines covering fees, trading protocols, awareness raising, and risk management. The exchange has also enjoyed initial success in brokering 10 water trades as of March 2017. Some of these

trades have been conducted jointly with provincial-level exchanges, most notably in Inner Mongolia. These trades, as shown in table 4.4, illustrate several features of water rights trading as currently practiced in China. First, such trades are disproportionately concentrated in a few jurisdictions such as Inner Mongolia and Beijing. Second, trades are overwhelmingly conducted within single jurisdictions; there are few inter-provincial water trades. Third, trades take a number of distinct forms. These include inter-governmental agreements, usually referred to in Chinese as "agreed trades" (*xieyi jiaoyi*), company-to-company transactions, called "public trades" (*gongkai jiaoyi*), and transfers involving a state-owned water storage entity, such as a reservoir or irrigation district (*xieyi zhuanrong*). Fourth, most trades are facilitated through irrigation district water savings, most often through lining canals to prevent seepage, after which the "saved" water is transferred to industry. Fifth, prices remain quite low, and are highest in

Table 4.4 Water Rights Transactions Brokered by the China Water Exchange as of March 2017

Buyer	Seller	Quantity of Water Traded (m ³)	Source of Water Traded	Trade Price (RMB/m ³)	Trade Duration (years)	Trade Type
Xinzheng People's Government (Henan)	Nanyang Water Conservancy Bureau (Henan)	240 million	South-North Water Transfer	0.74	3	Agreed trade
Songxin Chemical Company (Inner Mongolia)	Inner Mongolia Autonomous Region Water Rights Trading Center Company	20 million	Irrigation District Water Savings	0.6	25	Public trade
Jingnengshuangxin Electric Generating Company (Inner Mongolia)	Inner Mongolia Autonomous Region Water Rights Trading Center Company	5 million	Irrigation District Water Savings	0.6	25	Public trade
Niaohaishenwu Coal Chemical Technology Company	Inner Mongolia Autonomous Region Water Rights Trading Center Company	1.25 billion	Irrigation District Water Savings	0.6	25	Public trade
Alxa Prefecture Luanjinghuai Demonstration Area Water Affairs Company	Inner Mongolia Autonomous Region Water Rights Trading Center Company	2.5 million	Irrigation District Water Savings	0.6	25	Public trade
Shanxi Zhongshenhua-pushozao Company	Shanxi Yunchengkuiquan Irrigation District	90,000	Irrigation District Water Savings	1.2	5	Agreed transfer
Beijing Baihebao Reservoir	Hebei Zhangjiakou City Yunzhou Reservoir	1.3 million	Reservoir	0.06–0.35	1	Agreed transfer
Beijing Gongting Reservoir	Hebei Zhangjiakou City Faxie Reservoir	5.741 million	Reservoir	0.294	1	Agreed transfer
Xinmi City Water Affairs Bureau (Henan)	Pingdingshan City Water Conservancy Bureau (Henan)	2.4 million	South-North Water Transfer Project	0.87	3	Agreed transfer
Ningxia Jingnengzhongning Power Plant	Zhongning State-Owned Capital Transfer Company	3.285 million	County agricultural water savings	0.931	15	Agreed transfer

Source: World Bank/DRC 2017i.

transactions involving the South-North Water Transfer Project (World Bank/DRC 2017h). These features of water rights trading in China suggest the potential of trading mechanisms, but also the lingering challenges to creating a fully functional, thickly traded market that covers most water users throughout the country.

A comparison to the water rights trading system in Australia's Murray-Darling River Basin can highlight areas for improvement in China. Average market turnover in the Murray-Darling Basin is some \$A 2 billion per year. Water rights in the basin are entitlements (based on withdrawals and not consumption), and legally provide owners with the right to a clearly defined right to a share of the available water in a particular water source. Shares vary from year to year (and within years) depending on water availability at a sub-basin level. There are many different entitlement types, defined in state legislation, which have very different levels of reliability. "High security" entitlement holders can expect to receive a "full" volumetric allocation in 95 percent of years. "General security" or "low reliability" entitlements receive full volumetric allocation in a lower percentage of years. Entitlements are thus by the water source or sub-basin, reliability, and notional full volume. Trading of entitlements (or seasonal allocations) does not affect these characteristics; states sometime pose limits on trade out of their jurisdictions, and exchange rates apply to long-distance trades to account for real water delivery losses. In comparison, in such regions as the western United States where actual seasonal water entitlements are dependent in part on actual flows, there is less year-to-year certainty, undermining confidence in water rights transfers. Additionally, in Murray-Darling sub-basins with significant reservoir storage, entitlement holders can bank, or carry over, water from one year to another, expanding the scope of possible trading (Grafton et al. 2010). Entitlement holders have access to a proportional share of the reservoir storage.

The sophistication and relative success of the Murray-Darling entitlement system stemmed from a sustained process of reform that eventually produced a number of key features. The Water Reform Framework, introduced in 1994, has created perhaps the most important of these, namely the concept of tradable water licenses separate from land ownership. The National Water Initiative of 2004 has created a more comprehensive and sophisticated approach to allocating usage rights by distinguishing between permanent, seasonal, and other forms of water use entitlements, which together allow for the management of water use through tradable entitlements. Subsequent reforms have added two additional key features to address flaws in the original market design (Varghese 2013). First, new regulations were introduced to prevent groundwater mining as an

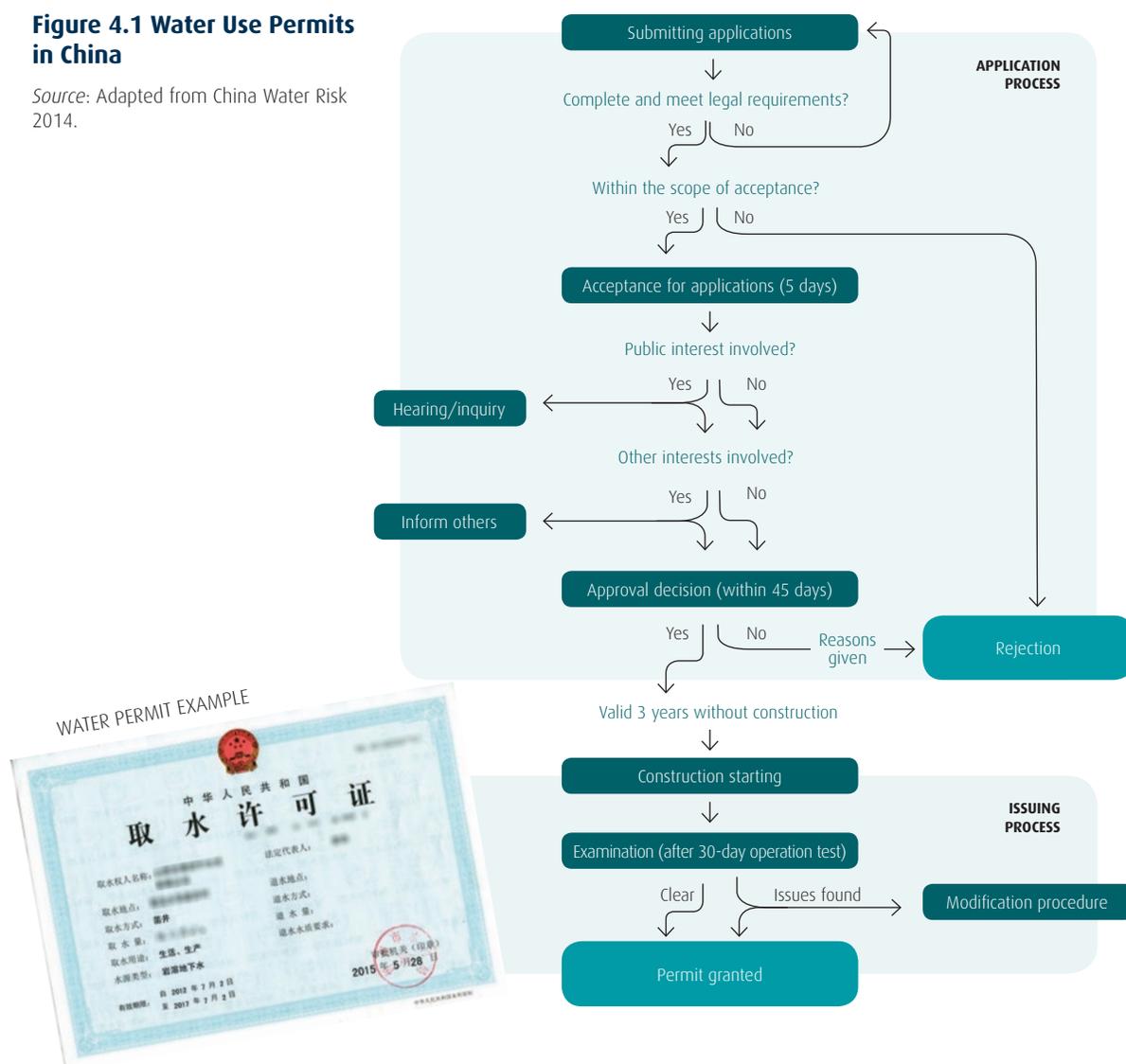
alternative to purchasing surface water usage rights. And second, water use entitlements have been created for environmental uses, helping to ensure that minimum streamflow and environmental water availability are maintained. These features of water rights trading in the Murray-Darling Basin have helped to address increasing water scarcity by allocating most water to its highest marginal value uses, increasing the total economic benefit of water use (Grafton et al. 2010). By adopting similar principles for water rights trading systems and using the opportunity of the Three Red Lines' regional water use caps, China can help to build robust water markets that efficiently allocate water between uses and users.

Cross-Reference Water Withdrawal and Pollution Discharge Permit Systems

As is the case in many countries, China regulates water withdrawals (or abstraction) primarily by granting water withdrawal permits to individual water users. This permitting system was first established under the 2002 Water Law. The modification by State Council decree in 2006 clarifies that permits should be granted so to ensure that the overall volume of water use does not exceed local water availability. The approval process, which was until recently handled by the Ministry of Water Resources, is supposed to entail a comprehensive review that may impose conditions on the water user as well as public hearings (see figure 4.1). Water withdrawal permits are granted for a period of five years, during which holders may request modifications to the original conditions, including changes to the permitted use volume or purpose. At present, however, there is no mechanism to permit water withdrawal permits to be traded, so holders are incentivized to utilize the full permitted volume of water (Griffiths and Dongsheng 2014). Similarly, China began establishing pollutant discharge permit systems in parts of the country in the late 1980s, which prohibit discharge of designated water pollutants into waterways without securing a permit to do so (Wang 2008). In 2017, the Ministry of Environmental Protection issued instructions strengthening and expanding the pollutant discharge permit system nationwide, requiring all stationary water pollution sources across 82 designated industries to apply for permits to discharge into waterways. Pollutant discharge permit holders may reduce own emissions to generate surfeit emission volumes by eliminating backward and excess manufacturing capacity, promoting clean production, improving pollution management and upgrading pollution control technology. Unlike in the case of water withdrawal permits, these surfeit emission volumes can be traded to other holders, creating a pollutant emissions trading system

Figure 4.1 Water Use Permits in China

Source: Adapted from China Water Risk 2014.



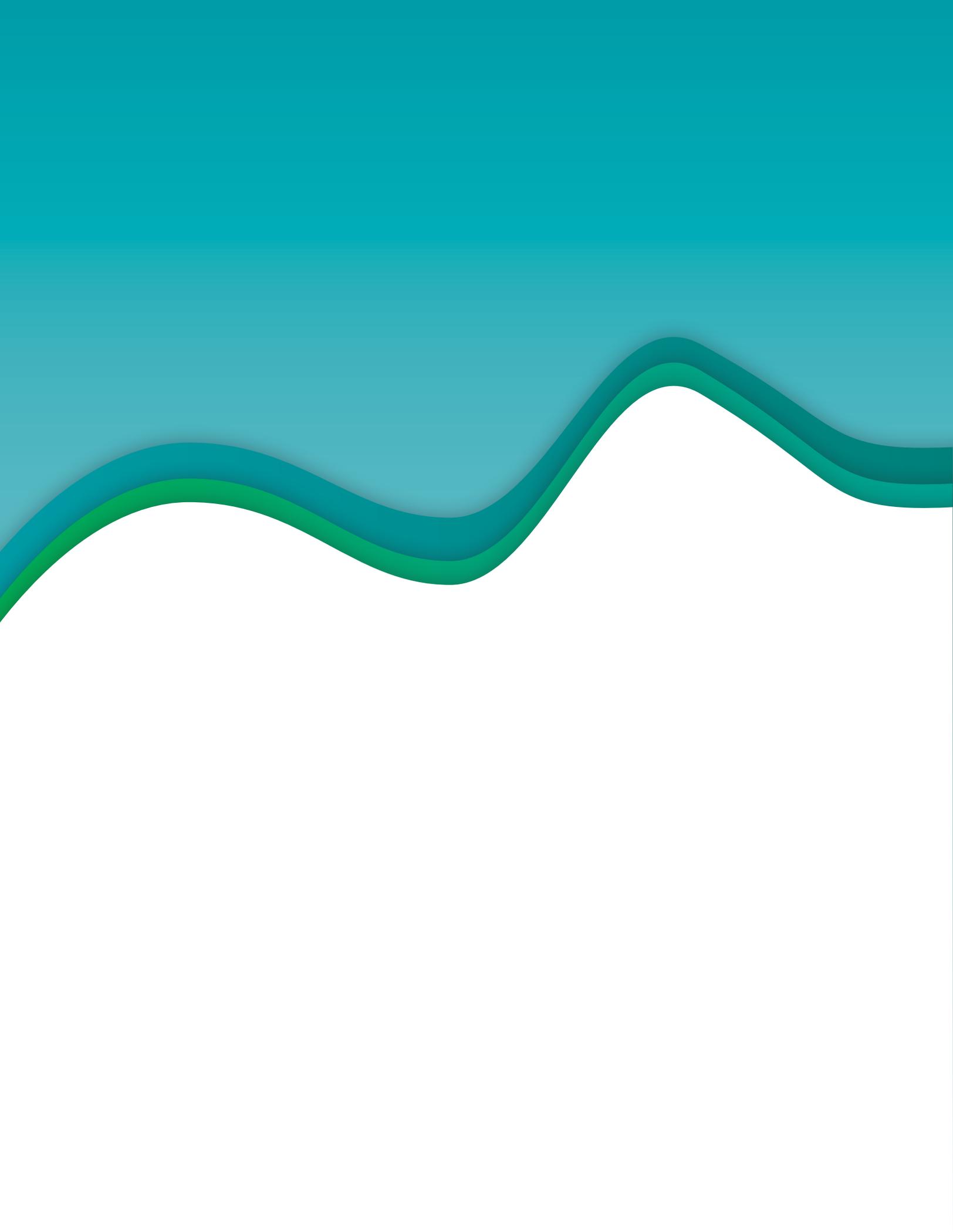
(GoC 2017). In summary, China uses separate nationwide permitting systems for both water use permits and for pollution discharge permits.

China could strengthen the administrative and regulatory ability to control water pollution as well as total water consumption by cross-referencing the water use and discharge permit systems. For example, if an enterprise discharges pollution more than its permit, that violation could trigger a limitation of the enterprise's right (permit) to withdraw its supply of water (in addition to the fine or limitation associated with the pollution violation). This dual penalty would send stronger signals to the firm and incentivize improved stewardship of China's water resources in terms of both quantity and quality. Currently many firms routinely violate their pollutant discharge permits, and either ignore fines or pay fines as a small cost of doing business.

Formulating regulations that explicitly cross-reference these systems can promote further their control. Moreover, this may help to coordinate economic management of natural resources that is the primary responsibility of the Ministry of Natural Resources. For example, the granting of water use rights or permits can be coordinated with soil use management to help prevent erosion and improve water quality, presenting new opportunities for the co-management of natural resources.

Note

1. Non-beneficial evapotranspiration does not contribute to crop production, such as unproductive transpiration from weeds; evaporation from reservoirs, canals, sprinklers, soil, and plant surfaces; and return flows that are not captured and reused.



PRIORITY 4

Strengthen Adaptive Capacity to Climate and Environmental Change

Macro-scale pressures, including increasing urbanization and climate change, will require China's policy makers to enhance the resilience of people and infrastructure to threats like flooding and droughts. At the same time, additional investments must be made to preserve the functioning of aquatic ecosystems and the services they provide, including water purification. Many of China's recent environmental and water resource management policies, including the environmental protection and water laws, stress the need to protect the natural environment. However, China's current water governance framework has two notable gaps relating to environmental protection: maintaining ecosystem services by ensuring adequate hydrology in major rivers, lakes, and aquifers; and addressing non-point source (NPS) pollution, especially from agricultural sources. The value of preserving ecosystem services in China in general, and of sustaining aquatic ecosystems in particular, is substantial. Water ecosystems, including streams, rivers, wetlands, and lakes, provide many economically valuable services, including flood and water retention, purification, and recreation. Accordingly, a fourth priority for China's water governance reforms should be to strengthen adaptive capacity to climatic and environmental change by strengthening resilience to floods, exploring Red Line targets for ecological flows, and by sharpening the policy focus on NPS pollution.

Strengthen Resilience to Floods

Flood control has long been a priority for China's water resource managers, and it has enjoyed considerable success in reducing flood risk and exposure. Over the past 70 years, about 47 million hectares of land area and 500 million people have been protected from flooding, and the average annual number of deaths as a result of flooding has been reduced from about 9,000 in the 1950s to 1,500 by the early 2000s. Overall investment in flood control infrastructure increased by over four times just from the 1990s to the early 2000s (Cheng 2006). Much of this progress, however, is built on a comprehensive flood control system that includes infrastructure; early warning systems; and a closely coordinated flood response structure that includes disaster response headquarters at central, river basin, provincial, municipal, and county levels (see figure 5.1). China's 1997 Flood Control Law, amended in 2005, designates certain regions as flood-prone, and requires authorities to develop appropriate flood management plans. Consequently, a particular area of focus is the integration of weather prediction and forecasting into decision support systems to allow local officials to respond more quickly to predicted flood emergencies, helping further improve the capacity of the Flood and Drought Control Headquarters. Full dam and reservoir operation and evacuation plans have also been

developed for 98 areas designated as national flood storage and detention zones (Moore 2018).

However, as presently constituted, China's flood control system is still dependent on infrastructure. Rapid urbanization has dramatically reduced the storage capacity of such flood retention bodies as wetlands and subsurface aquifers, because nonpermeable surfaces now impede aquifer recharge. In the case of Shanghai, for example, the percentage of urbanized land area increased from 60 percent in 1950 to 80 percent in 2001, sharply increasing runoff and reducing storage capacity in lakes, wetlands, aquifers, and other waterbodies that were filled in and reclaimed to make room for the rapidly growing city (She et al. 2015). As a result, 15 million additional people in the Shanghai region are expected to be exposed to coastal storm surges, and economic damages are expected to increase by US\$30 billion. Traditional capital-intensive flood control infrastructure is likely to be too expensive to address such challenges adequately (World Bank/DRC 2017d).

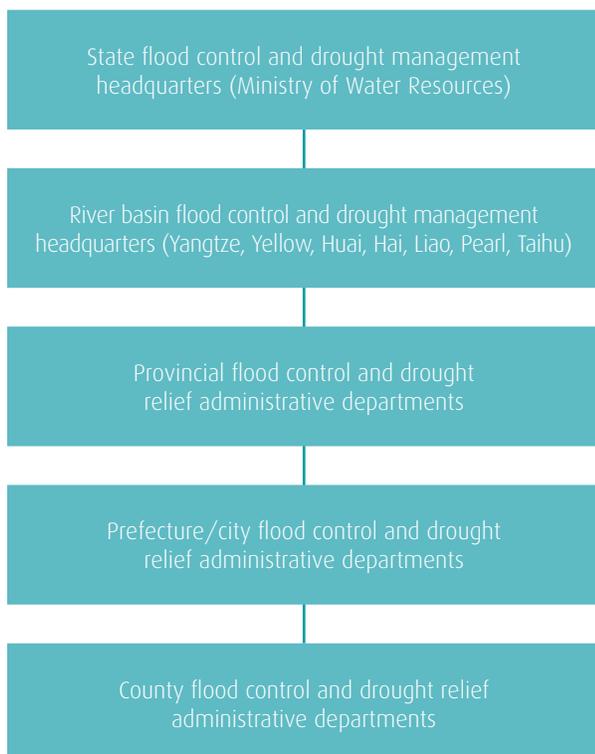
In this context, green infrastructure and the use of ecological alternatives can be expanded upon, including the use of bioswales, natural wetlands, flood retention areas, permeable pavement, green roofs, and rainwater harvesting. It is necessary to carry out combined grey

and green land development to mitigate flood risks in flood protection zones. Preserving open land can help improve aquifer recharge and enhance aquifer flood storage capacity. Preserving and restoring wetlands can likewise add to flood storage capacity, while providing additional benefits in the form of water purification and habitat for fish and wildlife (see box 5.1) (World Bank/DRC 2017d). China is already considering some of these measures under its sponge city initiative. One of the pilot cities designated under this initiative, Baicheng, Jinan Province, embarked on an ambitious effort to connect about 25 reservoirs and 160 lakes, creating about 67,000 hectares of additional waterway and total storage capacity of over 3 billion cubic meters, enhancing the city's ability to absorb floodwaters (Li et al. 2016). Note that this may also increase aquifer storage, which will build further resilience to droughts. The government can further expand and experiment with these approaches. Hybrid solutions can also be considered that combine traditional and green infrastructure (World Bank 2017a).

Moreover, countries are increasingly adopting more integrated flood risk management approaches. Instead of attempting to protect all areas from flooding, targeted investments are made based on risk assessments (Hall et al. 2003). To some extent, China's flood control policies already incorporate similar principles. The Flood Control Law outlines an elaborate zoning system to classify flood risk, and discourages dense development or infrastructure construction in designated flood retention zones (Moore 2017). In 2010, the State Council issued a related directive to focus on improving flood risk planning and management, especially on smaller rivers (World Bank 2013a). However, other countries go considerably further in using planning, zoning, and other policy tools to reduce flood risk, rather than seek to enhance flood control. The European Union (EU) Floods Directive, for example, requires the formulation of flood risk management plans for major river basins and coastal areas that include consideration of where construction of residential and industrial areas should be avoided both currently and into the future (see box 5.2). China could consider incorporating a similarly strong mandate into a revised version of its existing Flood Control Law.

Finally, China should continue its efforts to encourage the use of flood insurance schemes. Pilot flood insurance schemes were first introduced in China in the 1980s, but they suffered from individuals' and enterprises' general unfamiliarity with the concept of insurance, and premiums that were widely viewed as unaffordable. Moreover, flood insurance has often been made available as part of a basket of risks (e.g., flood, earthquake, and typhoon). Over the past decade, however, these challenges have been

Figure 5.1 Flood Control and Drought Relief Headquarters



partly alleviated. A successful crop insurance scheme, introduced in 2007, has helped to encourage the use of insurance, with premium income increasing by one-third from 2007 to 2012. Commercial insurance coverage has also increased from a very low rate to 3.5 percent as of 2015. Recent directives, including a Ministry of Water Resources set of guiding opinions, issued in 2014, also encourage the expansion of flood insurance schemes. Several additional steps are needed to improve flood insurance coverage and uptake (World Bank/DRC 2017d). First, carefully calibrating premiums based on improved detailed flood risk data and flood risk zoning plans could help

to rationalize prices and encourage landowners to purchase insurance. Currently, there are no official public flood risk maps available. Second, government needs to work with industry to expand the coverage and indemnity amounts of insurance and improve the efficiency of claims settlement. Finally, greater public awareness and understanding of the potential benefits of flood insurance could likewise help to strengthen the flood insurance industry and encourage uptake (World Bank/DRC 2017d). Special focus could be placed first on encouraging uptake by commercial enterprises. See box 5.3 for an example of the flood insurance program in the United States.

Box 5.1 Yolo Bypass, California

The 16,000-acre Yolo Bypass Wildlife Area near Sacramento, California is one of the largest public-private restoration projects in the United States, with 3,700 acres of land in the Yolo Bypass floodway restored to wetlands and other associated habitats (photograph B4.1.1). Through a system of weirs, the bypass diverts floodwaters from the Sacramento River away from the city, helping to prevent flooding. At the same time, the

bypass consists of a mosaic of seasonal and permanent ponds, grasslands, and riparian forest, creating natural habitat for birds and other wildlife. The bypass was developed by the State of California in cooperation with private foundations and the U.S. federal government, is managed by the California Department of Fish and Wildlife, and is widely regarded as a model for wetland construction and restoration efforts.

Photograph B5.1.1 Yolo Bypass When Flooded



Source: USFWS Photo/Steve Martarano.

Explore Red Line Targets for Ecological Water Flows

Although the Three Red Lines include important targets for water quality, these targets do not directly address broader ecosystem functions and requirements. Ecological systems provide important ecosystem services and functions that can generate significant benefits to human societies and economic development. Such ecosystem services include purification and regulation of water flows; oxygen generation; soil formation and retention; food supply; habitats for plants, animals, and microorganisms; and recreational opportunities (Cui et al. 2009). A 2008 study, for instance, puts the value of water retention and water purification provided by wetlands and water bodies in the city of Shenzhen at about ¥ 100 million, while a similar figure estimated in 2015 for Beijing's Miyun District is about ¥ 60 million (Li, Li, and Qian 2008). Unfortunately, both studies conclude that urbanization and the attendant destruction and modification of wetlands and water

bodies have substantially reduced the value of these ecosystem services. New ecological targets can be set with due consideration to the value of these critical ecosystem functions.

One possible metric is to use a river and lake health index, which has been proposed for use by the government. Given the complexity and diversity of aquatic ecosystems, the comprehensive river and lake health index could be used as a target. The index comprises several sub-indicators covering hydrology, physical structure, chemistry, biology, and function (which include sufficient ecological flow, benthic and plankton diversity, bank and slope vegetation and stability, and public satisfaction). Alternatively, the “*quality elements for the classification of ecological status*,” defined in the EU Water Framework Directive (WFD), can also serve as an example for the structure of a proposed target for ecological water. The WFD Directive 2000/60/EC prescribes a list of quality elements, according to which the ecological status of EU

Box 5.2 Requirements of the EU Floods Directive

The EU Floods Directive, formally issued in 2007, aims to reduce and manage risks from flooding, which the EU estimate has caused more than 1,000 deaths and about US\$64 billion in damages in the period 1998–2009. The directive requires EU member states to adopt a flood risk management approach. In contrast to more traditional flood control strategies that attempt to maximize the physical protection of people and property from flooding, flood risk management emphasizes a risk-centered process whereby urban planning and zoning are used to prevent construction of houses and vulnerable infrastructure in flood-prone areas, as well as using land management and land use strategies to help buffer flood impacts. Preserving and restoring wetlands, for example, can help reduce the impact of flooding by storing and retaining excess water during flood events. Increasing the percentage of permeable surfaces in urban areas can similarly enhance water absorption and prevent urban surface flooding.

The directive requires member states to prepare flood hazard maps that can serve as the basis for flood risk management plans. These plans specify measures to be taken to prevent flood damage, protect people and property where needed, facilitate emergency response when flooding does occur, and facilitating rapid recovery to normal conditions in the aftermath of flood emergencies.

Box 5.3 U.S. National Flood Insurance Program

The U.S. National Flood Insurance Program (NFIP) is the United States' principal national policy related to flood assistance. As its name implies, NFIP is primarily a federally sponsored insurance scheme that enables homeowners, businesses, and others living in areas at risk of flooding to insure property against flood damage. However, as originally designed, NFIP is also intended to limit development in areas at high risk of flooding and to base premiums on actual flood risk, so that the economic costs of building in high-risk areas would be passed on to policyholders. NFIP has three primary components: the development of flood risk maps, promulgation of minimum structural standards within flood hazard areas, and a set of regulations governing payment of premiums. NFIP's risk mitigation and premium setting policies were intended originally to enable the program to be largely self-financing. However, political pressure to keep premiums low combined with a rising number of claims due to extensive urban development and an increasing frequency of extreme weather events have resulted in NFIP being technically insolvent, requiring large government subsidies: approximately US\$25 billion since 2005. According to many assessments, NFIP has been only partly effective in restraining development in flood-prone areas because of loopholes, infrequent flood risk mapping, and artificially low premiums that do not fully reflect actual flood risk.

Source: Lee and Wessel 2017.

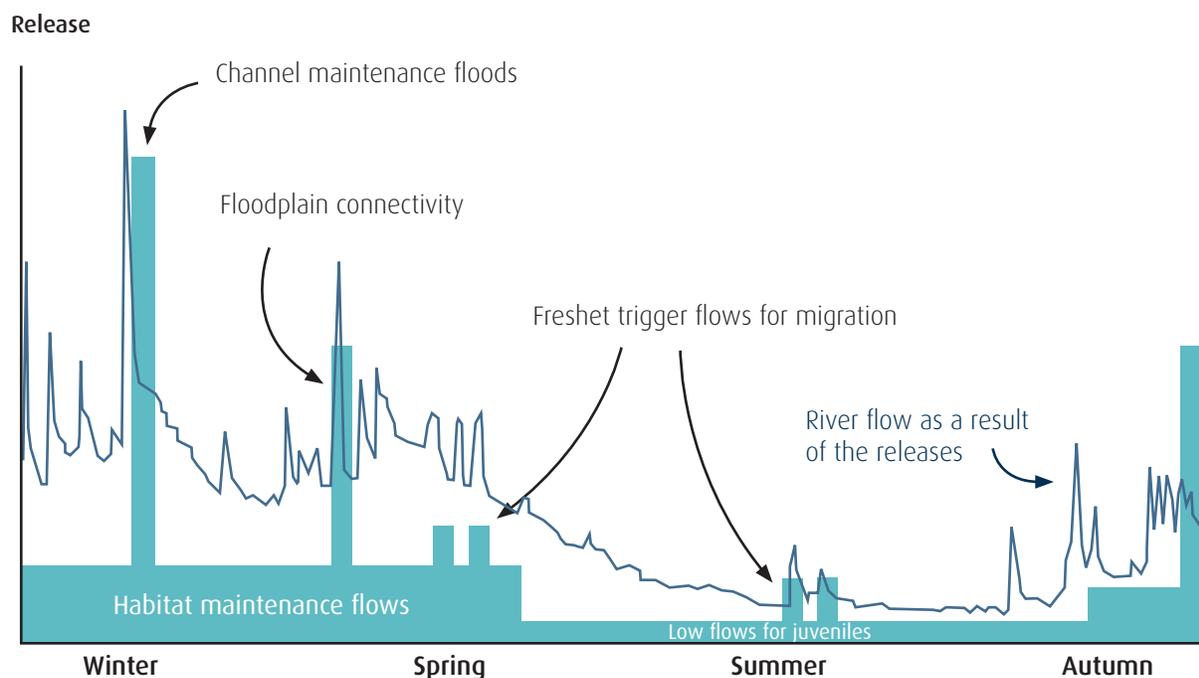
ivers, lakes, transitional waters, and coastal waters is assessed. This list contains biological elements (composition and abundance of aquatic flora and benthic invertebrate fauna; composition, abundance, and age structure of fish and fauna); hydro-morphological elements (quantity and dynamics of water flow; connection to groundwater bodies; width and depth variation; structure and substrate of the river and lake beds; structure of the river's riparian zone and lake shore); and chemical and physio-chemical elements (thermal and oxygenation conditions, salinity, acidification status, nutrient conditions, and specific pollutants). For the purposes of classifying the values for the quality elements of ecological status, the WFD further provides definitions for high, good, and moderate ecological status for each element and each surface water category, respectively. A similar model could be used in China for deriving ecological water requirements.

Another approach would be to prescribe specific hydrology requirements (seasonal or annual) in each river and tributary. To protect critical aquatic ecosystem services, not only do waterways need to be of appropriate quality (e.g., temperature, chemical composition) but also a certain hydrograph must be maintained to provide sufficient habitat for flora and fauna that is consistent with their biological processes (see figure 5.2)

(Acreman and Dunbar 2004). Ecological flows also help to maintain overall water quality, since they dilute pollutant concentrations. Minimum flows may also be important for achieving other water policy goals such as navigation or hydropower generation. Although China's water quantity allocation system does consider ecological water requirements, it does not specify a separate process for how these requirements are determined and ensured. Examples from other countries offer models for how this can be accomplished. The EU WFD explicitly states: *"For the purposes of environmental protection there is a need for a greater integration of qualitative and quantitative aspects of both surface waters and ground waters, considering the natural flow conditions of water."* The Directive explicitly requires EU member states to guarantee environmental flows, stipulating that they must *"protect and enhance the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems."* China presently lacks explicit legislation or regulations concerning the guarantee of environmental flows.

A challenge arises for maintaining ecological flows when, as in many parts of China, surface water flows may be affected by the allocation of water rights. Australia's Murray-Darling Basin has addressed this

Figure 5.2 Environmental Flow Releases from Dams



Source: Acreman 2016.

Note: Environmental flows releases from dams can be achieved by building a flow regime from a zero flow baseline using hydrograph components (blue blocks) that support particular parts of the river ecosystem.

problem through multiple interventions. Central is the establishment of long-term average sustainable diversion limits under the Murray-Darling Basin Plan to limit the level of abstraction. To achieve these limits, the Australian Government has acquired water entitlements (through trade and efficiency investments) to establish a portfolio of environmental water, actively managed by the Commonwealth Environmental Water Holder (CEWH), established by the 2007 Water Act (see box 5.4). State governments have also established environmental water holders, and various not-for-profit entities own and manage entitlement water for environmental outcomes. The Government has established rules and regulations to place limits of abstraction during low flows (including on pumping rates and durations) to protect both the environment and downstream users. The goal of these interventions is to protect and restore environmental assets and ecological functions through targeted watering of floodplains and wetlands and protection and reinstatement of some key elements of prior flow regimes. By strategically using its environmental water holdings, usually to supplement other water in the river system, the Australian government aims to improve the health of the Murray-Darling Basin's rich natural environments and protect the basin's aquatic biota. The organization's water holdings comprise 75 water entitlement types across 17 Basin Plan regions.¹ As of November 2017, the Commonwealth environmental water holdings total 2,670,106 megaliters of registered entitlements with a long-term average annual yield of 1,835,182 megaliters.² China could establish an entity to define ecological water requirement and acquire and manage water to meet these requirements. This option is especially relevant as China expands the use of water rights trading as a form of water allocation, as suggested in Priority 3. A Chinese Environmental Water Holder could be established through legislation or amendments to the various regulations governing China's water rights system. In addition, while setting the ecological flow target of "Three Red Lines", it is necessary to establish the monitoring and coordinating mechanism for the rivers with insufficient ecological flow. The enforcement of ecological flow can help control the total water use and enhance the water use efficiency."

Sharpen Policy Focus on Non-Point Source Pollution

China has made significant strides in improving enforcement of point source pollution regulations, as well as expanding wastewater treatment. China has established a robust set of water quality standards and accompanying policy frameworks to support implementation. While enforcement must be improved, this framework provides the basis for China to control

Box 5.4 Australia's Commonwealth Environmental Water Holder

The key function of the CEWH as laid out in the Water Act (2007) is to manage the Commonwealth environmental water holdings for protecting or restoring the environmental assets of the Murray-Darling Basin (and outside the basin where the Commonwealth holds water), and in line with the requirement of the Murray-Darling Basin Plan, and the basin-wide environmental watering strategy.

The Water Act defines "Commonwealth environmental water holdings" as "the rights that the Commonwealth holds that are water access rights, water delivery rights, irrigation rights or other similar rights relating to water; and the interests in, or in relation to, such rights." In other words, water holdings are entitlements with annual allocations that are acquired through the Australian Government's investment in water saving infrastructure and strategic water purchasing throughout the irrigation districts of the Murray-Darling Basin. The tasks of purchasing water for the environment and recovering water through investments in water delivery and irrigation efficiency are carried out by the Department of Agriculture and Water Resources.

Regarding the water it holds, the CEWH can do the following:

- Use the water to meet identified environmental demands.
- Hold on to the water and carry it over for use in the next water year.
- Trade (buy or sell water) for equal or greater environmental benefit.

water pollution from point sources such as factories and enterprises. Non-point source (NPS) pollution, however, remains a major challenge for which existing policy frameworks remain inadequate. Because NPS pollution is so diffuse, it is much more challenging to regulate, monitor, and reduce. Moreover, managing NPS pollution often entails significant changes to agronomic and land management practices, which are often outside the remit of water resource management agencies. Agricultural NPS pollution has surpassed industrial point source pollution as the country's main source of water pollution according to a recent census (Xu and Berck 2014). Annual application of these synthetic nitrogen fertilizers increased by almost 51 percent, and pesticides by an astonishing 120 percent, during the period 1991–2008, providing some indication of the scale of NPS pollution. Much of this rapid growth in pesticide

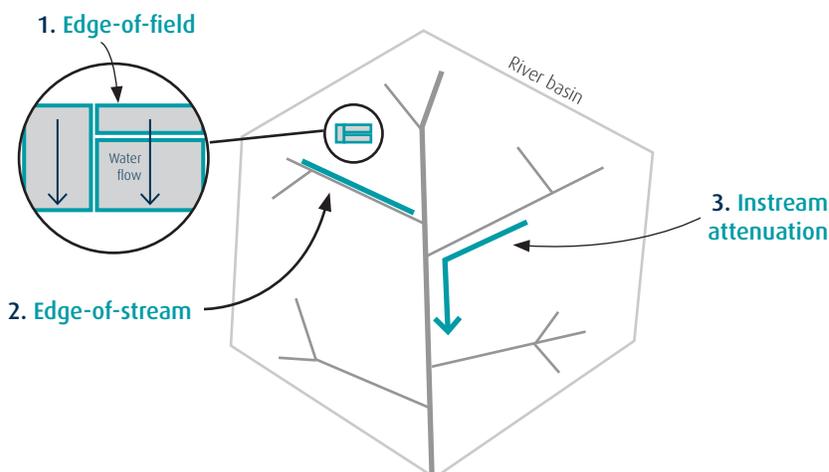
and fertilizer use has been due to a combination of subsidies and policies encouraging farmers to boost yields, which has had the perverse effect of dramatically increasing organic pollution (Sun 2012). High concentrations of such chemicals in waterways nonetheless may lead to significant negative impacts on human health (Lu et al. 2015).

A series of policy reforms have been introduced by the Chinese government to address the problem of non-point source pollution. In 2015, the Ministry of Agriculture announced that it would promote the reduction of fertilizer and pesticide, encouraging farmers to use more formulated fertilizers, which typically require smaller applications, and formulated a zero-growth action plan to effectively cap national fertilizer and pesticide use by 2020. In 2017, the Ministry of Agriculture promulgated the “Opinions on Implementing the Key Combat of Agricultural Non-Point Source Pollution Prevention and Control” and put forward the agricultural pollution control objectives, including controlling the total amount of agricultural water use and reducing the use of pesticides and fertilizers. The Action Plan for the Prevention and Control of Water Pollution, formulated by 12 ministries and commissions organized by the State Council, was a landmark directive that singled out pesticide production and nitrogen fertilizers as sectors targeted for more stringent enforcement and technological improvements designed to reduce pollutant emissions. The Plan actively promotes the control of rural non-point source pollution, formulates a comprehensive prevention and control plan for agricultural non-point source pollution, and includes a series of measures to control agricultural non-point source pollution. While these steps are important in reducing NPS pollution, the scale of the

challenge is such that China will require more ambitious, far-reaching policy options.

One option is further experimentation with water quality trading. Water quality trading promises to achieve pollution control limits at lower compliance costs in much the same way as water rights trading. Water quality trading establishes a cap on pollutants from both point and non-point sources within a given region. Because it is often easier to reduce point source pollutants, compliance with an overall pollution cap can be achieved more cheaply and efficiently by allowing point source polluters to buy and sell water quality credits from NPS polluters, which may be able to reduce pollution more cheaply, for example, by changing farming practices. Alternatively, NPS polluters can take measures, such as stream bank restoration, that reduce runoff from fields or into waterways, thereby creating water quality credits that can likewise be bought or sold (see figure 5.3). As an example, New Zealand’s Lake Taupo water quality trading program, launched in 2011, has involved the creation of a special entity, the Lake Taupo Preservation Trust. This Trust is responsible for reducing nitrogen emissions below a cap, either by buying farmland and converting it to forest to reduce nitrogen run-off into the lake, or purchasing water quality credits directly from farmers. As of 2012, 32 trades had occurred involving about 186,000 pounds of nitrogen, resulting in about 5,800 hectares being converted from farmland into forestry (World Bank/DRC 2017a). Similarly, in the United States, localized water quality trading programs have achieved significant reductions in pollutant loads at lower cost than command-and-control approaches (see table 5.1). In the United States some estimates suggest that water quality trading programs account for 68 percent to

Figure 5.3 Options for Generating Water Quality Credits by Reducing Nonpoint Source (NPS) Pollution



Source: Adapted from World Bank/DRC 2017a.

Table 5.1 Selected Examples of Water Quality Market Initiatives, Outcomes, and Status

Example	Outcome	Ongoing Issues
Long Island Sound, NY, U.S.	Achieved a 65% reduction in nitrogen loading from 79 sewer treatment plants between 2002–14. Saved US\$300 million.	Transactions costs are high.
Lake Taupo, New Zealand	Achieved 16% of nitrogen reduction goal from farmers as of 2012 from 32 trades. Farmers increasingly supportive of management interventions.	Transactions costs are high.
Hunter River, Australia	Reduced salinity pollution from farms well below target of 900 $\mu\text{S}/\text{cm}$	Occasional exceedances of salinity targets have occurred; however, these are largely attributed to natural or diffuse sources.
South Nation, Canada	Phosphorus reduction targets are being achieved. While water quality trends show a reduction of instream phosphorus, it is not possible to attribute this solely to the Total Phosphorus Management program.	Ongoing monitoring and assessment is needed to verify phosphorus reductions.

Source: World Bank/DRC 2017a.

83 percent of total pollutant loads (Wang et al. 2015). In Long Island Sound, for example, a water quality trading program has achieved a 65 percent reduction in nitrogen loading from 79 sewer treatment plants, generating a savings of US\$300 million.

For several decades, a major element of China's water quality control regime has been the issuance of pollutant discharge permits. According to implementation guidance issued by the State Council in 2000, China's Water Pollution Prevention and Control Law requires all entities discharging certain categories of pollutants, including total phosphorous and organic nitrogen, into waterways to obtain a permit to do so from local environmental protection authorities. Because total pollutant loads are capped in any given jurisdiction and waterway, a market for buying and selling pollutant permits has existed for some time. Trading pollutant permits has been allowed in China since the late 1980s, and a pilot program was initiated in the Tai Lake basin in the mid-2000s. Growing enthusiasm for market-oriented policy tools has led to the promulgation of new regulations intended to provide a stronger basis for compensated transfers of pollutants. Most notably, in 2014, the State Council issued its Guiding Opinions on Further Piloting the Paid Use of Trading Emission Permits. This was followed by the Implementation Scheme for Pollutant Emission Permit Control, issued in 2016, which explicitly permits the creation of markets in tradable pollutant emissions permits. As of 2013, total transacted allowances in water quality markets were 175,600 tons of chemical oxygen demand,

0.01 million tons of total phosphorous, and 0.16 million tons in ammonia nitrogen (World Bank/DRC 2017a). Relative to the scale of such pollution nationwide, these trading volumes are small.

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 (e.g., industry) and agriculture, a key type of NPS pollution. Programs in New Zealand, Canada, and the United States involve point sources as buyers and agriculture as sellers or agriculture as both buyer and seller (Duhan, McDonald, and Kerr 2015; O'Grady 2008; Selman, Branosky, and Jones 2009).

As such, inclusion of agriculture in water quality markets in China will be necessary. The characteristics of China's agricultural sector make this challenging; 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. Programs in New Zealand and Oregon have built markets with small farmers that grow specialty crops. As a first step, the government might consider inclusion of more professionally operated larger, corporate-owned, or state farms in water quality markets. Scaling up while also addressing transactions costs and risk might be approached by contracting whole villages as a single entity in water quality markets trades.

Finally, the international experience has produced several lessons for how to establish effective water quality trading programs in China. This includes, first, recognizing that water quality markets need clear goals and monitoring to verify that pollution reductions are real. Stipulating percentage reduction targets for particular pollutants from particular sectors is a 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 government will need to provide guidelines for how to (i) measure and report pollution reductions; (ii) centralize the databases and reporting structures for pollution discharges; (iii) ensure these databases can also track pollution reductions and market transactions; (iv) provide tools to local government to predict and measure pollution reductions in a low-cost, standardized way (e.g., a standardized nutrient reduction model for farms); and (v) provide a standardized verification template for monitoring performance and compliance for credit sellers. Second, the national government can do much to encourage provincial and sub-provincial 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—as well as the role of market enabler (Scherr and Bennett 2011). This latter role consists of raising awareness of water quality markets as a tool, providing technical support and guidance, conducting feasibility studies to identify locales where water quality trading pilots are most likely to succeed, and increasing consistency across market policies and implementation (World Bank/DRC 2017a). The opportunity promised by water quality markets in China is real, but particular actions will be needed to overcome the challenges. Markets are not magic, and though 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 in China.

Innovative Financial Mechanisms

NPS pollution may also be addressed through innovative financial mechanisms. Ecological compensation mechanisms, for example, have been piloted in China since the 1990s (Bennett 2009). These approaches, similar to Payment for Ecosystem Service models, involve payments and incentives to polluters (often farmers or landowners) to reduce damages to the environment and ecosystem. These payments can be made

by a beneficiary or user of the ecosystem service. Lately, however, their financial sustainability in China is of growing concern due to low or incomplete payments, lack of transparency in the operations, and high transaction costs. Moreover, ecological compensation mechanism applications have largely been driven by government interventions and transfers of public funds. Market-oriented approaches may serve better in facilitating payments between ecosystem service providers and beneficiaries especially when the links are clear.

One alternative mechanism is a water fund; it can finance investments in environmentally sensitive areas to change farming practices in water source regions, reforest, or undertake other measures that naturally abate NPS pollution. Water funds can be structured around a variety of payment mechanisms, including fees or contributions paid by downstream water users that benefit from improved water quality (The Nature Conservancy 2016). By putting the financial burden on beneficiaries of the desired ecosystem services, water funds can create a win-win situation for all investors. These schemes should be supported by strong evidence-based research on how changes in land use and other interventions directly contribute to improving water quality and other ecosystem services. For example, to help fulfill commitments made under a 2000 inter-state agreement to improve the quality of the Chesapeake Bay, the State of Maryland in the United States established the Bay Restoration Fund in 2004.³ The commitments made under the agreement specifically relate to reducing nutrient pollution in the Chesapeake Bay. The purpose of the fund is to finance upgrades to wastewater treatment plants so that they can significantly improve wastewater effluent quality by reducing nutrient loading (e.g., to no more than 3 milligrams per liter of total nitrogen and 0.3 milligrams per liter of total phosphorus). This program also supports upgrading onsite septic systems and using cover crops to reduce further nitrogen loading into the bay. Thus, this fund aims to reduce both point source and NPS pollution. This fund is financed through a fee, set at US\$5 for most individual households, collected from each home, commercial, and industrial user of the wastewater treatment plants and septic systems in the watershed. These funds also back the issuance of bonds to generate further financial resources.

There is already some experimentation with water fund-like activities in China, such as the five-year agreement between Beijing and the City of Chengde, Hebei Province, signed in 2005. The two cities agreed that Beijing would pay Chengde RMB 20 million per year to abate soil erosion in upstream watersheds, and the agreement was extended in 2011 (see box 5.5 for additional examples).⁴ Another promising set of financial mechanisms concerns

Payments for Ecosystem Services. While China currently has 16 active Payments for Ecosystem Service schemes, most involve transfers between governments rather than direct beneficiaries. This largely reflects insufficient knowledge of Payments for Ecosystem Services; therefore, funded schemes and continued experimentation are needed

(World Bank/DRC 2017c) Finally, financing of water quality improvements can be directly addressed through the establishment of a dedicated revolving fund. The case of the successful U.S. Environmental Protection Agency Clean Water State Revolving Fund (EPA CWSRF) offers a potential model that could be experimented with in China (see box 5.6).

Box 5.5 Financial Mechanisms to Improve Water Quality in China

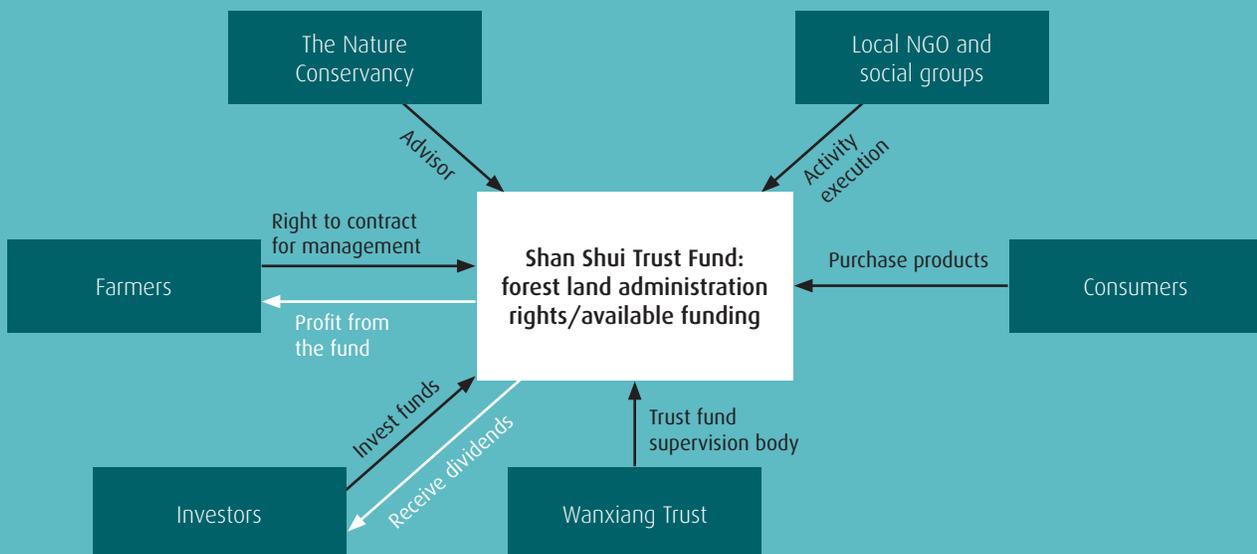
Water fund for Longwu Reservoir. Longwu Reservoir is primarily used to supply domestic water to the villages of Qingshan and Cibi. The bamboo industry covers approximately 60 percent of the total catchment. Fertilizers and herbicides used in bamboo production are major contributors to the nutrient pollution into the reservoir. In 2015, with the support of The Nature Conservancy, a water fund was established allowing local government, farmers, nongovernmental organizations (NGOs), and a trust company to collaborate to environmentally management lands (The Nature Conservancy 2014).

Beijing's Paddy Land to Dry Land program. Miyun Reservoir is the main surface water source for Beijing. Over the years, NPS pollution from agriculture activities

in the catchment have degraded water quality. The Paddy Land to Dry Land program aims to reduce both agricultural nutrient and chemical runoff and siltation by offering a subsidy to farmers to switch from water-intensive rice cultivation to corn. These subsidies are funded by Beijing urban residents.

Planned program for Lashihai Nature Reserve and Lijiang Old City. This is a payment for ecosystem services pilot program consisting of special fees charged to tourists for visiting Lijiang Old City and the Laishihai Nature Reserve to be used to compensate upper watershed farmers adjacent to the Laishi Lake for changing their land use practices. The Laishi Lake is a key part of the Lijiang Basin from which various rivers flow through and around Lijiang Old City.

Figure B5.5.1 General Design of a Water Fund



Source: The Nature Conservancy 2014.

Note: NGOs = nongovernmental organizations.

Notes

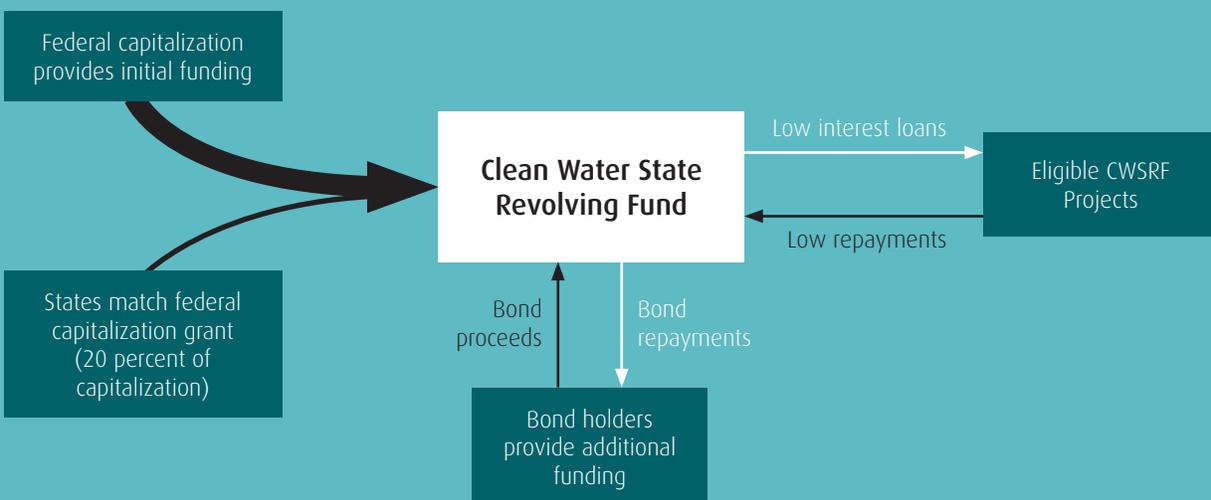
1. The Murray Darling Basin spans southern Queensland, the Australian Capital Territory, much of New South Wales, over half of Victoria, and the southeast of South Australia.
2. See the Australian government's website for details of all Commonwealth Environmental Water holdings: <http://www.environment.gov.au/water/cewo/about/water-holdings>.
3. See the government of Maryland's website, <http://mde.maryland.gov/programs/Water/BayRestorationFund/Pages/Index.aspx>.
4. See the government of Maryland's website, <http://mde.maryland.gov/programs/Water/BayRestorationFund/Pages/Index.aspx>.

Box 5.6 U.S. Environmental Protection Agency Clean Water State Revolving Fund

The Clean Water State Revolving Fund (CWSRF) was established in 1987 as an amendment to the Clean Water Act to provide financial assistance to a wide range of water infrastructure projects (see figure B5.7.1). Loans are provided to eligible recipients to construct municipal wastewater facilities, control NPS pollution, build decentralized wastewater treatment systems, create green infrastructure projects, protect estuaries, and fund water quality projects. The EPA provides grants to all 50 states to capitalize a state CWSRF, with states contributing an additional 20 percent to match the federal grants. The program functions like an infrastructure bank by providing

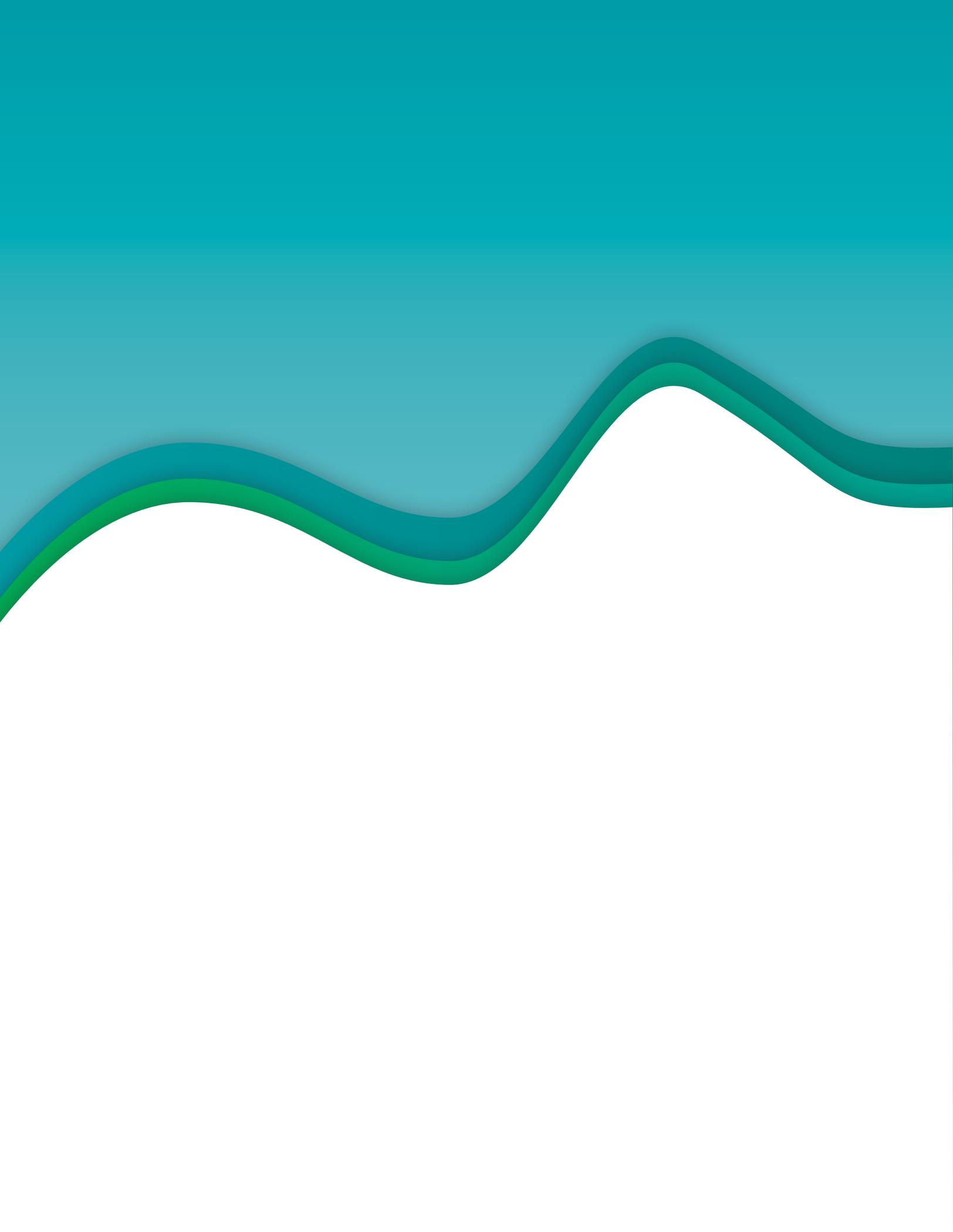
low interest loans. As money is paid back into the state's revolving loan fund, the state makes new loans to other recipients for high priority water quality activities. Under the CWSRF, states may purchase or refinance debt, provide guarantees and insurance, and provide additional subsidization. For example, a Green Project Reserve is established to target critical green infrastructure, water and energy efficiency improvements, and other environmentally innovative activities. To date, CWSRF has provided over 36,100 assistance agreements to communities throughout the United States, financing over US\$111 billion in high priority water quality projects.

Figure B5.6.1 General Design of State Revolving Fund



Source: EPA website, https://www.epa.gov/sites/production/files/2015-06/documents/cwsrf_101-033115.pdf.

Note: CWSRF = Clean Water State Revolving Fund.



PRIORITY 5

Improve Data Collection and Information Sharing

China possesses strong technical capabilities in water resources data collection and monitoring. However, operational decision making and investment planning can be strengthened if data and information are more widely shared and accessible to a broader set of stakeholders. Moreover, open data platform approaches can help to foster coordination and collaboration across agencies and will support entrepreneurship, innovation, and scientific discovery in the water sector. This is consistent with the government's current focus on data and technology.

Improve the Legislative Framework for Producing and Sharing Water-Related Data

It is widely recognized that producing and sharing high-quality data are essential for good water governance and management. The importance of making such data accessible to a variety of stakeholders, including water user groups as well as policy makers, is heightened by the increasing variability in water availability as a result of climate change and other global environmental changes (Laituri and Sternlieb 2014). In its March 2018 report, the High Level Panel on Water (HLPW) recognizes that access to water data is a prerequisite to better water resource management

around the globe (UN Water 2018). The Panel also issued Good Practice Guidelines for Water Data Management Policy, which identifies seven key elements of water data policy: (i) identifying priority water management objectives; (ii) strengthening water data institutions; (iii) establishing sustainable water data monitoring systems; (iv) adopting water data standards; (v) embracing an open data approach to data access; (vi) implementing effective water data information systems; and (vii) employing water data quality management processes. Implementing these principles as part of a coherent water data policy often requires reform, which is best accomplished through building a legislative framework.

A clear legislative or regulatory mandate is needed to encourage all ministries and officials to share water and environment related data and, where appropriate, to disseminate it to relevant stakeholders and the public. This can be considered with updates to the Water Law. Currently, various ministries and government agencies collect water-related data for their own analysis and use. This limits an integrated view of China's water resources challenges. Legislation mandating the sharing of water-related data across agencies will help all agencies. This legislation will need to be explicit in terms of the types of information to be gathered and necessary standards to be set for data quality and transfer.

For instance, the Australian Water Regulation (2008) under the Water Act (2007), provides all persons or organizations with certainty about their obligations to provide water information to the Bureau of Meteorology and the categories of water information (e.g., surface and ground water information, water storage information, meteorological information, water use data, information about water rights, allocations and trades, water quality information, and water information for flood warning purposes). These categories are comprehensive, covering almost every major aspect of water resource management, including groundwater and surface water and water quality and quantity (see table 6.1). The regulation defines who must give specified water information to the Bureau and the time and format in which it must be given, and names over 200 organizations required to give the Bureau specified water information in their possession, custody, or control.

Another example of data sharing legislation can be found in California's Open and Transparent Water Data Act of September 2016. This Act requires the Department of Water Resources, in consultation with the California Water Quality Monitoring Council, the State Board, and the Department of Fish and Wildlife, to *"create, operate, and maintain a statewide integrated water data platform."* This platform will *"integrate existing water and ecological data information from multiple autonomous databases managed by federal, state, and local agencies and academia using consistent and standardized formats."* The act requires the Department of Water Resources to *"develop protocols for data sharing, documentation, quality control, public access, and promotion of open-source platforms and decision support tools related to water data."*

Any future recipient of state funds must adhere to the protocols to be developed by the department. The act also creates the Water Data Administration Fund. Moneys appropriated to this fund will be used for the implementation of the act, i.e., for the collection, management, and improvement of water and ecological data. Finally, the legislation states that integrating existing water and ecological data into an open-access platform will improve state agency operations and enable data-driven decision making. The Act is explicit in its goal to *"foster collaboration among state agencies."*

The key element of both the California and Australia examples is a clear, strong, and legal mandate to require and facilitate water data sharing among key water resource management stakeholders. Provisions that support data standardization and require data collection on key parameters are also important in ensuring collected data can be easily distributed and utilized. To utilize this data most effectively, China should also create a National Water Data Portal to expand access to water-related information.

Create a National Water Information Sharing Platform

A robust, easily accessible, and transparent water monitoring network is needed to support a wide range of operational and investment planning decisions. For example, to enhance the trading of water permits and rights and water pollution discharge permits, markets need verifiable transparent data on actual transfers and pollutant reductions. At present, data resides in several databases and not in a central location that is easy for provincial officials, market participants, and the public to see. Creation of a single, National Water Information

Table 6.1 Categories and Data Collection Elements under Australian Water Regulations

Information Category	Data Elements
Surface water	Level and flow of surface water in water courses
Groundwater	Level and pressure of groundwater and aquifer recharge volumes
Water storage	Water storage level, volume, inflows, and outflows Location, capacity, and ownership of major storage facilities
Meteorology	Rainfall, wind, humidity, evaporation, temperature, pressure, and vapor pressure
Water use	Water withdrawals and returns
Water rights, allocations, and trades	Water access rights, irrigation rights, trades, and permit information
Urban Water Management	Urban water withdrawals, supplies, sewage, storm water, and recycled water
Water restrictions	Water use restrictions in effect
Water quality	Electrical conductivity, suspended solids, turbidity, nutrient content, acidity, and temperature of surface water; electrical conductivity and acidity of groundwater
Flood warning	Level and flow of surface water, rainfall

Sharing Platform would provide multiple advantages. First, a comprehensive single data portal would facilitate the sharing of information across government agencies and enhance the integrated management of water resources. This would increase the transparency of water information underpinning water policies and management decisions across various levels. Second, a comprehensive data portal available to the broad research community and the private sector could help to identify new innovations in water management and water policy. Emerging tools and capabilities from the “Big Data” sciences could be utilized more broadly on these datasets. Third, having consistent national information can be used to benchmark the performance of managed water systems both in space and time. Finally, public disclosure of water entitlements, allocations, trades and use can help to improve the performance of water markets and improve water availability forecasts. All of this will lead to greater certainty in water resources planning and improved community understanding of water resources management.

As an example, in 2004 the Council of Australian Governments incorporated a directive into the National Water Initiative to develop water resource accounting, requiring water data to be identified, quantified, reported, and published for the public. Water accounting in Australia is based on the principles of financial accounting, not statistics, and focuses on the flows of volumes of water (WWAP 2012). In 2007, Australia launched the \$A 450 million 10-year Improving Water Information Program. This includes issuing national water information standards, collecting and publishing water information, conducting regular national water resource assessments, publishing an annual National Water Account, providing regular water availability forecasts, giving advice on matters relating to water information, and enhancing understanding of Australia’s water resources. The Act also requires the Bureau of Meteorology to “*annually publish the National Water Account in a form readily accessible by the public.*” The National Water Account reports on the volumes of water traded, extracted, and managed for 10 nationally significant water regions.¹ The Act also requires that all trades in water access entitlements should be recorded on a water register. Registers will be “*compatible, publicly accessible and reliable,*” recording information on a whole-of-catchment basis.

Another example is with the U.S. Geological Survey (USGS). The USGS investigates the occurrence, quantity, quality, distribution, and movement of surface and ground waters and disseminates the data to the public, State and local governments, public and private utilities, and other Federal agencies involved with managing water resources. As part of the USGS program for disseminating water data, the USGS maintains a

distributed network of servers for the acquisition, processing, review, and long-term storage of water data, called the National Water Information System (NWIS). The NWIS is the principal repository of water resources data for the United States. It includes data from more than 1.5 million sites in all 50 States, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa, and the N. Mariana Islands. Some of these sites have been in operation for more than 100 years. The USGS has been providing real-time and historic streamflow data on its website since 1994. In the early 2000s, the USGS aggregated all the data from the separate websites of each State into one national database accessible through one website. The NWIS integrates streamflow information with many other types of water data, including historic water quality data from rivers and aquifers; historic ground water level data; and real-time water quality, precipitation, and groundwater levels.² The data collected comprises gage height (stage) and streamflow (discharge), temperature, specific conductance, pH, nutrients, pesticides, and volatile organic compounds.³

Water Data for the Nation⁴ is the USGS public web interface to much of the data stored and managed within NWIS. The goal of the Water Data for the Nation website is to provide all users with a geographically seamless and easy-to-use interface to most of the USGS water data maintained in NWIS. Data provided by this site are regularly updated from NWIS, and current condition data are generally updated upon receipt at local Water Science Centers. The USGS has also developed the website WaterWatch, which displays maps, graphs, and tables describing real-time, recent, and past streamflow conditions for the United States.⁵ The real-time streamflow maps highlight flood and high flow conditions. The seven-day average streamflow maps highlight below-normal and drought conditions.

Strengthening the Role of Public Awareness and Participation

Engaging the public in general, and water users in particular, is helpful, if not essential, in addressing certain challenges inherent to managing water resources. Adopting a participatory approach to water governance is a means of navigating complex ethical issues concerning the allocation of water resources across different users, regions, and socioeconomic groups (Prisco 2004). For China, public participation in water governance holds the added attraction of helping compensate for the often-limited resources of local environmental protection bureaus. Directly engaging the public in monitoring and enforcing pollution regulations promises to help redress this imbalance and advance the vision stated at the 19th Party Congress of

strengthening efforts to combat water pollution (World Bank/DRC 2017e).

The Water Law, Water Pollution Prevention and Control Law, and Environmental Impact Assessment Law have specific provisions concerning public participation. The Water Pollution Prevention and Control Law, for example, stipulates that each individual has the right and responsibility to help protect waterways and to report instances of illegal pollution. These legislative provisions signal that Chinese policy makers see a need to more directly and better engage citizens and private enterprises in the business of improving water quality and use efficiency. Local authorities have also developed some innovative platforms to encourage public participation in some aspects of water resource management. In Zhejiang, officials have developed an app-based platform to enable individual citizens to report water that appears to be polluted, and to track the official response to each report. Guangdong is similarly experimenting with the use of big data to better monitor water pollution based on crowd-sourced reporting (World Bank/DRC 2017b).

However, despite these provisions and innovations, public participation in actual water resource management remains limited. Channels for the public to access water-related data and information, submit complaints, and otherwise engage in water resource management are uneven in scope, and are often lacking. Current regulatory and legislative provisions provide a clear right for citizens to submit complaints and opinions on water resource management, but there is no clear right to engage in decision making. Moreover, public

awareness of water issues is low, with the result that public engagement often takes the form of passive participation (World Bank/DRC 2017b).

The experience of other countries offers several lessons for how to improve awareness and public participation in water governance. A number of countries, especially in Europe, have formulated regulations, policies, and other measures to formally incorporate the principle of public participation into water resource management (see table 6.2). These provisions vary significantly, ranging from simple awareness-raising activities (such as Singapore's Clean and Green Week) to the Aarhus Convention, which establishes a general right for the public to participate in all environmental decision-making processes that might meaningfully affect them, as well as to seek redress from the government if proper procedures are not followed (Pu et al. 2007). Most of these provisions establish at least some right for the public to provide input on various water resource issues directly to the relevant authorities, and to participate to some degree in decision-making processes. Another salient feature is a right to know concerning information on water resource issues that might directly threaten or harm the public, including water pollution and flooding.

The potential to expand public participation in water governance more fully in China is especially evident with respect to Water User Associations in the irrigation sector. Water User Associations have gained favor in China as a means to bridge the gap between old forms of organization in rural areas under collective agriculture and the realities of China's complex, modern economy. They are often used as

Table 6.2 International Models for Incorporating Public Participation into Law and Policy

Jurisdiction	Relevant Policies and Regulations	Description
European Union	Aarhus Convention	Establishes the right of the public to know, participate, and question environmental decision making
	Framework Guidelines in Water Resource Management	Encourages all interested parties to become involved in water resource management based on the Aarhus Convention
	Guidelines for Public Access to Environmental Information	Establishes right of the public to know; defines administrative responsibilities
France	Water Law	Mandates public participation in most aspects of water resource management, including river basin management plans
Singapore	Special activities to make Singapore clean and clear; Clean and Green Week	Special activities to spread awareness on water conservation, water quality, and related issues
United Kingdom	Committee of Water Consumers	Provides a platform for consumer input on operation of water service companies
United States	Clean Water Act; Safe Drinking Water Act	Establishes requirements to solicit public participation in decision making
	Public Involvement Policy	Lays out specific requirements for public participation

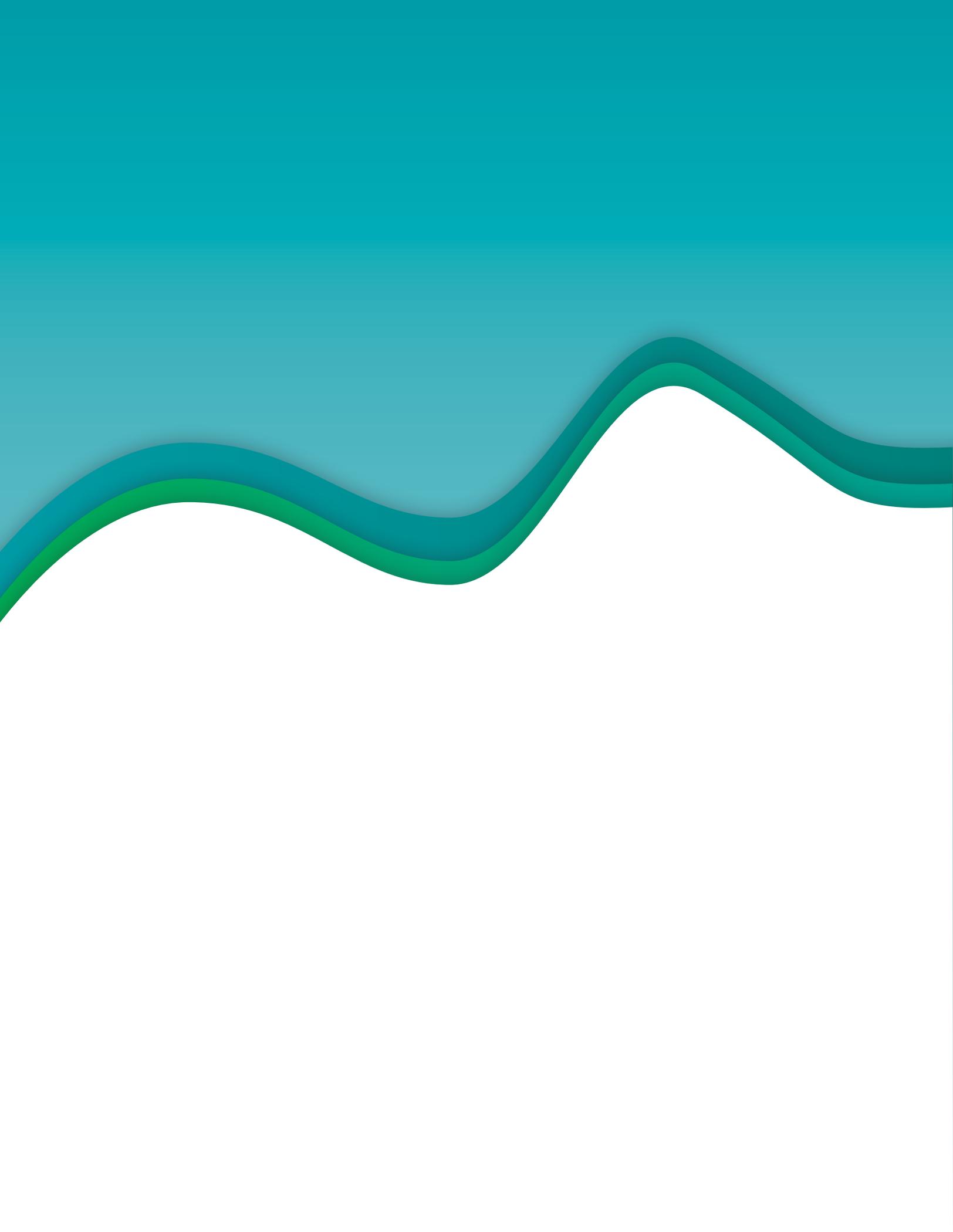
the primary means of engagement and mobilization for agricultural water users, and are often relied on to help implement government policies related to agricultural water saving and irrigation modernization. Several studies have concluded that properly designed Water User Associations improve water use efficiency and improve irrigation service delivery, even relative to irrigation systems managed by professional contractors (Huang 2014; Wang et al. 2010). However, in practice most do not function as self-governing entities, and often act simply as an extension of local government organizations. Most Water User Association positions are unpaid, so there is little incentive to develop capacity (World Bank/DRC 2017b). Yet at the same time, they are organized in most rural areas, offering an ideal platform to build local capacity and diffuse lessons related to water use efficiency and conservation.

Another promising mechanism for engaging a broader set of water sector stakeholders is the Water Efficiency Leader Campaign, announced in 2016 as a joint initiative of the Ministries of Industry and Information Technology and Water Resources, the National Development and Reform Commission and the Ministry of Housing and Urban-Rural Development (World Bank/DRC 2017b). The program is intended to support several existing initiatives, such as the Water-Saving Society, and envisions recruiting enterprises and organizations in key sectors, including industrial and agricultural water users, who will serve as models for reducing water consumption and improving water use efficiency. It is envisioned that Water Leader enterprises will report on their efforts at least once every two years. However, the modalities of the initiative remain largely unspecified. Adding detail to this initiative and supporting its expansion can play a key role in strengthening public participation.

These examples suggest several steps for improving public awareness and participation in water governance. Revised legislation or regulations should clarify rights and responsibilities of the public to have access to water-related information and to participate in decision making. The public should also play a role in supervising the enforcement of government policies and regulations with regard to environmental issues. This is consistent with the government vision to promote public participation as outlined in the 19th Party Congress report. Legislation or regulation should also clarify freedom of information with respect to water pollution, flood risk, and other water-related harms. In addition, the government should continue the process of strengthening Water User Associations, incorporating best practices, and engaging them to support water conservation and water use efficiency efforts. At the same time, the Water Efficiency Leader Campaign should be expanded.

Notes

1. These 10 water regions are home to 75 percent of Australia's population: Adelaide, Burdekin, Canberra, Daly, Melbourne, Murray-Darling Basin, Ord, Perth, South East Queensland, and Sydney. To download the National Water Accounts, visit the Bureau of Meteorology's website, <http://www.bom.gov.au/water/nwa/about.shtml>.
2. See the USGS website for a description of the development and contents of NWIS, <https://pubs.water.usgs.gov/FS-027-98>.
3. See the USGS Water Resources Home Page, <http://water.usgs.gov>.
4. To access the platform, visit the USGS website, <https://waterdata.usgs.gov/nwis/qw>. Background information on the platform can be found at the USGS website, <https://help.waterdata.usgs.gov/faq/additional-background>.
5. See the USGS Waterwatch website, <http://waterwatch.usgs.gov>.



Conclusion

Water is the common currency that underpins China's historical and future sustainable development. For China to maintain food and energy security while its cities grow rapidly, it will need to use water more efficiently and effectively, and enhance the protection and restoration of the environment. For China to adapt to climate change, it must better integrate land, urban, energy, and water policies. For China to safeguard the health and well-being of its people and its environment, it needs to invest in maintaining natural ecosystems and improving water quality. This report has detailed several priority reform areas to enhance China's system of water governance to support these aims.

Realizing a new era of water governance for China will require integration, balance, participation, innovation, accountability, and gradualism. The 16 words of wisdom issued by President Xi Jinping give a clear direction for the management of water in China, specifically in relation to the "priority on water-saving, spatial equilibrium, systematic governance, and the combined efforts of government and the market". Proper water management is fundamentally about taking water out of its sectoral silo and managing it in a way that reflects its crucial importance and inter-connectedness to all parts of the economy and society. As such, water policy tools must be integrated horizontally (i.e., water

policy cannot be made in isolation from food, energy, or land management policy) and vertically (i.e., across administrative jurisdictions). Implementation will also require the balance of multiple, sometimes competing objectives and the participation of stakeholders at all levels, especially local communities. Roles and responsibilities of entities should be clear to ensure accountability. Finally, a new water governance strategy must embrace innovation and experimentation, especially the use of advanced technologies, market mechanisms, and integrated information sharing platforms. These new reforms will take time to evolve gradually, and will require flexibility and iteration. If China can successfully adopt the reforms described in this report, it can put itself on a more sustainable path to future growth.

China must address five key water governance reform priorities. First, China needs to enhance the legislative foundation for water governance by expanding existing policies and initiatives. This includes updating the existing Water Law to reflect current principles and strengthening the enforcement of existing water pollution laws. Second, water governance needs to be strengthened at the national and basin scales. A national coordination mechanism for water management should be established to improve coordination around key water policy issues, management plans, as well as the identification

of national strategic priorities. The role of river basin agencies should be given enhanced authority and clarity in key areas of planning, coordination, implementation, enforcement and financing. Third, existing piloted economic policy instruments need to be harmonized for maximum effect and scaled up where appropriate. More empirical evidence is needed to assess the effectiveness of these instruments. Early pilot programs on water rights trading show promise. Fourth, human and ecological systems need to be made more resilient to meet future threats and challenges. This includes expanding on green infrastructure approaches for flood management and experimenting with water quality markets and different financial mechanisms to reduce non-point source pollution. Fifth, data and information sharing need to be improved among agencies, jurisdictions, and water users. The establishment of a national water information sharing platform will help to foster coordination and collaboration across agencies and will support innovation in the water sector.

China has already established the foundation for pursuing these priorities with changes to its overall environmental governance system announced in March 2018, most notably creation of the Ministry of Ecology and Environment and the Ministry of Natural Resources along with consolidation and optimization of responsibilities within the Ministry of Water Resources and other related ministries. These changes are an opportunity to optimize China's water governance system further. While the authorities granted to the Ministry of Ecology and Environment appear sufficient to allow it to address most water quality issues, some matters, such as flood management and soil erosion control, will require extensive coordination with other ministries. For the Ministry of Natural Resources, its responsibilities with respect to water resource investigations and evaluation needs to be further clarified. In addition, the composition and functions of river basin agencies and their relationship with local governments also need further clarification. While these ministerial changes promise to address some of the institutional coordination

issues that have hindered effective water governance in the past, they do not obviate the need to strengthen existing bodies, such as the river basin commissions, and to establish new institutions, such as a national coordinating mechanism for water governance. In this new institutional architecture, water governance would be closely integrated at the local, river basin, and national levels, paving the way toward a more focused approach to critical water resource management tasks such as NPS pollution and ecosystem protection. As proposed in this report, these arrangements will establish a new water governance strategy by which central government ministries have clearly defined responsibilities, but whose actions are closely coordinated at the national level by a coordinating mechanism, at the regional level by river basin commissions, and at local levels by sub-basin committees. An important part of the reform process is to ensure that each ministry and organization possesses sufficient budget and staffing to fulfill its assigned responsibilities.

China's ambitious measures to address its water-related development challenges promise to offer lessons for other countries facing similar issues. In terms of policy and regulation, the Three Red Lines presents a model for capping national and regional water use, which coupled with monitoring, enforcement, and allocation mechanisms can help other countries promote more efficient use of limited water resources. In terms of innovative governance approaches, the River and Lake Chief system presents a striking example of how to make the management of inter-jurisdictional water resources a core responsibility for local officials. Finally, the experimentation with economic instruments, such as China's Water Rights Exchange, offers new ideas to help in allocating water resources. While this report has drawn on international examples to inform recommendations to improve water governance in China, going forward, China's experience will be of considerable benefit and interest to other countries as well. China can provide a strong model for other countries in tackling the challenges of water sustainability in the 21st century.

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