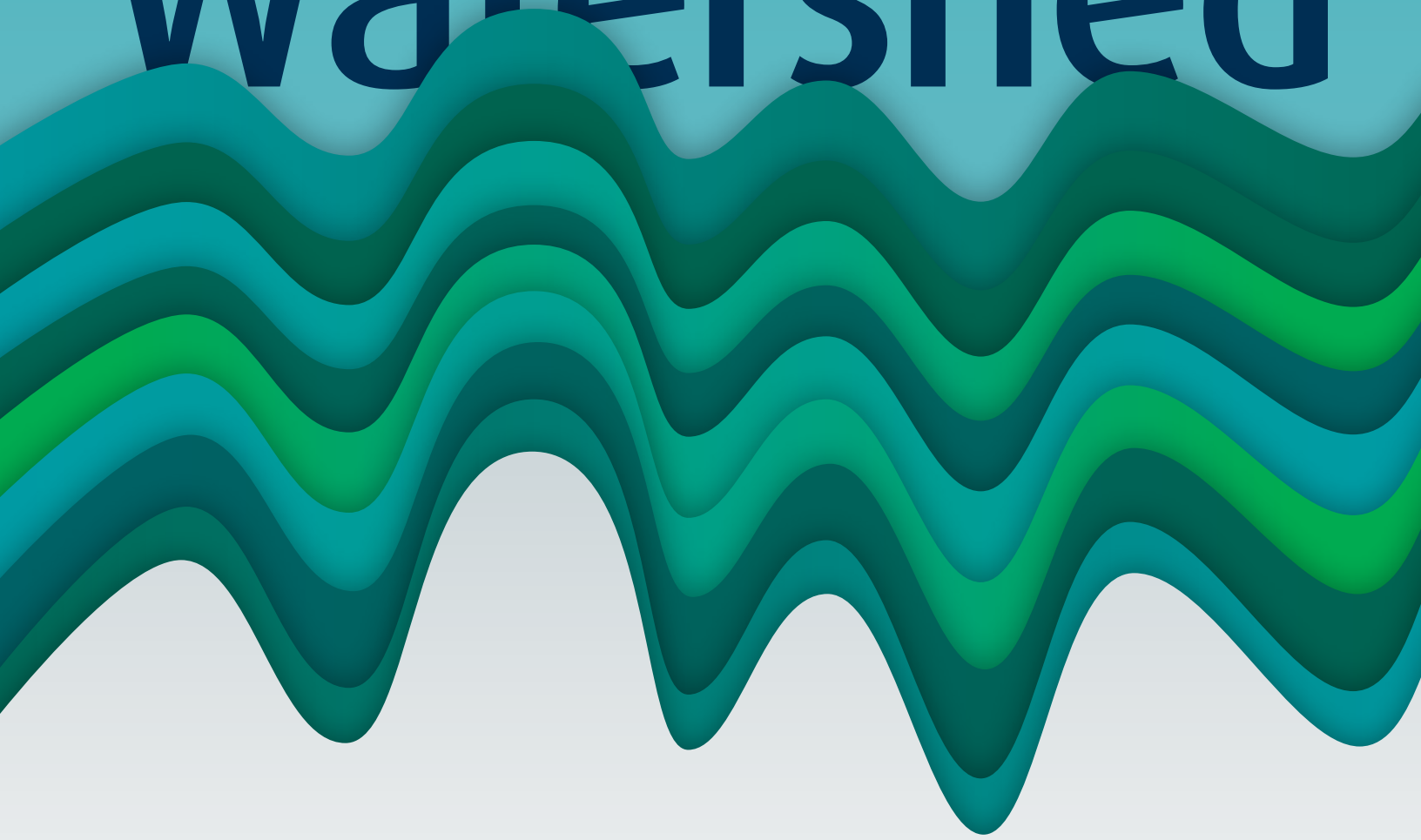
POLICY BRIEF

A New Era of Water Governance in China

Watershed



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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 40 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 estimated to be 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 is 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; hydropower capacity now stands at 341,000 megawatts. 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. 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. The control on total utilization introduced under the Three Red Lines is intended to limit increases in future demand but will require innovations and improvements in efficiency to maintain levels of productivity. 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 under 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 countr. 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 responsibil-

ities 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 resources,

environmental flows 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. Strengthened 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 existing river basin commissions. 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.

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A New Era of Water Governance in China