MANAGING WATER RESOURCES FOR SUSTAINABLE SOCIOECONOMIC DEVELOPMENT

A Country Water Assessment for the People's Republic of China

DECEMBER 2018

ASIAN DEVELOPMENT BANK

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On the cover: The five key dimensions of water security (design by Jasper Lauzon).

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Foreword

For the past 65 years, the Government of the People's Republic of China (PRC) has been plotting its path to progress and modernization with a series of 5-year socioeconomic plans. These plans lay out the priorities and targets for public and private sectors to conform to the national development agenda that the country has been tracking, its vision for the near future, and how it intends to use policies and investments to achieve its goals. But no story is ever without tension and, for the PRC, that tension is between economic growth and the environment, specifically its water resources. The latest of these plans, the 13th Five-Year Plan (2016–2020), has put more pressure on the country's scarce water resources to play the expected dual economic and ecological role. Water itself is paramount to the implementation of the PRC government's main priority agenda, including green development, rural vitalization, development of the Yangtze River Economic Belt, and ecological civilization.

Water is one of the most pressing resource bottlenecks in the PRC's ongoing rapid economic growth. The gap between the country's growing water demand and dwindling water supply is creating pressure on all sectors to do more with less; besides, its annual per capita freshwater resources are among the lowest for a major country. An uneven spatial and temporal water distribution is another problem that the PRC has to contend with—e.g., a more water-stressed agricultural northern region versus the industrial southern region; imbalanced rainfall patterns, with rainy season clustered in consecutive months; and a natural proclivity to long dry seasons and multiyear droughts. Likewise, climate change has brought tremendous uncertainty, damages, and losses. The impacts of water scarcity, including water pollution, have cost the country roughly 2.3% of gross domestic product (GDP) annually, while the damages caused by all types of pollution have reached an estimated 6%-9% of GDP. Growth in the PRC's population, cities, and economies will continue to drive up demand for water.

The government is, nonetheless, determined to keep the economy on track. Accomplishing the country's economic goals with minimal costs to the environment is the real challenge. One of the primary targets of the 13th Five-Year Plan has been to create a "moderately prosperous society," with 60% of the population living in cities by 2020. This requires concentrations of people with spendable income in cities. Implementation of the plan has highlighted the growing tension generated by continuing fast-paced economic growth amidst the slower-paced development of water resources and service delivery, which has been exacerbated by the uncoordinated actions of diverse agencies and bureaus that manage them in an attempt to meet demand. In early 2018, the PRC government began its comprehensive institutional reform aimed at making the administration better structured, more efficient, and service-oriented. Although the water-related tasks across ministries seem fragmented and, thus, remain a bottleneck to water reforms, the recent restructuring can be considered a positive step forward.

To address the question of how secure the country's water resources are, the Asian Development Bank (ADB) supported the Ministry of Water Resources in preparing a country water assessment (CWA) of the PRC. The CWA developed a baseline of the country's general water situation. It also took stock of laws, policies, plans, and practices that are affecting water resources, water service delivery, climate resilience, and the country's long-term water prospects. With water security declining in many parts of the PRC, strengthening the resilience of affected regions and their populations to water-related stress becomes crucial not only to ensure future water supply but also to combat food and energy price volatilities that have major global ramifications. The country's ability to make more water available for domestic, agriculture, energy, industry, and environment uses will depend on better water resources management and more cross-sector planning and integration.

The objective of this study is to provide an overview of the PRC's water security situation, assess the policy and institutional requirements for addressing it, and recommend strategic areas for strengthening and reform. The five dimensions of water security covered in the research are domestic water security, economic production water security, environmental water security, ecological water security, and resilience to water-related disasters. A summary of key policy recommendations identifies the essential measures needed to effectively move forward the alleviation of water security issues in different timeframes. Among these measures are the strengthening of water security governance and regulatory framework; promotion of an integrated and coordinated approach to water resources development and management; improvement of water infrastructure and eco-environment protection, including the establishment of red lines for aquatic ecological restoration; and promotion of market instruments, research and development, and public participation.

The partnership between ADB and the PRC on water sector development goes back 30 years. Overall, the ADB–PRC partnership has contributed to a fundamental change in water resources management. This publication affirms the actions for the water sector outlined in the current plan, and will support the formulation of the 14th Five-Year Plan (2021–2025). The recommendations section aims to leverage the progress that has so far been made but, at the same time, address the gaps and problematic areas in the upcoming development plans.

The PRC has long been facing major challenges in managing its scarce water resources to sustain economic growth, maintain its ecosystem, and protect its water resources in the years ahead. I believe this comprehensive publication will assist the government in accelerating its efforts to address water security issues. This is also an excellent resource for shaping the framework of future ADB–PRC collaboration and for strengthening support to the government's goal of building a prosperous, secure, and healthy society.

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Abbreviations

ADB	–	Asian Development Bank
AWDO	–	Asian Water Development Outlook
CNY	–	yuan (currency of the People's Republic of China)
COD	–	chemical oxygen demand
CPS	–	country partnership strategy
CWA	–	country water assessment
CWWTP	–	centralized wastewater treatment plant
DWS	–	domestic water security
EcWS	–	ecological water security
EnWS	–	environmental water security
EPWS	–	economic production water security
GDP	–	gross domestic product
NH_3-N	–	ammonia nitrogen
NPSP	–	nonpoint source pollution
PPP	–	public–private partnership
PRC	–	People's Republic of China
PSP	–	point source pollution
RWD	–	resilience to water-related disaster
SDG	–	Sustainable Development Goal
WPA	–	water protected area
WUA	–	water user association
YREB	–	Yangtze River Economic Belt

Weights and Measures

bcm	–	billion cubic meter
km	–	kilometer
km^2	–	square kilometer
m^3	–	cubic meter
MW	–	megawatt

Executive Summary

Introduction and Approach

The 13th Five-Year Plan (2016–2020) for Economic and Social Development of the People's Republic of China (PRC) details the country's development directions. According to the plan, efforts should be made to raise efficiency in developing and utilizing resources, and sharply reducing the discharge of major pollutants. Specific attention would be given to promoting coordinated development of the Beijing–Tianjin–Hebei region and building the Yangtze River Economic Belt (YREB). Also, the development of urban–rural integration will be promoted, space for rural development will be broadened, and targeted measures will be taken to alleviate and eliminate poverty. An important policy objective is also to upgrade the stability of natural ecosystems (such as forests, rivers, lakes, wetlands, and oceans) and to ensure the ecosystem services they provide.

Continuous acceleration in the PRC's population, socioeconomic, and industry growth over the past 100 years has led to progressively severe issues relating to freshwater shortage, ecological destruction, water pollution, and increase incidence of drought and flood risks. In some areas, water resources development has already exceeded its carrying capacity or is close to the point of resource limitation. The deterioration of water quality has destroyed the functioning of the ecosystem, and water risks caused by human interventions have increased considerably. In other words, water security in the PRC has become a major constraint for the sustainable development of the country.

Lack of water security has particularly become a major problem. This was hardly imagined 50 years ago, but it is now widely accepted that the conventional ways of developing and managing the country's water resources must be significantly reformed to support sustainable growth in the 21st century. To avoid catastrophic consequences for future generations, comprehensive and sustained commitments and immediate actions must be made to apply without delay the strategies and actions needed to bring water resources utilization back to a sustainable balance, to restore healthy aquatic ecosystem, and to lower the water risks to an acceptable level.

Understanding the importance of water security for national sustainable development and to ensure water security, the Asian Development Bank (ADB), in cooperation with the Ministry of Water Resources and the Ministry of Finance, initiated the technical assistance project on country water assessment (CWA) of the PRC, which started in May 2015. The inception workshop was undertaken in June 2015, the interim workshop in November 2015, and the final workshop in June 2016, to review the inception report, interim report, and final report, respectively, with wider participation of the stakeholders.

The results of the CWA are summarized in this report. Chapter I gives an overview of the methodological approach and conceptual framework used in the study; Chapter II delves on the issues and current state of the PRC's freshwater resources; and Chapter III presents the legal and policy environment as means for the government to address the country's water issues. Chapter IV provides an in-depth discussion and analysis of the results of the CWA. Chapter V highlights the drivers for improving water management, followed by a proposed strategic framework for water resources management in Chapter VI. Chapter VII summarizes key policy recommendations to improve water security in the PRC. Finally, Chapter VIII explores the opportunities for further cooperation between ADB and the PRC.

The State of Freshwater Resources in the People's Republic of China

Water resources play a very important role in the rapid socioeconomic development of the PRC. The country's annual freshwater resources reach about 2,800 billion cubic meters (bcm), and per capita water availability is 2,026 cubic meters (m^3), which is only 27% of the world average. Moreover, the spatial and temporal distribution of the water resources is very unbalanced. The northern PRC, for example, covers 64% of the national territory area, 46% of the population, and 60% of the cultivated areas, yet it has only 19% of the national water resources.

In 2014, the PRC's water supply was approximately 609.5 bcm, 81% of which came from surface water. Development and utilization degrees of water resources are uneven across the country: high in the northern PRC and the northwest region, and relatively low in the southeast coast and southwest region. The rural sector accounts for over 60% of total water use. Domestic or household water use and industry water use are higher in developed regions, while the proportion of agriculture water use is higher in the relatively backward regions. In 2014, the PRC's per capita water use was reported at 447 m^3—much lower than the water use quota in the United States and other developed countries. The national rural tap water coverage was 75%.

In terms of water quality issues, national urban domestic and industrial wastewater effluent reached 77.1 bcm in 2014, of which an estimated 61.0 bcm is discharged into water bodies. Although surface water quality has improved somewhat in a few local areas in recent years, groundwater pollution continues to be a prominent issue in some regions. The ratio of state-controlled sections of surface water bodies assessed as worse than water quality Class V reached 9% in 2014.

More than 55% of the land area belong to ecologically fragile regions. Most of these areas are located in the middle and western PRC, with less water availability and vulnerable vegetation coverage. These areas are generally poor and highly sensitive to ecosystem stability, are prone to impacts of human activities, and are difficult to protect and rehabilitate.

In addition, the PRC suffers from frequent flood and drought disasters each year, which constrain socioeconomic development. Annual average losses from these disasters, as a proportion of gross domestic product, was estimated at 0.6% (2012–2014), with 124.6 million people affected.

The following are the main water issues faced by the PRC:

(i) **Water shortage.** This is caused by insufficient natural water resources, a deficit of supply over demand, and low water use efficiency in urban areas, by industry and by agriculture across the country. National water shortage is estimated to be about 50 bcm per year. Water shortages are relatively pronounced in Hai River, Liao River, and Yellow River.

(ii) **Severe water pollution.** Because of the untreated pollutant discharge, the ecological assimilative capacity of many water bodies has been exhausted. Eutrophication of several lakes and reservoirs remains unabated. Groundwater pollution has spread from the urban areas to the periphery.

(iii) **Aquatic ecosystem degradation.** The aquatic ecosystems in many of the PRC's rivers and lakes are in an advanced stage of degradation, with some areas having passed the tipping point where restoration becomes very challenging.

(iv) **Insufficient water-related disaster mitigation capacity.** Frequent flood and drought disasters have brought threats to regional economic development as well as social well-being and security.

(v) **Low water use efficiency.** Although water use efficiency has improved in recent years, the overall level is still low. Leakage rates of city water supply pipeline networks are as high as 15%. Water use per CNY10,000 industry added value is 60 m^3, while farmland irrigation efficiency is 0.53. These data demonstrate large gaps when compared with levels in advanced countries.

(vi) **Insufficient water services.** The deficiencies in the management of water supply and wastewater services have become prominent. Only 70% of surface drinking water sources used for public water supply meet the PRC's national water quality standard. Urban wastewater management is poor compared to water supply management. However, rural wastewater collection and treatment are much weaker.

(vii) **Weak water governance.** The PRC's water security risk has been exacerbated by ineffective water legislation and its poor enforcement, a fragmented institutional setup, limited public involvement in water affairs, and insufficient mobilization of market and economic instruments. A growing number of policy instruments and their weak linkages may cause some of these dilemmas.

Legal and Policy Environment

The PRC has made remarkable progress in improving its legal framework and implementing institutional reforms in water management. The government attaches great importance to law enforcement. Public participation and supervision have been strengthened, particularly in terms of law formulation and enforcement.

At the same time, major policy development and macrostrategies related to water have been implemented, with beneficial implications for water resources management. These include the Beijing–Tianjin–Hebei region water resources system development and the YREB development.

Water resource allocation schemes in and between basins have been developed. Meanwhile, implementation of stricter regulatory and economic instruments, such as water and pollution discharge trading, has been started. Water monitoring and metering have likewise been strengthened.

Some of the specific policies being implemented include the following:

(i) the three water resource red lines for water use, irrigation efficiency, and water quality;

(ii) the ecological red line policy, which targets ecosystem protection;

(iii) rural vitalization, which aims to improve irrigation efficiency and reduce erosion and pollution from nonpoint sources;

(iv) the "sponge city" concept for addressing urban flooding problems and improving the livability of cities; and

(v) the "river chief" system in which local government officials are appointed to improve water governance, particularly in relation to controlling water pollution.

All these developments form important boundary conditions and provide supporting tools to increase the water security of the country.

Assessment of Water Security: Providing Water-Related Services

"Water security" in this report follows broadly the definition of the United Nations: the reliable and sustainable availability of an acceptable quantity and quality of water for health, livelihoods, and production, coupled with an acceptable level of water-related risks (UN-Water Task Force on Water Security). In order to provide a better understanding of the PRC's current water security condition, and to support the development of water scenarios and policy options for the future, a comprehensive quantitative water security assessment has been conducted, taking reference from the approach and principles of ADB's 2016 *Asian Water Development Outlook* (AWDO).

The PRC's water assessment methodology utilized five overarching water security dimensions: domestic water security (DWS), economic production water security (EPWS), environmental water security (EnWS), ecological water security (EcWS), and resilience to water-related disasters (RWD). The methodology identified 20 assessment indicators based on the current and most important water security risks facing the PRC. The CWA approach was applied at both provincial and river basin levels, and results were aggregated at the national level. Projections were made for 2020 and 2030 to assess future water security risk.

The overall result of the assessment indicates that the PRC's current water security is *basically secure* at the national level. DWS and RWD are considered *moderately secure*, whereas EPWS, EnWS, and EcWS are *basically secure*. EnWS is markedly at the lower end of the scale, at the border between *slightly insecure* and *basically secure*. The current water security status implies that there is further room for future improvement.

Another perspective on water security and on setting targets for increasing water security is to consider the Sustainable Development Goals (SDGs). In particular, SDG 6 on water is important; hence, the PRC government has defined clear actions to achieve the SDG 6 targets by 2030.

Drivers for Better Water Resources Management

The PRC has made great strides in socioeconomic development since 1949—i.e., achieving a long-term, sustained, rapid, and steady economic growth, and gradually shifting its economic structure from the primary industries to the higher-quality secondary and tertiary industries.

With a population reaching over 1.37 billion, the PRC is the most populous country in the world. In 2014, its urbanization rate has reached 54.8%. A reduction of about 5% in the PRC's natural growth rate has, nonetheless, been noted in 2010–2014. Regional population migration has also been observed from the western to the eastern regions, from the cold northeast toward the southern areas, and from the rural areas to the urban areas. The population of the PRC is facing two main challenges: aging and urbanization. The major driver of urbanization is the migration of people in the rural areas to work outside the agriculture sector and into urban industry and services. With the escalation of urbanization, city clusters and economic zones like the YREB have been established and have become the growth centers of the PRC's economy.

For the past 30 years, the income and consumption levels of urban and rural residents have significantly improved, and the consumption structure has also changed. However, the living standards in different regions of the PRC are still starkly unbalanced. The employed population has increased, with employment structure changing dramatically as the tertiary industry becomes the main hub of employment.

While population and economic growth are the major drivers for improving water management in the PRC, the following developments should also be taken into account:

(i) **Climate change.** This is an undeniable phenomenon foreseen to raise the frequency and intensity of floods and droughts. Sea level rise is also expected to adversely impact the coastal areas.

(ii) **Energy development.** This is taken in the context of economic development and welfare promotion, hydropower generation, and the need for cooling water, all of which will impact the water resource system.

(iii) **Rural development.** This includes relevant policy objectives of the government, which will also evolve as drivers for better water management, e.g., the rural vitalization program.

(iv) **Water–food–energy nexus.** This refers to the impacts of water scarcity, water pollution, or climate change on food and energy production.

(v) **Poverty reduction.** This shows that improving water supply and services, including water infrastructure, is essential in the government's poverty reduction efforts, particularly in the country's poverty regions.

Strategic Framework for Water Resources Management

Water security is regarded as a critical dimension of national security by the PRC government. Many recent national policies have addressed requirements for water resources management, protection, and sustainable utilization. The guidance for the planning of the national socioeconomic development used in the design of the 5-year plans, including the 13th Five-Year Plan, outlines the importance of water security and the requirements to mitigate all water risks—especially quality issues, quantity shortages, and continuing ecological deterioration.

Goals

The recommended strategy toward greater national water security of the PRC defines five primary goals: (i) accelerated green economy, (ii) improved modern water infrastructure networks, (iii) advanced water services, (iv) improved aquatic ecosystems protection and rehabilitation, and (v) modernized water governance and management systems.

Assessing the experience since 2000 and aggregated using 2014 as baseline, three scenarios (low, medium, and high) were developed that analyze several parameters—e.g., different development regimes, water conservation tracks, water supply options, and wastewater treatment alternatives. The analyses cover the period until 2030 and describe how the water sector could be improved.

Strategies

Underlying the aforementioned goals are the following recommended strategies:

(i) **Better harmony between human activities and water** through (a) establishment of a water resources carrying capacity warning system, (b) optimization of economic development in relation to water use, and (c) strengthening of watershed-based comprehensive planning.

(ii) **High efficiency utilization of water** including (a) improved agriculture water savings through rational utilization of agriculture water resources, water-saving irrigation, agronomic water-saving techniques, and improved agriculture management; (b) urban and commercial water savings through efficiency codes for water-using devices, leakage control programs in cities, and water conservation tariffs; and (c) industry water savings through the advancement of structural adjustment and water-saving transformation of high water-consumption industries.

(iii) **More efficient water infrastructure networks** including (a) improvement of main flood protection and disaster mitigation systems, both in the main stem and the small tributaries; (b) optimization of water supply networks through the development of new water resources; (c) promotion of nonconventional water use and development of contingency water sources; (d) improvement of rural water infrastructure through rehabilitation and upgrading of large and medium-sized irrigation systems; and (e) improvement of urban water infrastructure, including the sponge city approach development.

(iv) **Better water services** for urban–rural areas through (a) expansion of water services coverage; (b) improvement of water services standards; (c) enhancement of water services stability and reliability, including the promotion of urban water supply; (d) improvement of rural water supply; and (e) improvement of wastewater treatment services. The sustainable operation and maintenance provision of water services are essential to maintaining quality services.

(v) **Promotion of clean water initiatives** by (a) establishing water protection areas; (b) improving industrial pollution control through strengthened integrated water permits, promotion of cleaner production, and enforcement of separate collection of wastewater and pollutants at source; (c) improving domestic pollution control through domestic wastewater treatment plants; (d) improving management of nonpoint source pollution through strengthened monitoring of vulnerable areas, limited fertilizer and pesticide use, and promotion of bioshields; and (e) improving reuse of treated wastewater through strengthened wastewater recycling and reclamation of water used for nonhuman consumption.

(vi) **Healthy aquatic ecosystem and ecological resilience** to be advanced by (a) improving watershed management through better erosion and siltation control, (b) ensuring aquatic ecological functions and resilience, (c) strengthening the protection and rehabilitation of aquatic ecological space, (d) safeguarding environmental flows and promoting connectivity of water bodies, (e) promoting integrated habitat control and restoration through regulation and restriction of ecosystem abuse, (f) supporting aquatic ecological restoration, and (g) effectively controlling and monitoring groundwater exploitation and use.

(vii) **Modern water governance** to be fostered by (a) strengthening legislation and regulation; (b) establishing institutional reforms, with recommendation to bolster leadership of water security and to set up in each basin a River Basin Commission with legal authority and power to develop technical committees; (c) strengthening enforcement of water management and regulation for aquatic ecological space, including management of the permit and postpermit processes for water abstraction, wastewater pollution discharge, and environmental flows; (d) enhancing transparency and public participation; (e) developing economic instruments in the water sector; and (f) holistically improving the water monitoring process from water development to wastewater discharge, as well as administration and capacity building of operators. The PRC has already established an ecological and environmental supervision and management bureau for the Yangtze River Basin, and is planning to do the same for other river basins.

(viii) **Water risk management** to be strengthened through (a) national water risk mapping, (b) water hazard identification and marking, (c) enhanced risk management and regulation system, (d) improved water risk early warning system and emergency response system, and (e) heightened resilience to climate change risks.

Implementation Measures

The current PRC water governance framework should be reformed to make policies and institutions better adapted to the changing socioeconomic conditions, the evolving quality of the water environment, and the multiple water-related challenges faced by the country. Water governance has multiple dimensions, with each requiring specific rules, authority instruments, and management practices to ensure overall water security.

The following measures for policy improvement in water governance are therefore recommended:

(i) **Strengthen legislation and policy.** This will include (a) revision of some laws and formulation of new laws and regulations, (b) removal of policy inconsistency, (c) filling-in of policy gaps, (d) development of water rights, and (e) improvement of water abstraction and pollution discharge permits.

(ii) **Complement institutional reforms.** This will be done through (a) the establishment of water security leadership and coordination; (b) greater integration of water-related policies, institutions, and administrative procedures to speed up cross-sector planning and decision-making; (c) the development of more integrated watershed management and the integration of urban water affairs; (d) the development of independent regulators and water service operators; and (e) training of all levels of administrators and operators of water-related services to improve their management capacity.

(iii) **Improve regulation and enforcement.** This should encompass (a) aquatic ecological space protection through the designation of blue lines (potentially inundated areas or boundaries), green lines (buffer zones with prohibited or restricted development), and gray lines (controlled land use of areas that can impact or be impacted by water) to prevent land use and urban development from building permanent structures that encroach or occupy water spaces; (b) strict allocation of water resources within the sustainable availability levels to enhance water abstraction and use regulation; (c) effective control of treated wastewater from industries, cities, and towns discharged into water bodies; (d) strengthened regulation of environmental flows; (e) periodic analysis and assessment of water security and risks for the enhancement of water risk regulation; (f) clarification of ownership and responsibility of owners of different types of water infrastructure assets; and (g) improvement of metering and monitoring of water resources quality and quantity, water supply system, wastewater treatment discharge, and aquatic ecosystem changes.

(iv) **Promote better public and stakeholder involvement.** This can be pursued through improved access to water information, greater transparency, and open participatory procedures with respect to decision-making processes on water affairs. There should be greater accountability among managers and decision makers in water administration at all government levels, as well as in the water service sector, with the help of quantitative and objectively verifiable performance indicators and targets.

(v) **Establish market mechanisms.** These include (a) the use of water pricing in water services, irrigation water, water abstraction charges, and pollution charges for treated discharge into water bodies to better reflect water scarcity, water quality improvement needs, and the full cost of water supply and wastewater management services; (b) the establishment of water rights market and pollution discharge rights market, and the strengthening of regulation for water rights and pollution discharge rights trading; (c) the establishment and improvement of the engineering construction market with the promotion of public–private partnership solutions for revenue-generating water services; and (d) the establishment of operation and management markets with the development of water service enterprises and the implementation of contract management.

Key Policy Recommendations on Water Security

To improve water security in the PRC, the following key policy recommendations are provided: (i) strengthen water security leadership and coordination; (ii) promote an integrated approach to water resources development and management; (iii) upgrade and improve the legal and regulatory framework; (iv) set up red lines, criteria, and checklists for aquatic ecological protection; (v) implement better eco-environmental protection and restoration measures; (vi) improve water infrastructure upgrade, construction, and management; (vii) improve water demand management and water conservation; (viii) mobilize market and economic instruments; (ix) enhance transparency and public participation; and (x) promote research and development of innovative solutions.

Opportunities for Cooperation

From the water security issues and key recommendations discussed in this report, ADB can provide support for the development and implementation of new water-related policies, programs, projects, and strategies in the PRC. Other potential areas of cooperation include support for (i) implementing the PRC's commitments under its climate change strategic framework; (ii) achieving the country's targets under its 2030 sustainable development agenda; (iii) promoting the spatial, functional, and organizational integration of the PRC's water governance structure; (iv) integrating flood and environmental risk management into national plans and projects; (v) implementing eco-compensation mechanisms through both lending and nonlending operations; and (vi) preparing and formulating the PRC's 14th Five-Year Plan (2021–2025).

CHAPTER I

Introduction and Approach

Since 1950, the Government of the People's Republic of China (PRC) has been plotting its development with a series of 5-year socioeconomic plans that lay out the priorities and targets for public and private sectors. These plans conform to a centralized narrative of what the country has accomplished, its vision for the near future, and how it intends to use policies and investments to achieve its goals. The 5-year plans have increasingly recognized the symbiotic relationship between economic growth and the environment, specifically water resources, but that relationship has not been mutually beneficial. The current plan, the 13th Five-Year Plan (2016–2020), depends on water resources to continue to play a dual, and sometimes contradictory, economic and ecological role.

On the one hand, the latest plan calls for greater efficiency in developing and utilizing resources and in sharply reducing the discharge of major pollutants. On the other hand, the plan promotes the economic development of the Beijing–Tianjin–Hebei region and the Yangtze River Economic Belt (YREB), and even extends its targets transcontinentally with the proposed Silk Road Economic Belt and the 21st-Century Maritime Silk Road. At the local levels, the plan calls for continued urban–rural integration, broadened space for rural development, and targeted measures for poverty alleviation and elimination. It also aims to upgrade the stability of forests, rivers, lakes, wetlands, oceans, and their ecosystem functionality.

Water resource economists warn that water is the most pressing resource bottleneck in the ongoing growth path of the PRC over the next 10–15 years. Gaps between the growing water demand from all sectors and the dwindling water supply are creating pressure to do more with less. Annual per capita freshwater resources are among the lowest for a major country. The PRC also contends with the uneven distribution of water sources between the agricultural north and the industrial south, uneven rainfall patterns, and a natural proclivity to long dry seasons and multiyear droughts. In addition, climate variability and climate change bring uncertainty, damages, and losses. Water scarcity and the direct impacts of water pollution have already cost the PRC an estimated 2.3% of gross domestic product (GDP) annually.[1] The cost of all types of pollution damages is estimated to be between 6% and 9% of GDP.[2] Growth in the PRC's economies, cities, and population will continue to drive up demand for water across multiple sectors.

Determined to keep the economy on track, the government aims to attain 6.5% annual GDP growth and to double the 2010 GDP per capita by 2020. The government says it will do this by growing domestic consumption, which requires concentrations of people with spendable income, i.e., in cities.

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1 J. Xie et al. 2009. *Addressing China's Water Scarcity: Recommendations for Selected Water Resource Management Issues.* Washington, DC: World Bank.

2 ADB. 2012. *Toward an Environmentally Sustainable Future: Country Environmental Analysis of the People's Republic of China.* Manila.

By 2020, the 13th Five-Year Plan wants 60% of the population to be living in a "moderately prosperous society" in cities.

The challenge is to accomplish economic goals with minimal costs to the environment, taking into account that water resources are finite and in a troubled state. The 13th Five-Year Plan is another thorn in the growing tension between the PRC's continued medium–high economic growth and the slow-paced recovery of its degraded water systems. The latter is aggravated by weak service delivery and poor coordination among a disparate range of institutions, agencies, and bureaus that manage the country's water resources in an attempt to meet demand.

The traditional and conventional ways of developing and managing water resources in the PRC must be transformed if its water resources are to support continuing sustainable growth in the 21st century and avoid catastrophic consequences for future generations. Significant, comprehensive, and unrelenting commitments and immediate actions must be made to bring water resources utilization back to a sustainable balance, to restore aquatic ecosystem, and to reduce water risks to an acceptable level.

The Country Water Assessment Study

To understand the policy measures needed for water resources to thrive in support of socioeconomic development, the government recognized the need for a comprehensive assessment of the PRC's current water security and the intricate network of influencing factors. Essentially, the country water assessment (CWA) aimed to answer the question, "Just how secure is the country's water resources?" With the ultimate objective of restoring the quality of the PRC's water systems, the output of the CWA is a strategy to increase overall water security.

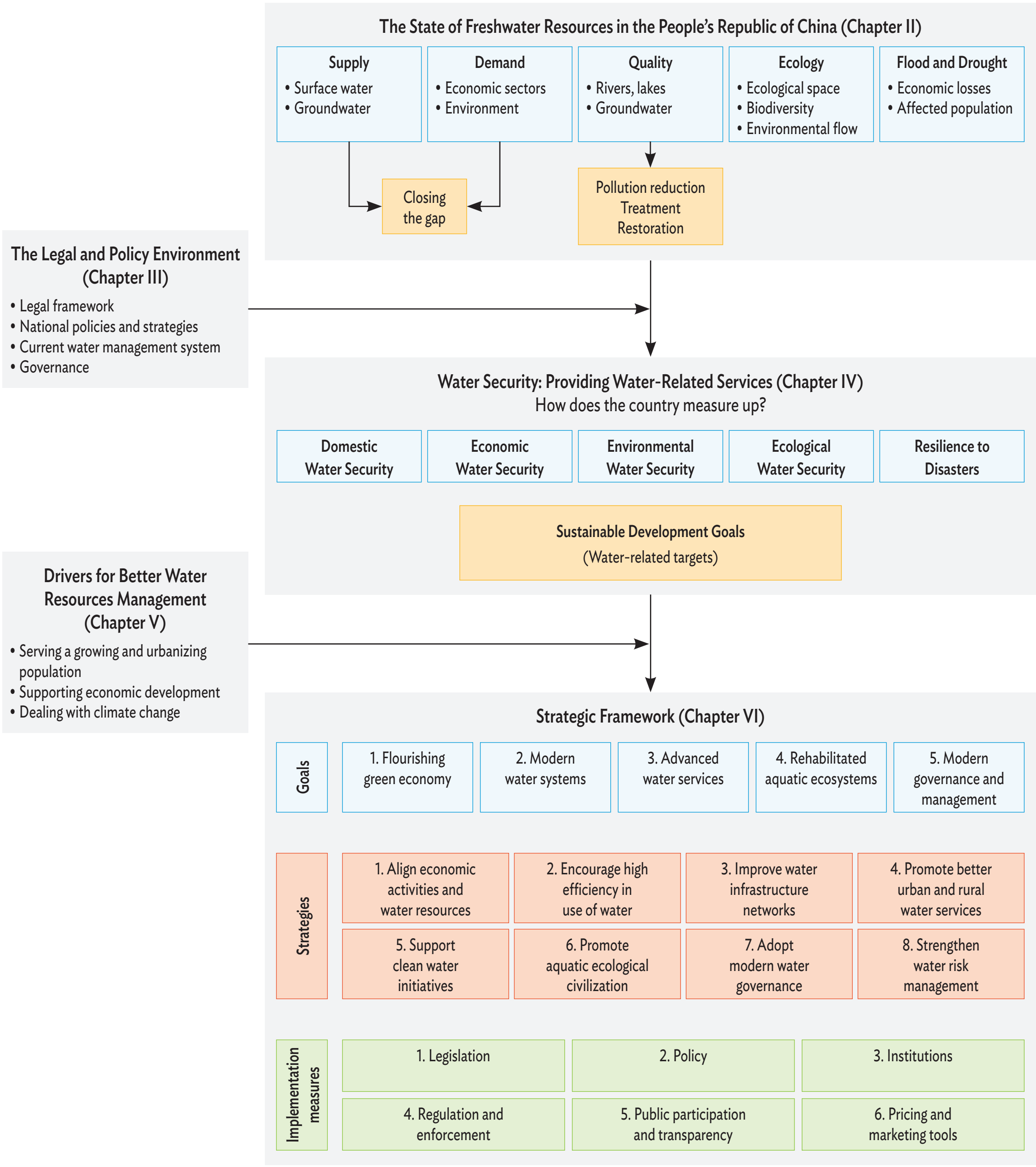
The Asian Development Bank (ADB), the Ministry of Water Resources, and the Ministry of Finance undertook the comprehensive CWA that created a new baseline for the country's general water situation. The yearlong study began in May 2015, with numerous consultations. The CWA took stock of the laws, policies, plans, and practices affecting water resources, service delivery, climate resilience, and the country's long-term prospects.

This report is a synthesis of the CWA's major findings, consequential analyses, and recommendations. The Ministry of Water Resources has used the assessment in formulating both near- and medium-term strategies—e.g., the ministerial-level 13th Five-Year Plan (2016–2020) and the PRC's water management strategy for achieving a green economy and moderately prosperous society by 2020. The CWA has also informed and steers ADB's water operations and country partnership strategy (CPS), thereby helping to prepare and better shape the upcoming ADB–PRC CPS as well as the PRC's 14th Five-Year Plan (2021–2025).

Conceptual Framework

The conceptual framework in Figure 1 provides a general overview of the structure of the publication. It describes the activities carried out in the CWA (further explained in Chapters II–VI) and underpins the analyses of issues and assessments.

Figure 1: Conceptual Framework of the Country Water Assessment of the People's Republic of China



Source: Asian Development Bank.

The State of Freshwater Resources in the People's Republic of China

The first step in the CWA study was to provide an overview of the present state of the country's freshwater resources, focusing on the supply–demand gap and the measures needed to close the gap (Chapter II).

Legal and Policy Environment

Elements of governance determine the enabling environment for overall water security. The CWA evaluated the country's current water-related policies (Chapter III) in order to formulate measures for increasing water security and propose new policy recommendations. Among the policies that were evaluated were on water use, water allocation, water pollution control, flood control, wastewater discharge, water rights trading, pollution discharge rights trading, water pricing, etc. Policies were evaluated from the perspectives of policy guidance, coordination, systems, and integrity. A series of workshops and seminars were held to discuss strategies and the feasibility of proposed measures for greater water security.

Assessment of Water Security: Providing Water-Related Services

In this CWA, the approach and principles used in ADB's *Asian Water Development Outlook* (AWDO) are applied to come up with a methodology adapted to the specific conditions of the PRC that makes scoring possible at the provincial level (Chapter IV). The adapted methodology of the CWA quantifies water security in five key dimensions: domestic water security, economic production water security, environmental water security, ecological water security, and resilience to water-related disasters. To assess these key dimensions and to calculate an overall water security rating, 20 measurable indicators were identified.

As the PRC's economy continues to grow, propelled by the twin engines of rapid industrialization and urbanization, the demand for water (particularly from agriculture, industry, and urban domestic sectors) swells. The geographic mismatch between the country's industrial layout and the location of its water resources has placed the security of regional water supply under increasing pressure. Higher living standards also raised expectations for better public water services. Global climate change and environmental stress from human activities are increasing the possibility of extreme and accidental water disasters. In addition, the PRC's goal of building an ecological civilization has pushed the requirements for better eco-environmental protection and management.

Drivers for Better Water Resources Management

The government has determined impressive ways to transfer massive volumes of water from long distances to where it is needed. Supply typically will match demand; but the question is "for how long?" The challenge of the 21st century for future water and economic security in the PRC is not on engineering but on governance. Effective policies require effective implementation, monitoring, and regulation. Effective institutions require jurisdictions that align with natural resources, rather than administrative functions. Moreover, sustainable water resources require strategically located economic and social activities.

The CWA examined the drivers that have the potential to undermine the country's progress in increasing water supply, managing water demand, and reducing water pollution. These drivers

(Chapter V) are socioeconomic forces that have proven to be beyond the local capacity of natural resources to sufficiently respond to. They are rapid growth in population and urbanization, economic development, climate change, energy development, rural development, pressure on production (water–food–energy nexus), and poverty.

Strategic Framework for Water Resources Management

The national government regards water security as a critical dimension of national security. Many recent national policies have raised expectations for water management, water protection, and sustainable water use. The 13th Five-Year Plan confirms the country's commitment to mitigating water risks, especially in the areas of water pollution, availability, and ecological deterioration.

The proposed overall integrated strategy of the CWA for the PRC's water development focuses on sustainable water resources management in order to improve water security. Chapter VI summarizes the recommended comprehensive strategic framework for addressing the broad issues that will undermine sustainable and long-term socioeconomic development: water shortage, water pollution, degraded aquatic ecosystems, weak water governance, and water-related disasters. The CWA proposes eight strategies, which have been identified for their ability to underpin the economy while bringing economic activities and development (especially urbanization) into alignment with water resources capacity and environmental capacity. These strategies involve major philosophical shifts on how progress and resources are viewed, and require major political will and determination to reign in unsustainable development, growth, and patterns of urbanization.

Methodological Approach for Assessing the Country's Water Resources

The CWA examines not only the PRC's water usage but also the effects of organizational and legislative governance, social and human dimensions, economic development, and eco-environmental processes on the country's water resources. The assessment is based on spatial and temporal scales, which contributed to the formulation of recommendations based on an aggregated analyses at the national, regional, and river basin levels. Comprehensive qualitative research is supported by multidisciplinary technology and data systems. Some of the salient features of the study's methodologies are explained below.

Integrated Information and Database

The CWA collected information and data on the detailed aspects of water usage by, and impacts on, various subsectors and regions. The information was analyzed and populated into an integrated database, which includes the following facts and figures:

(i) **Socioeconomic aspects.** These include impacts on water resources from the population (urban and city, rural); GDP (primary, secondary, and tertiary industries; subsectors); land use; agriculture production (grain production, plant structure, animal husbandry); city development (structure, scale); and energy development (energy production and consumption).

(ii) **Water resources and its development.** This is a profile of water resources, supply, and demand projections based on trends in precipitation; surface water and groundwater availability; water quality; water supply from different sources (surface water, groundwater, others); and water uses (urban and city, domestic or residential, industry, agriculture).

(iii) **Water pollution.** This covers the state of water resources as a result of effluent discharges from urban and industrial wastewater; rural domestic waste production; and nonpoint source pollution (NPSP), particularly from agriculture.

(iv) **Freshwater ecology.** This refers to the condition of the aquatic ecological system as a result of groundwater overexploitation, infringement on minimum environmental flows, and soil and water erosion.

(v) **Water-related disasters.** This pertains to the frequency and magnitude of floods and droughts, and their direct losses and impacts on disaster-affected populations, crop areas, etc.

Quantitative Analyses

The CWA study developed the following tools as bases for formulating measures to increase the country's water security and to set associated targets.

(i) **Water demand and balance model.** Water demand was estimated for sectors and regions based on different water conservation scenarios (low, medium, and high). The analysis included future indexes of socioeconomic development (population growth, urbanization, economic growth, industrial structure adjustment, etc.) in different provinces, regions, and river basins. Water supply and demand were analyzed under different rainfall frequencies in order to allocate water resources properly based on an understanding of restrictions on water resources and eco-environmental water needs, as well as the feasibility of water supply and water conservation.

(ii) **Water pollution load analysis model.** Based on pollution intensity and management level, three scenarios (low, medium, and high) of treatment policies yielded estimates of current and future pollution effluents and discharges of (a) wastewater, chemical oxygen demand (COD), and ammonia nitrogen (NH_3-N) generated as point source pollution (PSP) from urban and city domestic life and industry; (b) COD, NH_3-N, total nitrogen, and total phosphorus generated as NPSP from agriculture runoff, urban runoff, rural domestic life, livestock, and poultry husbandry; and (c) soil and water erosion. This model was run for different bodies of water.

The findings and results of the water demand and balance model and the water pollution load analysis model supported the development of the country water profile, as summarized in Chapter II.

(iii) **Water security assessment model.** Using the principles presented in ADB's *Asian Water Development Outlook*,[3] a water security assessment model was developed under this CWA study. The model comprises 20 indicators for the five key dimensions of water security: domestic water security, economic production water security, environmental water security, ecological water security, and resilience to water-related disasters.

[3] ADB. 2013. *Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific*. Manila; ADB. 2016. *Asian Water Development Outlook 2016: Strengthening Water Security in Asia and the Pacific*. Manila.

Details of this model, together with the resulting analyses and findings, are described in Chapter IV.

(iv) **Disaster resilience assessment model.** Based on various climate change forecasts, the study estimated the past climate change evolution trends and analyzed the future climate change trends and their possible impacts on water supply and water-risk resilience. Recommendations have been proposed for flood control and drought relief.

Detailed discussion on the approaches for the adoption of water-risk resilience to support water security are given in Chapter VI.

Spatial Differentiation

Systematic analyses and evaluation of water resources, water environment, aquatic ecology, water security situation, and water risks were conducted for 31 provinces (municipalities and autonomous regions) and specific water resources regions. To facilitate the presentation of the assessment findings, results were aggregated into six geo-economic regions (Map 1) and 10 Class-I river basins (Map 2). Table 1 presents basic information of these regions and river basins.

The six geo-economic regions are as follows:

(i) **Northeast:** Heilongjiang, Jilin, and Liaoning provinces; and the cities of Chifeng, Hinggan League, Hulun Buir, and Tongliao in the Inner Mongolia Autonomous Region;

(ii) **North:** Hebei, Henan, Shandong, and Shanxi provinces; and the municipalities of Beijing and Tianjin;

(iii) **Southeast Coast:** Fujian, Guangdong, Hainan, Jiangsu, and Zhejiang provinces; Shanghai municipality; and part of Guangxi Zhuang Autonomous Region (excluding the cities of Baise, Hechi, and Chongzuo);

(iv) **Central:** Anhui, Hubei, Hunan, and Jiangxi provinces;

(v) **Southwest:** Guizhou, Sichuan, and Yunnan provinces; Tibet Autonomous Region; Chongqing municipality; and the cities of Baise, Hechi, and Chongzuo in Guangxi Zhuang Autonomous Region; and

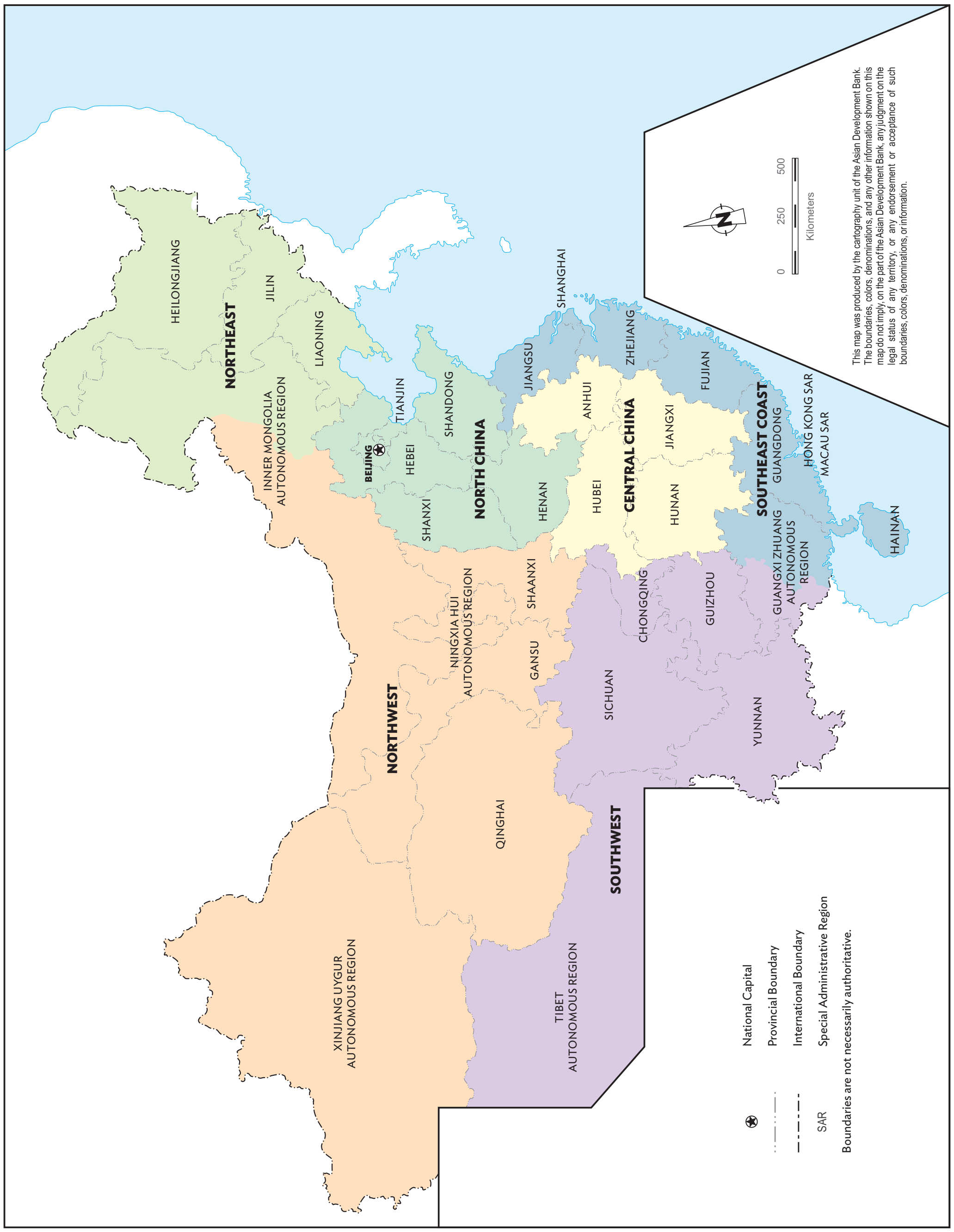
(vi) **Northwest:** Gansu, Qinghai, and Shaanxi provinces; the autonomous regions of Ningxia Hui and Xinjiang Uygur; and the middle and western part of the Inner Mongolia Autonomous Region (excluding the cities of Chifeng, Hinggan League, Hulun Buir, and Tongliao).

Low, Medium, and High Scenarios

Projections on future water security performance were made for 2020 and 2030. Three water security performance scenarios were defined (low, medium, and high) depending on the context: type of development regime or rate of growth (economic growth, industrial growth, population growth); level or intensity of effort employed to improve a particular situation (such as water security enhancement measures or water pollution reduction measures).

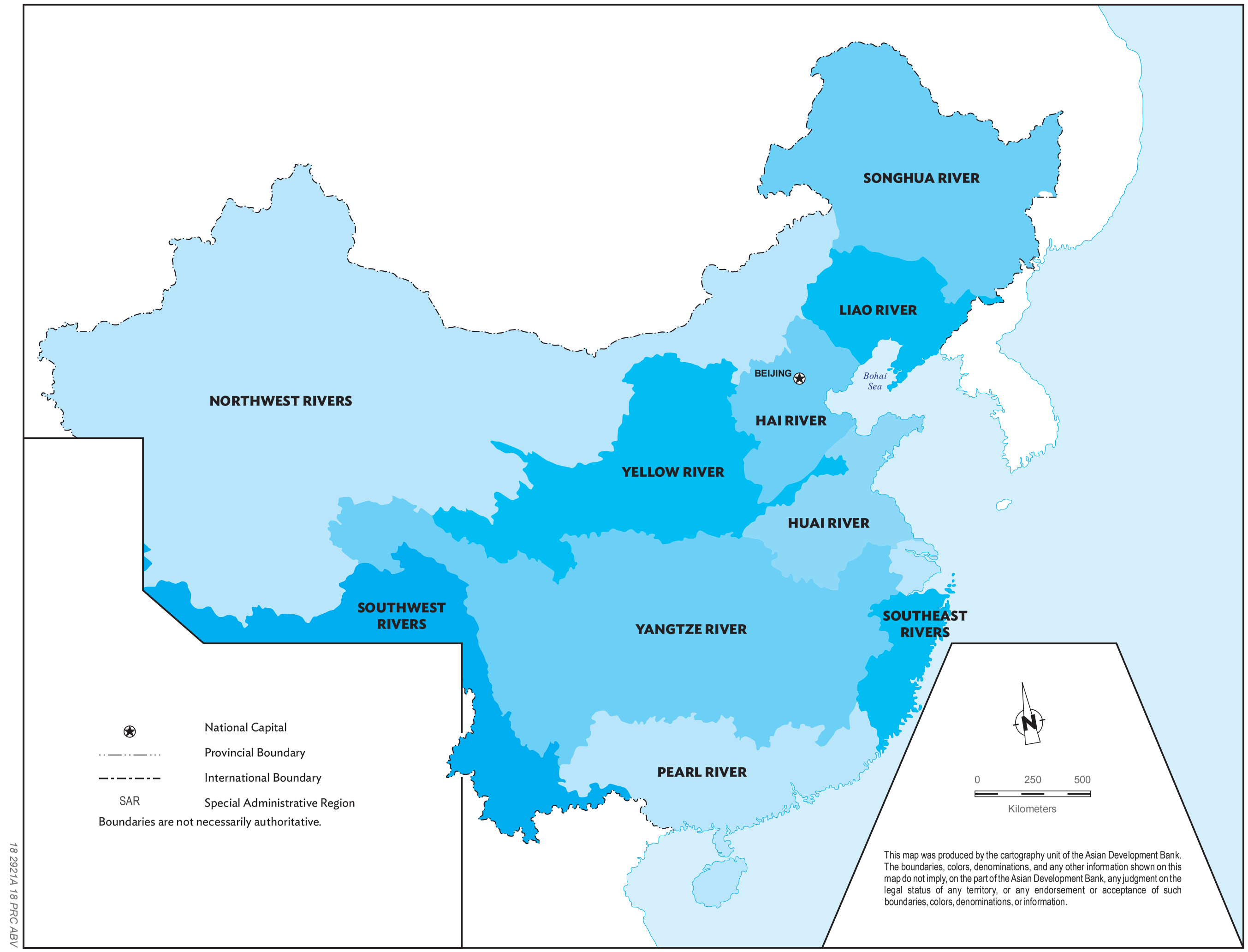
The estimated average growth rates of GDP in 2015–2030 in the PRC are 5.4%, 6.1%, and 6.6%, respectively, for low, medium, and high scenarios. In the low development scenario, the growth rate of the PRC's industries will be slightly slower than that of GDP, and the contribution rate of industry

Map 1: Six Geo-Economic Regions of the People's Republic of China



Source: Asian Development Bank.

Map 2: Division of Class-I Water Resources River Basins, People's Republic of China



Note: The map presents the individual river basins (Hai River, Huai River, Liao River, Pearl River, Songhua River, Yangtze River, and Yellow River) and the clustered river basins (Northwest Rivers, Southeast Rivers, and Southwest Rivers) that make up the 10 Class-I river basins used in the spatial aggregation of the country water assessment findings.

Source: Asian Development Bank.

Table 1: Zoning Adopted in the Country Water Assessment by Region and River Basin

Region/River Basin		Area (1,000 km^2)	Average Water Resources, 1956–2000 (bcm)	2014 Population (million)	2014 GDP (CNY billion)
National Total		**9,484**	**2,843**	**1,361**	**68,472**
Region	Northeast	1,193	155	119	6,369
	North	694	109	339	17,361
	Southeast Coast	749	652	352	23,788
	Central	704	501	232	9,098
	Southwest	2,364	1,155	204	6,815
	Northwest	3,780	271	115	5,041
River Basin	Songhua River	922	149	64	2,853
	Liao River	315	50	57	3,357
	Hai River	319	37	149	8,231
	Yellow River	795	72	119	5,616
	Huai River	329	91	199	9,498
	Yangtze River	1,781	996	453	22,363
	Southeast Rivers	239	268	80	5,341
	Pearl River	575	474	185	9,365
	Southwest Rivers	852	578	22	472
	Northwest Rivers	3,357	128	33	1,376

bcm = billion cubic meter, CNY = yuan, GDP = gross domestic product, km^2 = square kilometer.

Notes:

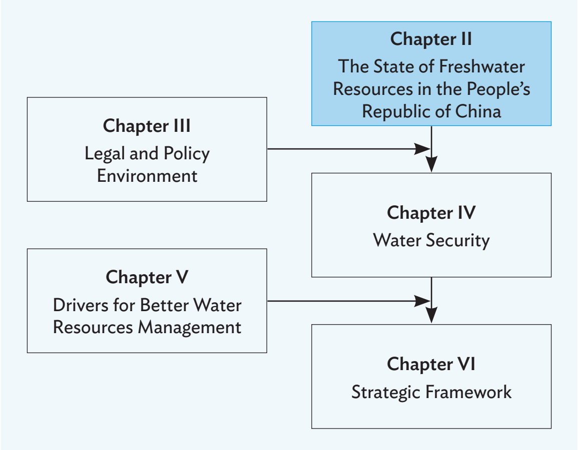
1. Population and GDP data were aggregated into regions and river basins.
2. Population and GDP data do not include Hong Kong, China; Macau, China; and Taipei,China.
3. Numbers may not sum precisely because of rounding.

Sources: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC); Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing; National Bureau of Statistics of China. Various years. *China Statistical Yearbook*. Beijing: China Statistics Press.

to the national economy will decline to about 36% by 2030. Under the medium growth scenario, the national population is estimated to reach 1.45 billion by 2030, and then slowly decline. The population will mainly be concentrated in the northern and southeast coast regions, namely the Pearl River Delta, Yangtze River Delta, and Beijing–Tianjin–Hebei region. After detailed comparison of the results per scenario, the medium scenario is adopted for the country water assessment.

CHAPTER II

The State of Freshwater Resources in the People's Republic of China



The state of freshwater resources in the People's Republic of China (PRC) is not determined by the mere billions of cubic meters flowing in rivers and aqueducts or stored in lakes, reservoirs, and glaciers. The true state of the country's freshwater resources is determined by the users—e.g., the productivity and efficiency of water use by industries and populations, and the quality of the wastewater they return to the river system. The state of national water resources is also not as telling as the conditions depicted at the regional and river basin levels, which (like the Hai and Yangtze river basins) reveal a very different, more troubled story. Still, a silver lining is evident even in the more problematic basins, where growth rates in water usage have begun to decline and stabilize.

This chapter presents a profile established by the country water assessment (CWA) of the PRC's water resources, which is largely determined by the geographic layout of water resources, population, economic activity, and capacity of the ecological landscape to absorb the development footprint.

Total Freshwater Resources

The country's average annual total water resources is 2,843 billion cubic meters (bcm), mostly from surface water (2,740 bcm) and groundwater (822 bcm)—although, about 20.6 bcm of these two sources are actually hyporheic flow or underflow, where the groundwater beneath rivers interacts and combines with surface water. Despite the relatively low significance of groundwater on a national scale, its real importance is evident when examining the structure of water sources in the northern PRC, where access to surface water is far less than in the southern regions. The average annual amount of water resources in the different regions and river basins is shown in Table 2.

The per capita ratio of water resources is just 2,026 cubic meters (m^3), only 27% of the world's average and among the lowest for a major country. Actual average per capita water use is only 447 m^3, which is a rate far less than other developed countries (e.g., 1,582 m^3 per capita in the United States).[4] According to the Food and Agriculture Organization of the United Nations (FAO), a country is facing

[4] Organisation for Economic Co-operation and Development. 2017. Water Withdrawals (Indicator). doi: 10.1787/17729979-en (accessed 6 September 2017).

Table 2: Average Annual Water Resources by Region and River Basin, 1956–2000
(bcm)

Region/River Basin		Precipitation	Surface Water	Groundwater	Overlapping	Total
National Total		**6,178**	**2,740**	**822**	**719**	**2,843**
Region	Northeast	456	133	54	32	155
	North	430	73	60	25	109
	Southeast Coast	1,220	643	167	159	652
	Central	964	489	125	113	501
	Southwest	1,957	1,155	272	272	1,155
	Northwest	1,058	247	129	105	271
River Basin	Songhua River	472	130	48	28	149
	Liao River	171	41	20	11	50
	Hai River	171	22	24	8	37
	Yellow River	354	61	38	26	72
	Huai River	277	68	40	16	91
	Yangtze River	1,937	986	249	239	996
	Southeast Rivers	437	266	67	65	268
	Pearl River	897	472	116	115	474
	Southwest Rivers	919	578	144	144	578
	Northwest Rivers	542	117	77	67	128

bcm = billion cubic meter.

Note: Numbers may not sum precisely because of rounding.

Sources: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC); Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing.

scarcity when the water availability is less than 1,000 m^3 per capita and absolute scarcity when the water availability is less than 500 m^3 per capita.

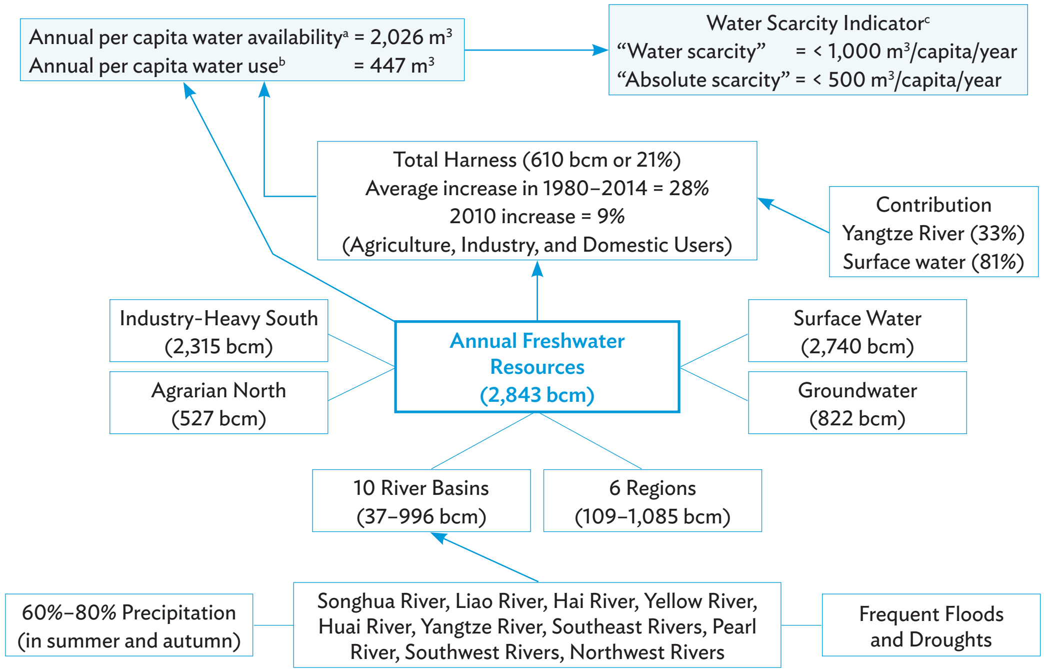
Distribution

Water resources are unevenly distributed across the country, with 81.5% of water resources concentrated in the industry-heavy southern PRC (2,314.5 bcm) compared to just 18.5% of water resources in the agrarian north (526.7 bcm) (Figure 2). To illustrate the imbalance between socioeconomic development and accessibility to water resources, consider that northern PRC covers 64% of the national territory and is home to 46% of the population and 60% of the country's cultivated areas, yet has access to less than 20% of the country's water resources (Map 3).

General Trends in Variation

On a national scale and over a relatively long time series (1956–2014), the volume of total freshwater resources would appear stable—no significant linear trend variation. Declining trends begin to appear in 2001 and in some basins. Average annual water resources from 2001 to 2014 were 20.1% below

Figure 2: Water Resources Distribution, Supply, and Per Capita Availability in the People's Republic of China



bcm = billion cubic meter; m^3 = cubic meter.

[a] The country's per capita water availability level is among the lowest globally at approximately 27% of the world's average.

[b] This is far below the per capita water use of other developed countries (e.g., 1,582 m^3 per capita per year in the United States).

[c] Water scarcity indicator refers to the amount of renewable freshwater that is available for each person per year.

Source: Asian Development Bank.

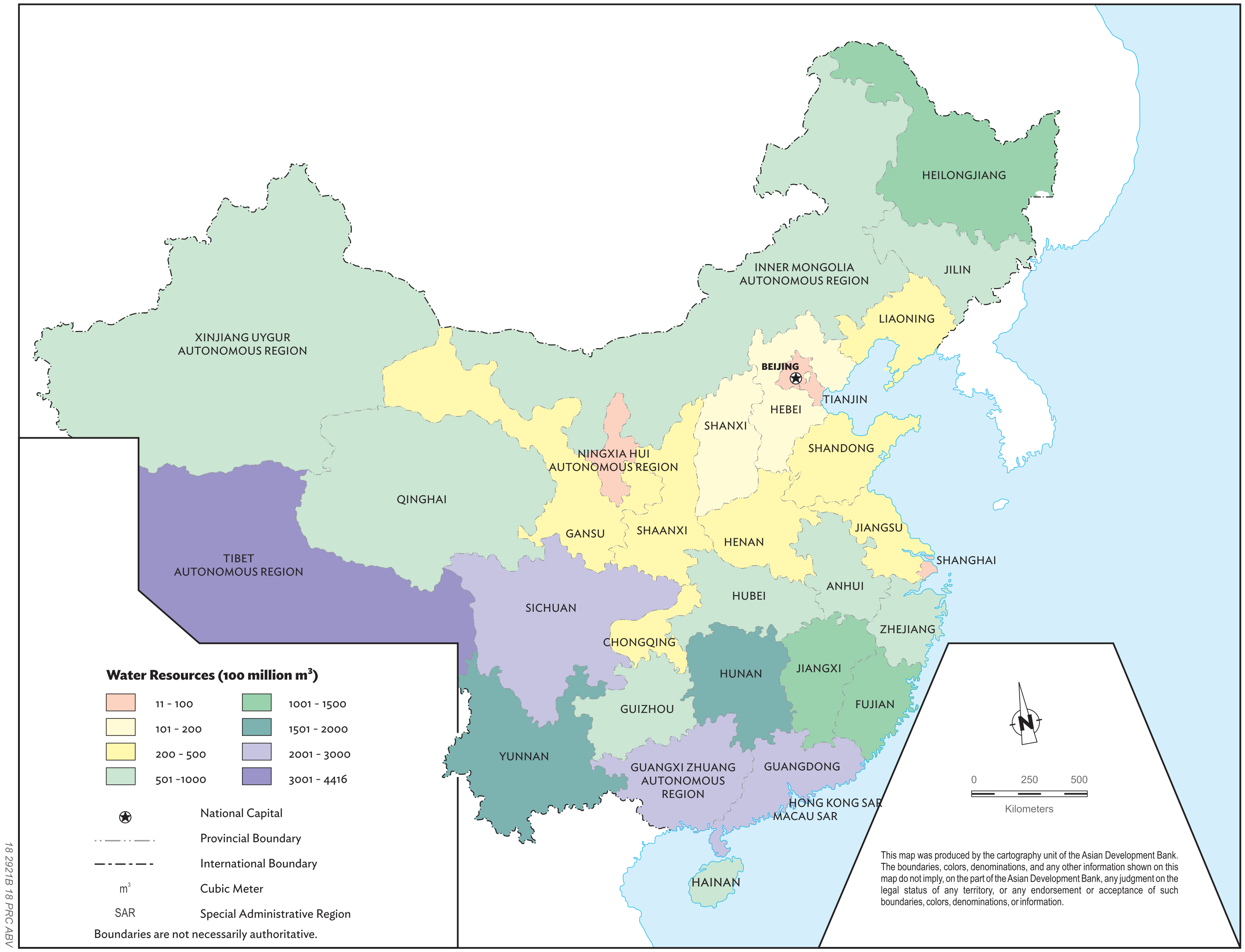
average in the Hai River, 5.3% below in the Yellow River, and almost 6.8% below in the Liao River. Figure 3 indicates a declining trend among the northern PRC basins of Hai River, Liao River, and Yellow River. Water resources in these northern regions compared to other regions are more variable. The same negative trend is not apparent among different river basins in the southern PRC, where annual average water resources show no obvious changes over time.

The Hai River Basin has experienced a unique and significant decline in absolute water resources since 2000 (Figure 4). With declining water resources in some areas and annual variation increases in others, there is an intensification of risk to water supply in those regions.

Water Supply

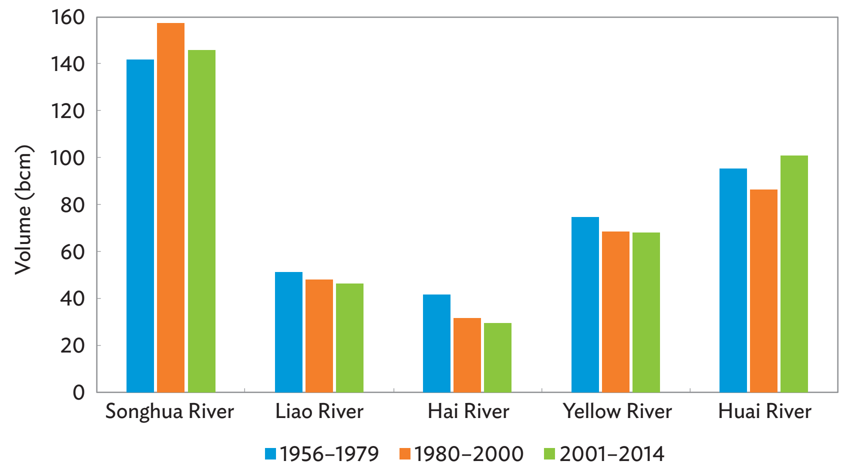
Of the 2,843 bcm of freshwater resources in the country, 609.5 bcm (21% of total freshwater resources) is harnessed to supply agriculture, industry, and domestic users. The majority of this supply comes from surface water (81% or 492.1 bcm), followed by groundwater (18% or 111.7 bcm), and other sources (1% or 5.8 bcm). Table 3 indicates water supply sources by region and river basin.

Map 3: Water Resources Distribution in the People's Republic of China, 1956–2000



Source: Asian Development Bank.

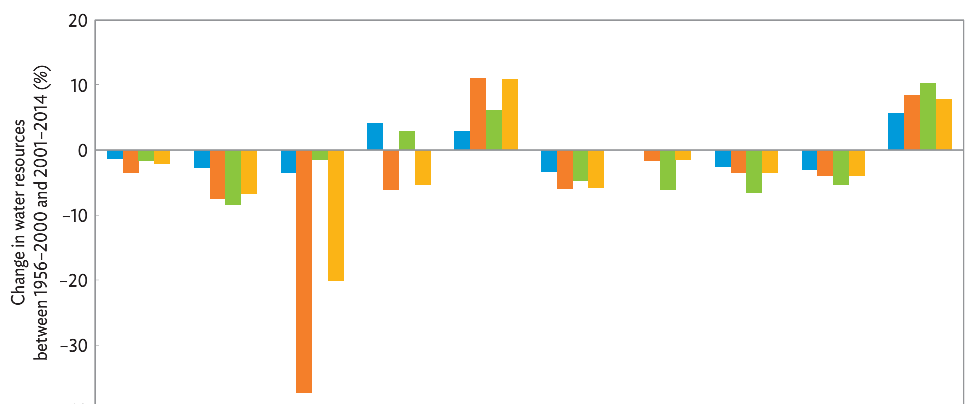
Figure 3: Water Resources of Selected Northern River Basins by Different Periods



bcm = billion cubic meter.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Figure 4: Comparative Trend in Total Water Resources of River Basins, 1956–2000 and 2001–2014



	Songhua River	Liao River	Hai River	Yellow River	Huai River	Yangtze River	Southeast Rivers	Pearl River	Southwest Rivers	Northwest Rivers
Precipitation	−1.4	−2.8	−3.6	4.1	3.0	−3.4	0.0	−2.6	−3.0	5.7
Surface Water	−3.5	−7.5	−37.3	−6.2	11.1	−6.0	−1.7	−3.6	−4.0	8.4
Groundwater	−1.6	−8.4	−1.5	2.9	6.2	−4.7	−6.2	−6.6	−5.4	10.3
Total	−2.2	−6.8	−20.1	−5.3	10.9	−5.8	−1.5	−3.6	−4.0	7.9

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 3: Water Supply by Region and River Basin, 2014
(bcm)

Region/River Basin		Surface Water	Groundwater	Others	Total
National Total		**492.1**	**111.7**	**5.8**	**609.5**
Region	Northeast	39.5	30.3	0.5	70.3
	North	31.5	40.8	2.8	75.0
	Southeast Coast	178.7	4.7	1.1	184.5
	Central	108.2	6.6	0.4	115.2
	Southwest	60.1	3.3	0.5	63.9
	Northwest	74.1	26.1	0.6	100.7
River Basin	Songhua River	28.9	21.9	0.1	50.8
	Liao River	9.8	10.4	0.3	20.5
	Hai River	13.3	22.0	1.8	37.0
	Yellow River	25.5	12.5	0.8	38.8
	Huai River	45.3	15.6	0.8	61.7
	Yangtze River	192.0	8.1	1.2	201.3
	Southeast Rivers	32.7	0.8	0.1	33.7
	Pearl River	82.5	3.3	0.4	86.2
	Southwest Rivers	9.9	0.5	0.0	10.4
	Northwest Rivers	52.4	16.6	0.2	69.2

bcm = billion cubic meter.

Note: Numbers may not sum precisely because of rounding.

Sources: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC); Ministry of Water Resources, People's Republic of China. 2015. *China Water Resources Bulletin 2014*. Beijing: China Waterpower Press.

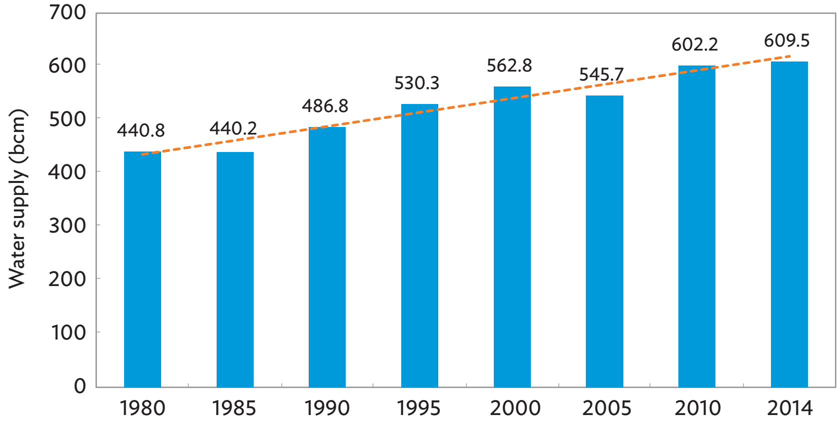
Total supply increased between 1980 and 2014, but the rate of annual increase has decreased. Total supply grew from 440.8 bcm in 1980 to 609.5 bcm in 2014—a substantial increase over the 24-year period—mostly from surface water and in the south (Figure 5).

Water supply has increased at different rates in different basins due to varying availability and needs for local socioeconomic activity. For example, water supply in the Songhua River Basin increased the fastest among the 10 basins between 1980 and 2014, at about 5% annually, while water supply in the Hai River Basin remained relatively stable, at about 37.8 bcm in the same period (Table 4). These rates correspond with the utilization rates in the basin—meaning that cities are increasing supply to meet demand rather than managing demand to maintain current supply levels (conservation).

Surface Water Supplies

Surface water provides a greater share of total water supply in the southern PRC than in the northern PRC. More than 95% of total water is sourced from surface water supply in the Yangtze River, southeast rivers, Pearl River, and southwest rivers.

Figure 5: Total Water Supply in the People's Republic of China, 1980–2014



bcm = billion cubic meter.

Note: Data for 1980–2000 were taken from the national water resources survey and assessment, and 2000–2014 data from the *China Water Resources Bulletin*.

Sources: Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2014*. Beijing: China Waterpower Press.

Table 4: Total Water Supply of Different River Basins, 1980–2014
(bcm)

River Basin	1980	1985	1990	1995	2000	2005	2010	2014
National Total	**440.8**	**440.2**	**486.8**	**530.3**	**562.8**	**545.7**	**602.2**	**609.5**
Songhua River	20.6	21.1	29.1	31.6	39.6	37.8	45.7	50.8
Liao River	14.5	14.4	17.7	19.8	20.3	19.1	20.9	20.5
Hai River	39.6	34.4	36.9	39.5	40.2	38.0	36.8	37.0
Yellow River	34.3	33.3	38.1	40.5	41.9	38.0	39.2	38.8
Huai River	51.9	45.6	50.7	57.0	58.5	53.1	63.9	61.7
Yangtze River	132.5	146.8	156.6	171.5	182.9	178.0	198.3	201.3
Southeast Rivers	21.4	22.6	23.9	29.8	31.4	31.2	34.3	33.7
Pearl River	65.8	66.3	72.9	78.1	82.1	82.8	88.3	86.2
Southwest Rivers	4.4	5.2	6.0	6.9	8.6	9.0	10.8	10.4
Northwest Rivers	55.7	50.5	54.9	55.6	57.3	58.7	64.0	69.2

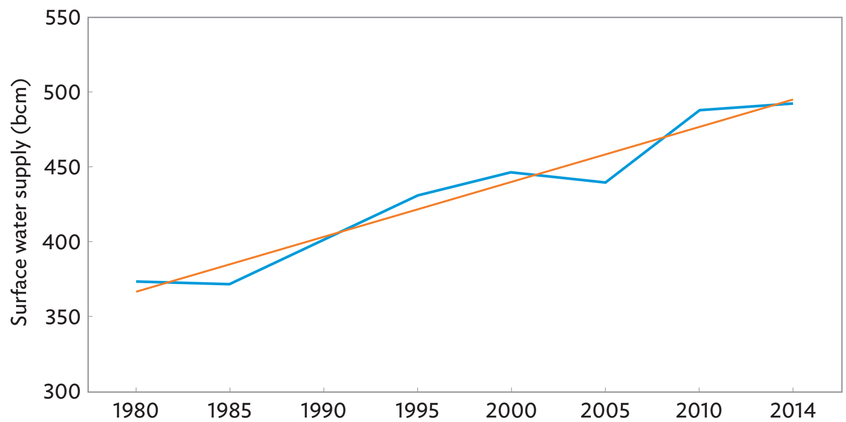
bcm = billion cubic meter.

Notes:

1. Data for 1980–2000 were taken from the national water resources survey and assessment, and 2000–2014 data from the *China Water Resources Bulletin*.
2. Numbers may not sum precisely because of rounding.

Sources: Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2014*. Beijing: China Waterpower Press.

Figure 6: Changes in Surface Water Supply, 1980–2014



bcm = billion cubic meter.

Note: Data for 1980–2000 were taken from the national water resources survey and assessment, and 2000–2014 data from the *China Water Resources Bulletin*.

Sources: Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2014*. Beijing: China Waterpower Press.

Nationally, surface water supply increased 24%, from 373.8 bcm in 1980 to 492.1 bcm in 2014 (Figure 6), but again, more so in the south. The trends for different river basins are dissimilar, as shown in Table 5. In the northern Hai and Yellow river basins, surface water supply has remained relatively stable, showing no significant increase since 1985.

Groundwater Supplies

Groundwater is a key water supply source for the northern PRC (Table 6). In 2014, groundwater exploitation for the six northern river basins accounted for 89% of the entire country's total groundwater use and 36% of the country's total water supply (see Table 4 for data on total water supply). The Hai River Basin has the highest ratio of groundwater to total water supply in the country, at 59% in 2014.

Most groundwater is extracted in the plains (87.3 bcm, or 78% of total groundwater extraction) compared to the mountain areas (24.4 bcm, or 22% of total groundwater extraction). The average intensity of groundwater development (i.e., the ratio of groundwater abstraction to sustainable exploitable groundwater) in the plain regions of the northern PRC is more than 85%. The intensity is more than 100% in the plain areas of Hebei, Henan, Shanxi, and Tianjin provinces. Figure 7 shows the intensity of groundwater exploitation in the plains of each province.

Most groundwater supply is being extracted from shallow, unconfined aqueducts (106.5 bcm); yet, 5.1 bcm has been extracted from deep aquifers, which experience little recharge and do not recover from overextraction.

Table 5: Surface Water Supply of Different River Basins, 1980–2014
(bcm)

River Basin	1980	1985	1990	1995	2000	2005	2010	2014
National Total	**373.8**	**371.7**	**401.9**	**431.4**	**447.1**	**439.6**	**488.2**	**492.1**
Songhua River	16.7	16.4	20.1	20.9	23.2	22.3	25.9	28.9
Liao River	9.5	7.4	8.9	10.3	9.1	8.0	9.2	9.8
Hai River	19.1	13.7	14.5	15.6	13.6	12.3	12.2	13.3
Yellow River	24.9	24.5	27.2	26.6	27.2	24.9	26.3	25.5
Huai River	39.1	35.4	37.2	39.2	38.8	37.3	46.4	45.3
Yangtze River	126.3	140.0	149.1	162.5	172.6	169.3	189.0	192.0
Southeast Rivers	20.5	21.8	23.0	28.9	30.5	30.2	33.3	32.7
Pearl River	61.9	62.1	68.0	72.8	76.4	78.5	84.1	82.5
Southwest Rivers	3.8	4.6	5.3	6.0	7.0	8.8	10.4	9.9
Northwest Rivers	51.9	45.7	48.5	48.6	48.6	48.1	51.4	52.4

bcm = billion cubic meter.

Notes:

1. Data for 1980–2000 were taken from the national water resources survey and assessment, and 2000–2014 data from the *China Water Resources Bulletin*.
2. Numbers may not sum precisely because of rounding.

Sources: Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2014*. Beijing: China Waterpower Press.

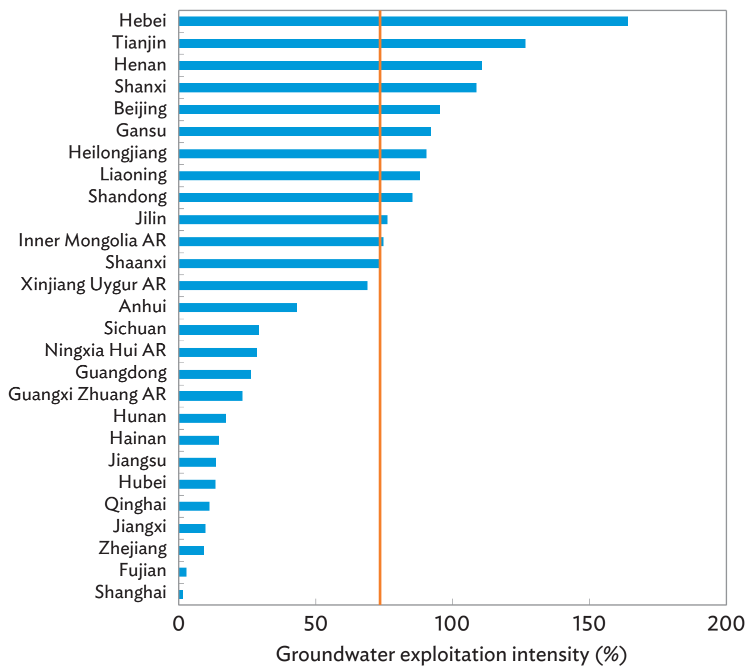
Table 6: Groundwater Exploitation of Different Regions and River Basins, 2014

Region/River Basin		Groundwater Exploitation (bcm)			Share of Groundwater Exploitation in Total Water Supply (%)
		Plain Areas	Mountain Areas	Total	
National Total		**87.3**	**24.4**	**111.7**	**18.3**
Region	Northern	84.2	14.7	98.9	35.6
	Southern	3.1	9.7	12.8	3.8
River Basin	Songhua River	19.4	2.5	21.9	43.1
	Liao River	8.2	2.1	10.4	50.7
	Hai River	18.7	3.3	22.0	59.5
	Yellow River	9.4	3.1	12.5	32.2
	Huai River	12.1	3.6	15.6	25.3
	Yangtze River	2.4	5.7	8.1	4.0
	Southeast Rivers	0.1	0.8	0.8	2.4
	Pearl River	0.6	2.7	3.3	3.8
	Southwest Rivers	0.0	0.5	0.5	4.8
	Northwest Rivers	16.5	0.1	16.6	24.0

bcm = billion cubic meter.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Figure 7: Intensity of Groundwater Exploitation in the Plain Areas by Province, 2014



AR = Autonomous Region.

Note: The orange line refers to the mean value of groundwater exploitation intensity in the plain areas of the People's Republic of China.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Other Water Supplies

A small, but growing proportion of water supply is from other sources, including reclaimed wastewater, harvested rainwater, and desalinized seawater. In 2014, water supply from other sources reached 5.8 bcm, accounting for 0.9% of total offstream water supply.

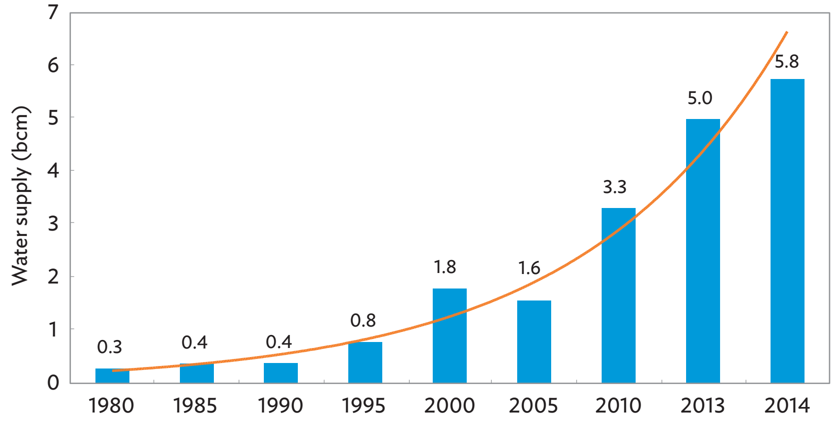
Water supply from other sources is mainly distributed in the Hai, Huai, Yangtze, and Yellow rivers. In Hai River, water supply from sources other than surface and groundwater reached 1.8 bcm in 2014, or 31% of the national total.

Figure 8 presents the water supply from other sources, which had rapidly increased since 1990, but at a somewhat uneven pace. From 1990 to 2014, water supply from other sources increased at an annual average rate of about 9%.

Water Use and Demand

The rate and structure of water use has been changing dramatically over the past decades, with some positive changes since 2010. Water use by agriculture and industry consumers has stabilized,

Figure 8: Water Supply from Other Sources, 1980–2014



bcm = billion cubic meter.

Note: Data for 1980–2000 were taken from the national water resources survey and assessment, and 2000–2014 data from the *China Water Resources Bulletin*.

Sources: Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2014*. Beijing: China Waterpower Press.

although there are structural changes and growth happening within these sectors. Water use has generally been increasing, but the rate of change has slowed and has been decreasing since 2010. National trends and analyses, however, mask problematic developments and conditions within basins and regions, which deserve a closer look and a more targeted policy response.

In 2014, the agriculture sector remained the largest total water user nationally, consuming 65% of all water supplies—though, variations are evident spatially (Table 7).[5] Industry use is the second-largest consumer at 22% of all water supplies, whereas domestic use accounts for 13%. Reflecting on some of the spatial variations, industries in the southeast coastal region account for 45% of all total water use, while industries in other regions account for less than 30%.

Rural and Agriculture Water Use

More water goes to the agriculture sector, specifically for the irrigation of farmland, than any other sector in the country. Farmland irrigation accounts for 56% of total water use in the PRC and 88% of total agriculture water use; the balance of 12% agriculture water use goes to forestry, fruit gardens, pasture irrigation, and fishponds (Table 8). The coverage of rural domestic water supply (mainly for drinking water and household use) has been improving, but the quality of the service (i.e., the availability of supply and quality of water) requires greater financial commitment and long-term investments.

Agriculture water use has been relatively stable (Figure 9).

[5] Total water use—i.e., the gross quantity of water distributed to users, including conveyance loss—is statistically classified into four major categories: domestic use, industry use, agriculture use, and eco-environment use (excluding directly used seawater).

Table 7: Sector Water Use by Region and River Basin, 2014
(bcm)

Region/River Basin		Industry	Agriculture	Domestic	Ecology	Total
National Total		**135.6**	**386.9**	**76.7**	**10.3**	**609.5**
Region	Northeast	8.6	54.4	5.6	1.5	70.3
	North	13.0	46.5	12.5	2.9	75.0
	Southeast Coast	60.4	93.2	29.4	1.9	184.5
	Central	33.2	66.8	14.2	1.0	115.2
	Southwest	14.4	38.2	10.1	0.8	63.9
	Northwest	6.0	87.8	5.0	2.2	100.7
River Basin	Songhua River	5.5	41.5	3.0	0.9	50.8
	Liao River	3.3	13.6	3.0	0.6	20.5
	Hai River	5.4	24.0	5.9	1.8	37.0
	Yellow River	5.9	27.5	4.4	1.1	38.8
	Huai River	10.6	42.1	8.2	0.9	61.7
	Yangtze River	70.8	100.3	28.2	2.0	201.3
	Southeast Rivers	11.5	15.0	6.4	0.7	33.7
	Pearl River	19.6	50.5	15.3	0.8	86.2
	Southwest Rivers	1.0	8.5	0.9	0.1	10.4
	Northwest Rivers	2.1	64.2	1.6	1.4	69.2

bcm = billion cubic meter.

Note: Numbers may not sum precisely because of rounding.

Sources: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC); Ministry of Water Resources, People's Republic of China. 2015. *China Water Resources Bulletin 2014*. Beijing: China Waterpower Press.

Industry Water Use

Industry water use reached about 135.6 bcm in 2014, or about 22% percent of total water use nationwide (Figure 10). From 2001 to 2010, industry water use began to decelerate before actually starting to decline past 2010. Although the decline may indicate improved water use efficiency or economic restructuring, the environmental impact from the industrial revolution, which triggered the highly concentrated increase in industry water use between 1980 (41.8 bcm or equivalent to 10% of total water use) and 2014, needs to be addressed.

Industry water use in 2014 varied greatly between river basins (Table 9). For example, industry water use in the Yangtze River Basin in 2014 was 70.8 bcm compared to just 1.0 bcm in the southwest rivers. Nationally and within basins and regions, industry water use has been steady or experiencing some decline.

Within the industry sector, water use for thermal and nuclear power generation is increasing, accounting for 35% of total industry water use in 2014 (47.8 bcm). Water abstraction for thermal power generation started a flatter upward trend in 2000, with slower growth rates after 2007 (Figure 11) when the PRC government began closure of inefficient, small, coal-fired power plants

Table 8: Rural Domestic and Agriculture Water Use by Region and River Basin, 2014
(bcm)

Region/River Basin		Rural Domestic	Agriculture Water Use		
			Farmland Irrigation	Agriculture Use (except farmland irrigation)	Total Agriculture
National Total		**18.4**	**338.6**	**48.3**	**386.9**
Region	Northeast	1.2	51.0	3.4	54.4
	North	3.8	41.4	5.1	46.5
	Southeast Coast	5.5	80.1	13.1	93.2
	Central	3.5	62.2	4.6	66.8
	Southwest	3.1	33.1	5.1	38.2
	Northwest	1.3	70.8	17.0	87.8
River Basin	Songhua River	0.6	39.5	1.9	41.5
	Liao River	0.6	12.1	1.5	13.6
	Hai River	1.6	21.6	2.3	24.0
	Yellow River	1.2	24.3	3.1	27.5
	Huai River	2.7	37.4	4.7	42.1
	Yangtze River	6.2	90.3	9.9	100.3
	Southeast Rivers	1.3	13.2	1.9	15.0
	Pearl River	3.5	43.1	7.4	50.5
	Southwest Rivers	0.4	7.0	1.5	8.5
	Northwest Rivers	0.4	50.0	14.2	64.2

bcm = billion cubic meter.

Note: Numbers may not sum precisely because of rounding.

Sources: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC); Ministry of Water Resources, People's Republic of China. 2015. *China Water Resources Bulletin 2014*. Beijing: China Waterpower Press.

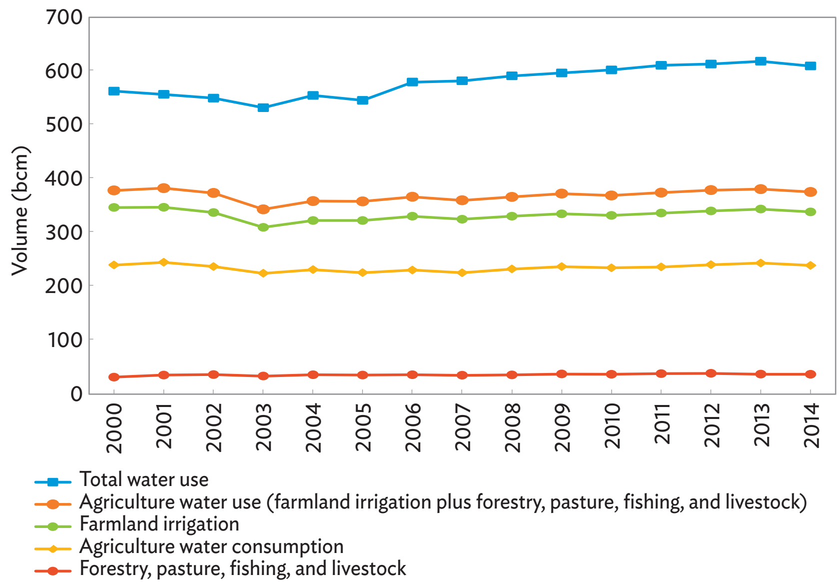
during the implementation of the 11th Five-Year Plan (2006–2010). In 2000, thermoelectric power generation accounted for 29% of total industry water use and, in 2012, increased to 39% (Figure 12). Within the power sector, around 85% of water use went to open-loop cooling system.

Domestic Water Use (Urban Areas and Cities)

Domestic water use measures consumption of both urban areas and cities. "Cities" are the older, downtown, or more built-up urban areas, while "urban areas" cover the older cities as well as the newer development in the outskirts of cities. Total urban water use is calculated for all uses (industry, ecology, and domestic water uses)—e.g., household or residential use; construction; and goods and services in the tertiary service sector such as restaurants, markets, wholesale and retail stores, transportation, etc.

Urban domestic water use reached 58.3 bcm, accounting for nearly a third of the total urban water use in 2014 (Table 10). Between 2000 and 2014, urban domestic water use nearly doubled, increasing

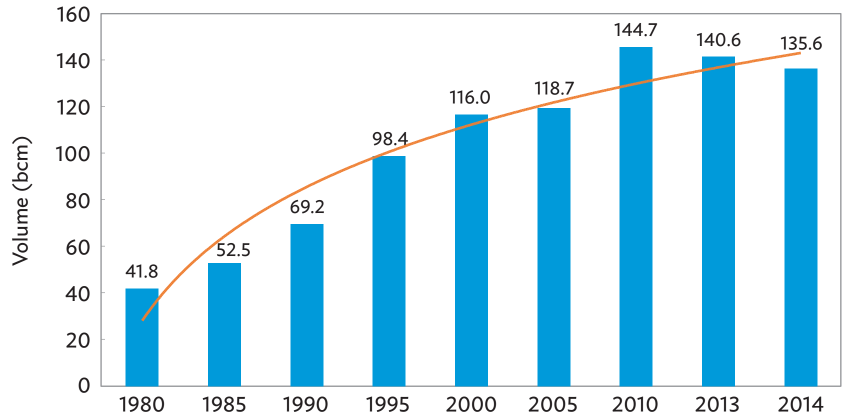
Figure 9: Agriculture Water Use and Consumption, 2000–2014



bcm = billion cubic meter.

Source: Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2014*. Beijing: China Waterpower Press.

Figure 10: Industry Water Use, 1980–2014



bcm = billion cubic meter.

Note: Data for 1980–2000 were taken from the national water resources survey and assessment, and 2000–2014 data from the *China Water Resources Bulletin*.

Sources: Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2014*. Beijing: China Waterpower Press.

Table 9: Industry Water Use by Region and River Basin, 1985–2014
(bcm)

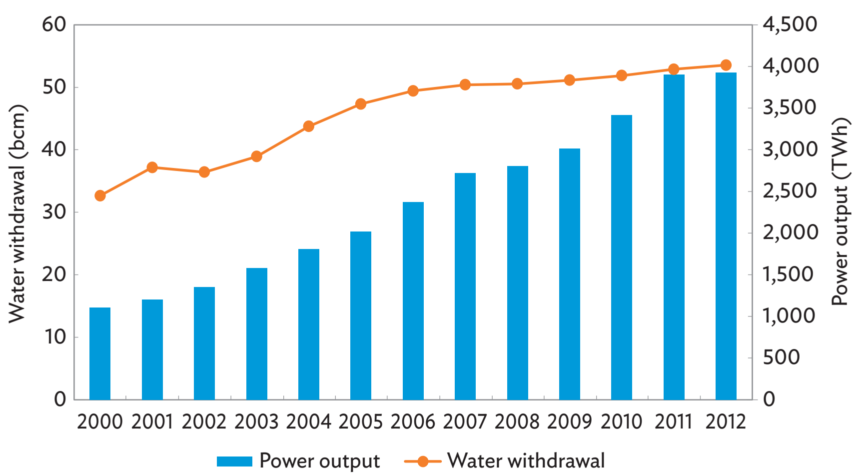
Region/River Basin		1985	1990	1995	2000	2005	2010	2014
Region	Northeast	...	...	...	14.5	9.99	11.5	8.6
	North	...	...	...	14.2	11.9	12.8	13.0
	Southeast Coast	...	...	...	46.0	58.6	60.7	60.4
	Central	...	...	...	21.9	28.2	35.8	33.2
	Southwest	...	...	...	11.8	14.4	18.0	14.4
	Northwest	...	...	...	5.5	5.5	5.9	6.0
River Basin	Songhua River	4.3	5.7	6.7	7.8	7.4	8.2	5.5
	Liao River	2.5	3.0	3.9	3.5	2.6	3.5	3.3
	Hai River	5.3	5.4	6.2	6.9	5.6	5.1	5.4
	Yellow River	3.2	4.3	5.4	5.9	5.5	6.2	5.9
	Huai River	5.0	6.8	9.1	10.1	9.3	9.9	10.6
	Yangtze River	25.6	32.3	46.6	55.6	59.5	74.7	70.8
	Southeast Rivers	2.2	3.3	6.2	8.5	9.6	12.2	11.5
	Pearl River	3.4	7.1	12.6	15.7	16.8	22.3	19.6
	Southwest Rivers	0.1	0.2	0.2	0.3	0.5	1.0	1.0
	Northwest Rivers	0.9	1.2	1.3	1.6	1.9	1.8	2.1

... = data not available, bcm = billion cubic meter.

Notes:
1. Data for 1985–2000 were taken from the national water resources survey and assessment, and 2000–2014 data from the *China Water Resources Bulletin*.
2. Numbers may not sum precisely because of rounding.

Sources: Ministry of Water Resources, People's Republic of China. 2000. *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2014*. Beijing: China Waterpower Press.

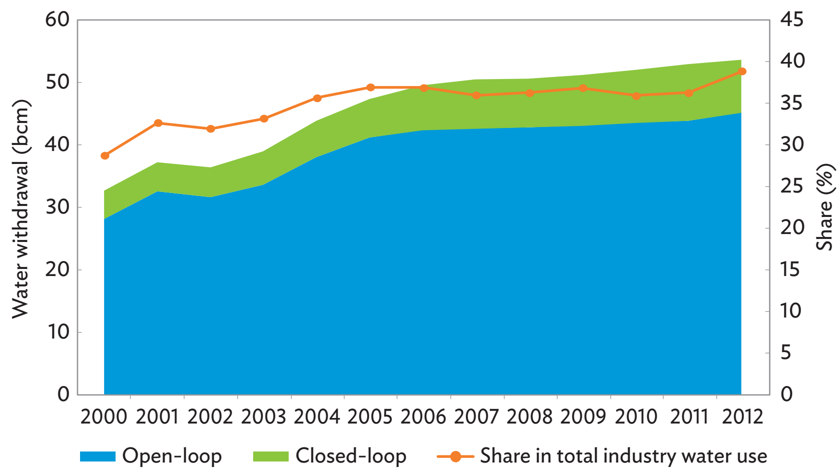
Figure 11: Water Use and Power Generation, 2000–2012



bcm = billion cubic meter, TWh = terawatt hour.

Sources: China Electricity Council. Various years. *National Electric Power Industry Statistical Bulletin, 2000–2012*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2012*. Beijing: China Waterpower Press.

Figure 12: Water Withdrawal by Cooling System Type, 2000–2012



bcm = billion cubic meter.

Sources: China Electricity Council. Various years. *National Electric Power Industry Statistical Bulletin, 2000–2012*. Beijing; Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2000–2012*. Beijing: China Waterpower Press.

Table 10: Urban Water Use by Region and River Basin, 2014
(bcm)

Region/River Basin		Urban Water Use			
		Domestic (residential and public)	Industry	Ecology	Total
National Total		**58.3**	**135.6**	**10.3**	**204.2**
Region	Northeast	4.4	8.5	1.5	14.5
	North	8.7	13.0	2.9	24.7
	Southeast Coast	23.9	60.4	1.9	86.2
	Central	10.7	33.2	1.0	44.9
	Southwest	7.0	14.4	0.8	22.2
	Northwest	3.7	6.0	2.2	11.9
River Basin	Songhua River	2.4	5.5	0.9	8.7
	Liao River	2.4	3.3	0.6	6.3
	Hai River	4.3	5.4	1.8	11.5
	Yellow River	3.2	5.9	1.1	10.1
	Huai River	5.5	10.6	0.9	17.0
	Yangtze River	22.0	70.8	2.0	94.8
	Southeast Rivers	5.1	11.5	0.7	17.4
	Pearl River	11.8	19.6	0.8	32.2
	Southwest Rivers	0.5	1.0	0.1	1.6
	Northwest Rivers	1.2	2.1	1.4	4.6

bcm = billion cubic meter.

Note: Numbers may not sum precisely because of rounding.

Sources: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC); Ministry of Water Resources, People's Republic of China. 2015. *China Water Resources Bulletin 2014*. Beijing: China Waterpower Press.

from 28.4 bcm to 58.3 bcm. But, similar to other high-growth sectors during that 14-year period, the rate of increase began to decline in 2010. Within the older, downtown, or more built-up city areas, domestic users accounted for 39% of total city water use (28.7 bcm). Industries within cities as well and the larger urban areas were the largest consumers of water, although the rate of use was steady. More than half of the total water supply for 653 cities was consumed by industries within these cities—i.e., 40.9 bcm of the total 72.9 bcm city water supply. In urban areas, the proportion of industry water use was even higher at 66% in 2014.[6]

Gap between Water Supply and Demand

By most measurement standards, the PRC has a water shortage. The country ranks 110th worldwide in per capita volume of available water at 2,026 m^3 or about one-fourth of the world average (Figure 2). Water distribution is grossly uneven: 81% of total water resources is found in areas south of the Huai River Basin. Moreover, annual and interyear water supply is irregular, with 60%–80% of precipitation occurring in most areas during summer and autumn, when floods and droughts are more frequent and more intense.

Water scarcity is a central, fundamental issue with corresponding adverse impacts. An analysis on urban–rural water integration examines how urbanization has influenced rural water security. The improving economy has brought changes to the water needs of rural residents— from water used solely for drinking, to water serving other purposes. Moreover, the demand for water is growing. Water-flushed toilets, water heaters, and washing machines have gained wider use in villages and households in recent years. But, in many parts of rural PRC, the water facilities cannot provide residents with the safe, convenient, adequate, and economic water services they seek.

In urban areas, people also do not have enough water, or enough clean water. According to the Ministry of Housing and Urban-Rural Development, current average leakage from the city water supply network is estimated to be around 15%.[7]

Total Water Demand Projections

Analysis of water demand of major sector users indicates that national water demand in 2020 during a moderately intensive water conservation scenario ("medium" scenario in Table 11) is expected to reach 671.6 bcm in 2020 and 705.9 bcm in 2030. The forecasts of total offstream water demand for 2020 and 2030 are also shown in Table 11.

Using the medium water conservation scenario, water demand will increase among nearly all users (except rural domestic users and farmland irrigation), but at significantly lower rates than what was experienced between 2000 and 2010, a rigorous period of heavy industrial development.

Agriculture will remain the country's largest consumer of water, yet the proportion of total water that farmland irrigation (the highest agriculture and national consumer of water) will consume will have dipped just below the 50% threshold by 2030 from 56% in 2014 (Figure 13).

[6] Unlike the water use statistics of the Ministry of Housing and Urban-Rural Development, statistics from the Ministry of Water Resources are based on abstraction rates and sector allocations and include conveyance losses.

[7] Leakage rate of city water supply pipe network refers to the ratio of city water supply leakage to total water supply in public water supply pipe network.

Table 11: Estimated Water Demand under Three Water Conservation Scenarios, 2014, 2020, and 2030
(bcm)

Sector	2014 (base year)	2020			2030		
		Low	Medium	High	Low	Medium	High
Urban residential	36.4	44.4	48.4	52.7	55.4	60.4	65.7
City residential	18.9	26.4	28.0	29.9	34.0	36.0	38.5
Urban public	21.9	26.9	29.6	31.8	33.6	36.5	39.8
City public	9.8	11.7	12.4	13.3	14.2	15.0	16.0
Rural domestic	18.4	21.6	22.5	23.6	20.5	21.6	22.6
Industry	135.6	139.7	145.8	155.7	151.3	164.8	175.9
Farmland irrigation	338.6	328.8	357.7	382.2	322.3	350.4	374.7
Forestry, livestock, and fishery	48.3	51.8	54.0	56.7	53.5	55.7	58.5
Offstream eco-environment	10.3	13.1	13.5	14.9	16.1	16.6	19.0
Urban water demand	204.2	222.8	236.0	253.5	254.8	276.6	298.5
City water demand	72.9	93.0	96.9	101.8	110.5	115.1	120.9
Rural water demand (average)	417.4	403.5	435.6	464.0	397.8	429.3	457.7
Total water demand (average)	**620.5**	**626.3**	**671.6**	**717.5**	**652.6**	**705.9**	**756.2**

bcm = billion cubic meter.

Notes:

1. The high, medium, and low scenarios correspond to the employment of highly intensive water conservation efforts, moderately intensive conservation efforts, and current levels of water conservation, respectively.
2. “City” refers to the older, downtown, or more built-up urban area; “urban” covers both the older cities and the new development in the outskirts of cities.
3. Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People’s Republic of China: Country Water Assessment*. Consultant’s report. Manila (TA 8715-PRC).

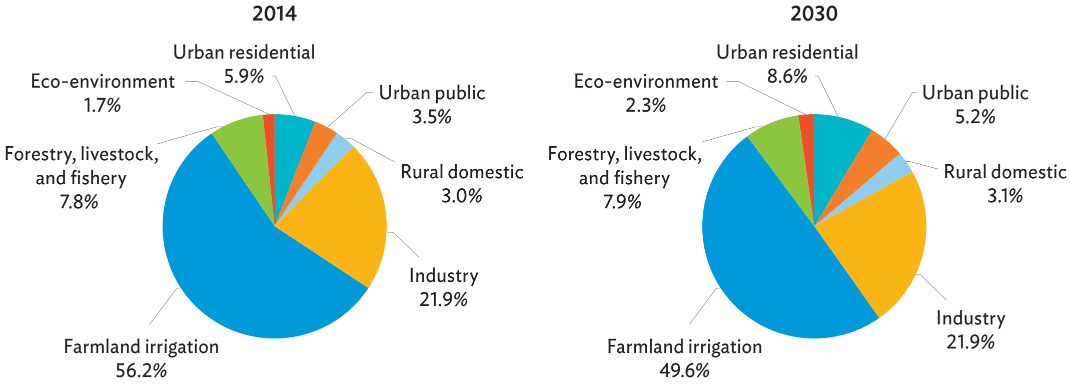
The second-largest water user in 2014, the industry sector, will continue to grow in demand and proportion of total water consumption, but at a more environmentally considerate rate. From a 2.4% average growth rate during 2000–2010, industry demand will grow at a slower pace of 1.3% by 2020. The proportion of total water going to industry in 2030 is forecast to reach 23%, up from 22% in 2014.

Demand is growing the fastest among domestic water users—household or residential and the tertiary service sector (public). Urban residential water consumption will grow at an annual average rate of 3.4% by 2030. The rural domestic water market will peak in 2020 at 22.5 bcm and then decrease after 2020 at the tail end of the country’s great wave of urbanization (Table 11).

Projections for Closing the Supply-Demand Gap

For the medium growth scenarios (i.e., both medium socioeconomic growth scenario and moderately intensive water conservation scenario), total projected water supply in the PRC from all sources is expected to reach about 700 bcm by 2030, an increase of 99 bcm compared to the 2014 base year water supply (Table 12 and Figure 14). This represents an average annual growth rate of 1.1%. New supply of water is expected to reduce the severity of future water shortages, lessen the overexploitation and depletion of groundwater sources, and allow more water to be left in the rivers (especially since surface water have now been overused) to improve ecological conditions.

Figure 13: Estimated Water Demand Structure under a Medium Water Conservation Scenario, 2014 and 2030



Notes:
1. Medium scenario corresponds to the application of moderately intensive water conservation efforts.
2. Percentages may not total 100% because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 12: Total Water Supply under Medium Growth Scenarios by River Basin, 2014, 2020, and 2030
(bcm)

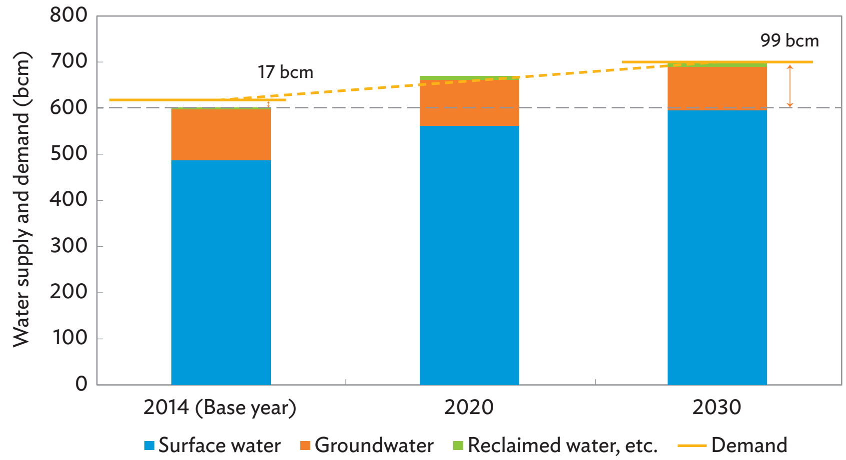
River Basin	Total Water Supply		
	2014 (base year)	2020	2030
National Total	**601.2**	**670.0**	**700.0**
Songhua River	47.1	55.0	58.5
Liao River	20.1	23.3	24.0
Hai River	37.4	45.3	49.7
Yellow River	39.2	45.1	51.2
Huai River	62.1	70.1	74.2
Yangtze River	196.9	225.7	231.1
Southeast Rivers	33.7	40.1	42.2
Pearl River	87.1	90.9	92.0
Southwest Rivers	10.7	12.4	13.0
Northwest Rivers	66.9	62.2	64.0

bcm = billion cubic meter.

Notes:
1. Medium growth scenarios refer to both medium socioeconomic growth scenario and medium (or moderately intensive) water conservation scenario.
2. Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Figure 14: Water Supply and Demand Projections under Medium Growth Scenarios, 2014, 2020, and 2030



bcm = billion cubic meter.

Note: Medium growth scenarios refer to both medium socioeconomic growth scenario and medium (or moderately intensive) water conservation scenario.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Current Water Imbalance

The country's total water shortage is the sum of direct water supply shortage and overexploitation of water resources (including groundwater overexploitation and occupation of instream environmental flows). Of the country's 50 bcm average annual shortfall in water supply, 60% (or about 30 bcm) is due to overextraction of water resources. Of the total 30-bcm overextracted water, 20 bcm comes from the overexploitation of groundwater. In addition, 13 bcm of environmental flow is being (mis) used. The country's current absolute water shortage is about 17 bcm (calculated as: 50 bcm – 20 bcm – 13 bcm), consisting of 2 bcm water supply shortage for urban domestic and industry demand and 15 bcm water supply shortage for agriculture demand.

Current offstream water shortages have two primary impacts. One is direct water supply shortage for the economy and society. The other is overuse of surface water in some rivers and groundwater, including failure to ensure minimum instream environmental flows and sufficient groundwater to maintain geological functions.

Under both medium socioeconomic growth and medium water conservation scenarios, the future water demand is estimated to match water supply at 700 bcm by 2030. This will require comprehensive demand management and implementation of conservation policies and programs that would bring a balance between projected water demand and restoration of shallow aquifers and instream environmental flows.

Risk of Future Water Imbalance

The future water-balanced state is highly unlikely though, particularly when taking into account the uncertainty involved in forecasting demand, estimating the amount of water saved through conservation, measuring current available supply, and projecting how much new supply will be developed in the future. Added to these uncertainties is the issue of variability in rainfall and hydrological conditions. The 2030 water supply–demand balance assumes average precipitation. But in several succeeding years, precipitation will be less than average, agriculture demand for irrigation water will be greater than average, and available water supply will be less than average.

This CWA analyzed the water supply–demand balance using the average precipitation forecast for supply and three forecast scenarios for demand: average, moderately dry (75% precipitation frequency), and severely dry (90% precipitation frequency). Since irrigation water demand increases during dry years, total water demand would exceed the average water supply by roughly 45 bcm in a 75% precipitation year and 85 bcm in a 90% precipitation year in 2030. However, during the dry years, water supply will most likely be lower than in average years; hence, the deficit could be much greater during dry years.

Water Quality and Trends

The water quality of the PRC's rivers has improved slightly since 2009, but not as expected, given the nationwide impetus for building wastewater treatment plants and the control that industrial pollution has come under.

The construction boom in new cities to meet the 2020 urbanization target of 60% will directly and indirectly impact water security, particularly when new city locations are chosen close to existing industry such as chemical factories. In the PRC, big petrochemical firms are usually situated along lakes or rivers since such proximity to the water source would help meet their huge production need for water as well as their need for a convenient wastewater discharge site. The identification of potential threats from urban construction and industry sites is crucial in the government's efforts to protect urban water supplies. In the design of new cities and layout of industries, water security should be among the top considerations.

The CWA examined the pressures of insufficient sewage lines, unsustainable tariffs, and increasing volumes of wastewater from larger cities—cities that have abundant capacity to invest in operations and maintenance as well as construction of sewer networks to collect wastewater, yet inadequately do so.

The focus of pollution control is slowly shifting to rural and nonpoint pollution sources. The *First National Census on Pollution Sources* in 2007 by the PRC's Ministry of Environmental Protection (now Ministry of Ecology and Environment) indicated that agriculture nonpoint source pollution (NPSP) emissions in 2007 accounted for 57% of total nitrogen emissions and 67% of total phosphorus emissions. These two nutrients are major contributors to the eutrophication of water bodies.

In the PRC's water-abundant regions, pollution-related water shortages resulting from frequent algal blooms in the country's largest lakes—such as Chao Lake, Dianchi Lake, Hongze Lake, and Tai Lake—are affecting the water supply for human use and for industries, and endangering the country's water security and sustainable development. Chao Lake and Poyang Lake demonstrate the impacts of NPSP and how government is trying to reverse and control pollution including, for example, major revamps in who manages the lakes, how, and to what extent. Local governments are taking integrated approaches that recognize the cross-jurisdictional span of water resources.

Water pollution, especially in cases of accidental water contamination, is a reminder of the cross-boundary threat of pollution, which can and does cause severe environmental and economic damages to large areas. However, water is often managed within administrative boundaries and, as such, has become a pervasive issue. There is progress in the application of cross-provincial eco-compensation as a mechanism and financial incentive, typically between two local governments, for environmental protection and conservation. Environmental pollution has fueled public concern, and serious incidents may lead to social unease, if not controlled in the short term.

Theoretically, agriculture modernization would alleviate the NPSP coming from the overapplication of fertilizers and pesticides and from poor rural sanitation practices. With small farmers still dominating the agriculture sector, there is a strong need to improve their environmental awareness and knowledge of how good farming practices could decrease water pollution.

Rapid urbanization will continue to be an important driver of change in agriculture and rural development. The urbanization rate in the PRC surged from 29% to 55% between 1995 and 2014. It is expected to reach 70% by 2030, when an estimated one billion people will be living in urbanized areas, thereby increasing pressure on urban domestic wastewater treatment.

Water Quality

Rivers

Water quality in the PRC's major rivers has slightly improved in recent years. At the national level, the proportion of evaluated river length with water quality Class I-III has increased from 63% in 2003 to 73% in 2014, according to the Ministry of Water Resources (Figure 15).[8] Meanwhile, the proportion of rivers with water quality worse than Class V has decreased from 21% to 12%. River water quality of monitored state-controlled section also showed improving trends from 2003 to 2014 (Figure 16).

The 2014 water quality assessment by the Ministry of Water Resources of a 216,000-kilometer (km) river length nationwide shows the respective proportion of the different water quality categories (Figure 17). Water quality in different river basins varies significantly (Table 13). Generally speaking, water quality is excellent in the Southwest and Northwest rivers, and much inferior in the Hai River.

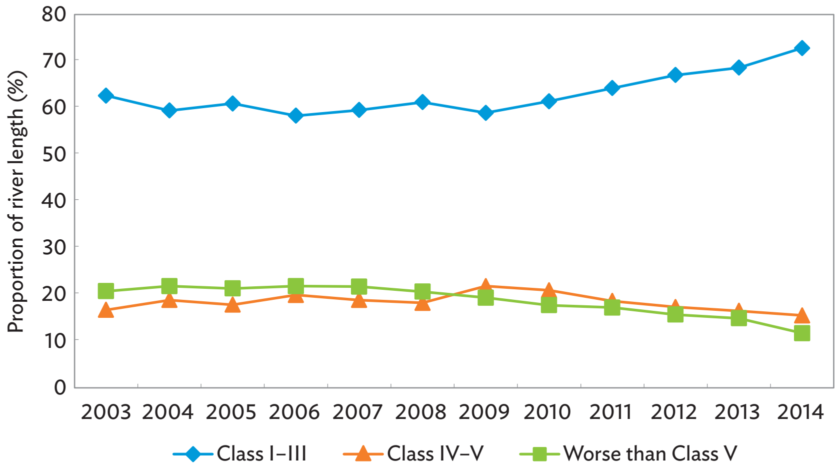
Lakes and Reservoirs

In 2014, the Ministry of Water Resources reported the trophic state of the PRC's monitored lakes and reservoirs.[9] Of the 121 monitored lakes, 77% were under a state of eutrophication and 23%

[8] Ministry of Water Resources, People's Republic of China. 2015. *China Water Resources Bulletin 2014*. Beijing: China Waterpower Press.

[9] The trophic state of a body of water evaluates its "fertility" based on the amount of biologically useful nutrients (e.g., phosphorus, nitrogen) it contains. The more the nutrients, the more fertile the body of water, hence, the more plant and algal growth. "Mesotrophic" means having medium or moderate levels of fertility or nutrients. A mesotrophic lake usually has clear water with abundant aquatic fauna and flora. "Eutrophic" means having high levels of nutrient productivity. Eutrophication can occur due to either anthropogenic or natural factors. (RMB Environmental Laboratories, Inc. Lake Trophic States. https://www.rmbel.info/primer/lake-trophic-states-2/;

Figure 15: Evaluation of River Water Quality by River Length, 2003–2014



Note: According to the *Environmental Quality Standards for Surface Water* formulated by the Ministry of Ecology and Environment (formerly the Ministry of Environmental Protection) of the People's Republic of China, water bodies (i.e., rivers, lakes, and reservoirs within the country) are grouped into five classes based on usage purposes and protection targets. Class I primarily covers water from the natural sources and from national nature reserves. Class II applies to the first-rate protected areas for centralized drinking water sources and the areas protected either as habitats for rare fish or as spawning grounds for fish and shrimps. Class III is for the second-rate protected areas for centralized drinking water sources, areas protected as habitats for common fish, and areas designated safe for swimming. Class IV refers to water bodies suitable for industry use and for recreation, but with no direct human contact. Class V is suitable only for irrigation and landscaping.

Source: Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2003–2014*. Beijing: China Waterpower Press.

were under a mesotrophic state. Meanwhile, of the 635 monitored reservoirs, 37% were eutrophic and 63% were mesotrophic (footnote 8). Overall, the quality of lakes and reservoirs (Table 14) is relatively poor due to the worsening state of eutrophication.

Groundwater

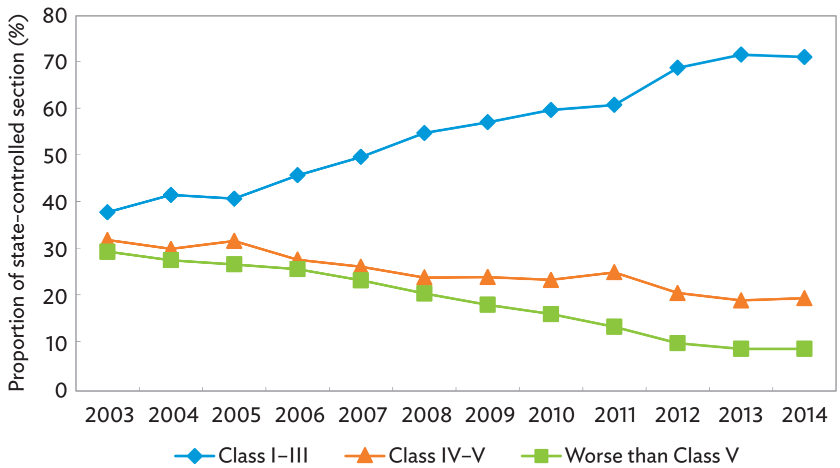
Results of the National Groundwater Resources Evaluation by the Ministry of Land and Resources (now Ministry of Natural Resources) in 2000–2002 revealed that "the quality of groundwater in southern regions is better than in northern regions, that mountainous regions are better than plains, and that deep aquifer is better than shallow aquifer."[10] Based on the *National Groundwater Environmental Quality Standards (GB/T 14848-93)*,[11] approximately 39% of national groundwater resources in 2014 meet Class I–III, and the remainder meet Class IV–V (Figure 18).

World Atlas. Environment: What Are Oligotrophic, Mesotrophic, and Eutrophic Lakes? https://www.worldatlas.com/articles/what-are-oligotrophic-mesotrophic-and-eutrophic-lakes.html.)

[10] Ministry of Land and Resources (now Ministry of Natural Resources), People's Republic of China. 2010. *Groundwater Resources in China: Result of New-round Groundwater Assessment*. http://www.mlr.gov.cn/dzhj/201003/t20100326_712812.htm.

[11] Ministry of Geology and Mineral Resources, People's Republic of China. 1993. *National Groundwater Environmental Quality Standards (GB/T 14848-93)*. State Bureau of Technical Supervision. https://www.chinesestandard.net/PDF.aspx/GBT14848-1993 (translated into English).

Figure 16: Evaluation of River Water Quality by State-Controlled Section, 2003–2014



Note: According to the *Environmental Quality Standards for Surface Water* formulated by the Ministry of Ecology and Environment (formerly the Ministry of Environmental Protection) of the People's Republic of China, water bodies (i.e., rivers, lakes, and reservoirs within the country) are grouped into five classes based on usage purposes and protection targets. Class I primarily covers water from the natural sources and from national nature reserves. Class II applies to the first-rate protected areas for centralized drinking water sources and the areas protected either as habitats for rare fish or as spawning grounds for fish and shrimps. Class III is for the second-rate protected areas for centralized drinking water sources, areas protected as habitats for common fish, and areas designated safe for swimming. Class IV refers to water bodies suitable for industry use and for recreation, but with no direct human contact. Class V is suitable only for irrigation and landscaping.

Source: Ministry of Environmental Protection (now Ministry of Ecology and Environment), People's Republic of China. Various years. *Report on the State of the Environment in China, 2003–2014.* Beijing.

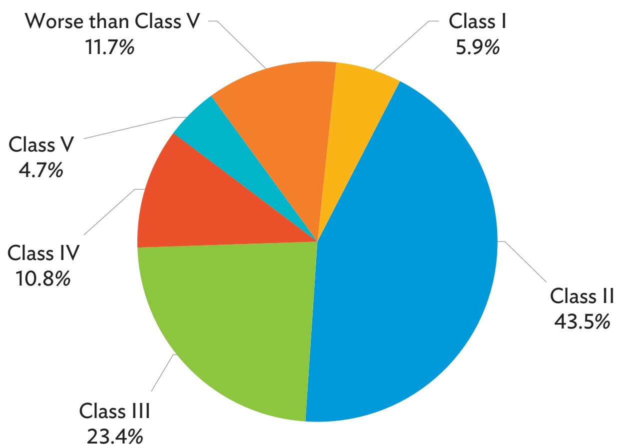
In most southern regions, the groundwater quality is relatively good, with more than 90% of total groundwater area conforming to Class I–III water quality standards. The shallow groundwater in some plain regions is severely polluted. In the northern regions, the groundwater quality is relatively good in hilly areas and piedmont plain areas, but poor in central plains, and worse in coastal areas.

According to the National Groundwater Pollution Prevention and Control Plan (2011–2020), groundwater pollution in the PRC is (i) coming from diffused sources—from point and line distribution to plane distribution, (ii) infiltrating deep stratum, and (iii) spreading from urban to rural areas. In the southern regions, the change in groundwater environment quality is relatively stable, with groundwater pollution mainly taking place in cities and the periphery. In the northern regions, the quality of the groundwater environment is gradually deteriorating, although it is stable in the northwest region.

Wastewater Collection and Treatment

With the PRC's rapid socioeconomic development, wastewater and pollutant effluents increase. The PRC has strengthened pollution control efforts in recent decades, and wastewater treatment collection and treatment capacity have developed quickly in cities (Figure 19). Domestic wastewater is generally treated by public wastewater treatment plants (WWTPs). Some industrial wastewater is

Figure 17: Proportion of River Water Quality Category by River Length, 2014



Note: According to the *Environmental Quality Standards for Surface Water* formulated by the Ministry of Ecology and Environment (formerly the Ministry of Environmental Protection) of the People's Republic of China, water bodies (i.e., rivers, lakes, and reservoirs within the country) are grouped into five classes based on usage purposes and protection targets. Class I primarily covers water from the natural sources and from national nature reserves. Class II applies to the first-rate protected areas for centralized drinking water sources and the areas protected either as habitats for rare fish or as spawning grounds for fish and shrimps. Class III is for the second-rate protected areas for centralized drinking water sources, areas protected as habitats for common fish, and areas designated safe for swimming. Class IV refers to water bodies suitable for industry use and for recreation, but with no direct human contact. Class V is suitable only for irrigation and landscaping.

Source: Ministry of Water Resources, People's Republic of China. 2015. *China Water Resources Bulletin 2014*. Beijing: China Waterpower Press.

treated by internal or simple treatment procedure before being discharged into open water bodies, and only a small amount is discharged into city WWTPs—i.e., only around 10%, according to data from the Ministry of Ecology and Environment (formerly Ministry of Environmental Protection).

Pollution Load

Domestic and Industrial Wastewater

According to the Ministry of Water Resources, national total wastewater effluents began to stabilize in 2011, reaching 77.1 bcm in 2014 (footnote 8). Wastewater effluents in the Yangtze River account for 39% of the nation's total at 30.1 bcm, of which 24.1 bcm is discharged into water bodies. Wastewater effluents in the southeast coast account for 38% and reach 29.3 bcm, of which 23.2 bcm is discharged into water bodies and more than half is discharged from urban domestic use.

Heavy Metals

If the values for heavy metals, petroleum pollutant, and volatile phenol effluents were included, the values of total wastewater effluents given above would be higher, though decreasing in recent years (Figure 20).

Table 13: Water Quality of River Basins by River Length, 2014

River Basin	Evaluated Length (kilometer)	Proportion of River Length According to Water Quality Category (%)					
		Class I	Class II	Class III	Class IV	Class V	Worse than Class V
National Total	**215,763**	**5.9**	**43.5**	**23.4**	**10.8**	**4.7**	**11.7**
Songhua River	15,300	0.5	17.6	45.3	23.2	5.0	8.4
Liao River	4,938	1.5	41.6	14.7	17.9	5.1	19.2
Hai River	14,468	2.6	19.4	13.4	9.7	10.7	44.2
Yellow River	19,066	5.3	41.6	19.1	8.0	7.1	18.9
Huai River	23,416	0.1	14.1	31.9	26.5	9.6	17.8
Yangtze River	64,553	6.2	46.4	24.9	9.0	3.9	9.6
Southeast Rivers	9,616	2.3	53.6	25.0	9.3	7.0	2.8
Pearl River	25,796	2.3	64.4	19.2	5.2	2.8	6.1
Southwest Rivers	18,419	2.0	68.0	26.2	2.2	0.2	1.4
Northwest Rivers	20,191	29.4	53.8	7.6	6.3	0.1	2.8

Note: According to the *Environmental Quality Standards for Surface Water* formulated by the Ministry of Ecology and Environment (formerly the Ministry of Environmental Protection) of the People's Republic of China, water bodies (i.e., rivers, lakes, and reservoirs within the country) are grouped into five classes based on usage purposes and protection targets. Class I primarily covers water from the natural sources and from national nature reserves. Class II applies to the first-rate protected areas for centralized drinking water sources and the areas protected either as habitats for rare fish or as spawning grounds for fish and shrimps. Class III is for the second-rate protected areas for centralized drinking water sources, areas protected as habitats for common fish, and areas designated safe for swimming. Class IV refers to water bodies suitable for industry use and for recreation, but with no direct human contact. Class V is suitable only for irrigation and landscaping.

Source: Ministry of Water Resources, People's Republic of China. 2015. *China Water Resources Bulletin 2014*. Beijing: China Waterpower Press.

Total Pollution Load and Trends

The CWA estimated that 2014 levels of chemical oxygen demand (COD) and ammonia nitrogen (NH_3-N) discharged into water bodies reached 21.7 million tons and 2.1 million tons, respectively (Table 15).[12]

Chemical oxygen demand is the greatest pollutant effluent being produced, and mainly by rural users, yet urban areas are responsible for the greatest discharge of COD into river bodies. The same trend is true for NH_3-N. Table 16 shows that the major point source pollution (PSP) in 2014 came from urban domestic wastewater, responsible for 8.6 million tons of COD (equivalent to 55% of total COD) and 1.4 million tons of NH_3-N (69% of total NH_3-N). Much of the PSP effluents were discharged directly into water bodies (77% of COD and 69% of NH_3-N).

[12] Based on wastewater and pollutant effluent statistics from the Ministry of Water Resources and the Ministry of Environmental Protection (now Ministry of Ecology and Environment), and the domestic wastewater effluent and discharge statistics from the Ministry of Housing and Urban-Rural Development, point source pollution analysis was comprehensively carried out for wastewater effluent and discharge into water bodies as well as main pollutant effluent and discharge into water bodies in 2014. The analysis applied the methodology in the *Survey and Assessment for National Water Resources and Its Development and Utilization of the People's Republic of China* in 2000 by the Ministry of Water Resources. The survey also included computation methodology and estimation results used in the calculation of the 2014 nonpoint source pollution according to the latest development condition.

Table 14: Water Quality of Lakes, 2003–2014

Year	Total Number of Monitored Lakes	Proportion of Lakes According to Water Quality Category (%)		
		Class I-III	Class IV–V	Worse than Class V
2003	52	40.4	9.6	50.0
2004	50	36.0	26.0	38.0
2005	48	35.4	39.6	25.0
2006	43	49.7	15.3	35.0
2007	44	48.9	21.6	29.5
2008	44	44.2	32.5	23.3
2009	71	58.4	27.6	14.0
2010	99	58.9	27.9	13.2
2011	103	58.8	16.5	24.7
2012	112	28.6	49.1	22.3
2013	119	31.9	42.0	26.1
2014	121	32.2	47.1	20.7

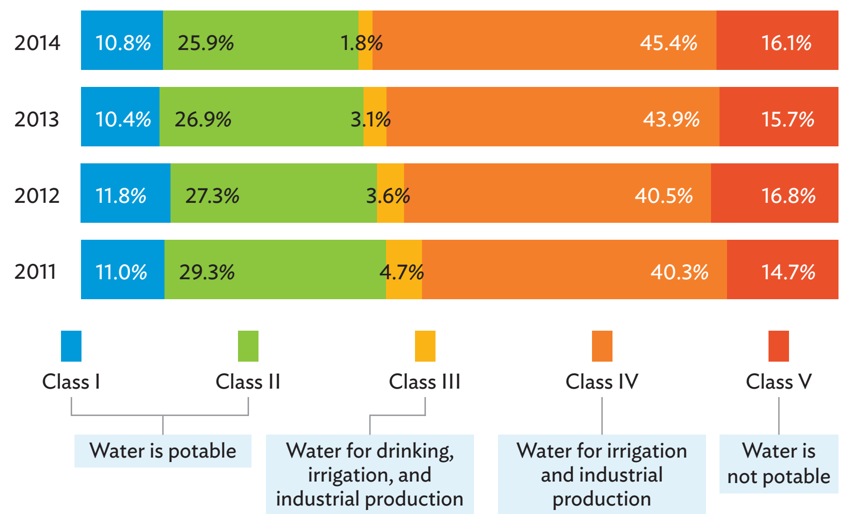
Note: According to the *Environmental Quality Standards for Surface Water* formulated by the Ministry of Ecology and Environment (formerly the Ministry of Environmental Protection) of the People's Republic of China, water bodies (i.e., rivers, lakes, and reservoirs within the country) are grouped into five classes based on usage purposes and protection targets. Class I primarily covers water from the natural sources and from national nature reserves. Class II applies to the first-rate protected areas for centralized drinking water sources and the areas protected either as habitats for rare fish or as spawning grounds for fish and shrimps. Class III is for the second-rate protected areas for centralized drinking water sources, areas protected as habitats for common fish, and areas designated safe for swimming. Class IV refers to water bodies suitable for industry use and for recreation, but with no direct human contact. Class V is suitable only for irrigation and landscaping.

Source: Ministry of Water Resources, People's Republic of China. Various years. *China Water Resources Bulletin, 2003–2014*. Beijing: China Waterpower Press.

Nonpoint source pollution (NPSP) effluents reached 68.4 million tons of COD in 2014, of which livestock and poultry production were responsible for 77% of total NPSP effluents (Table 17).

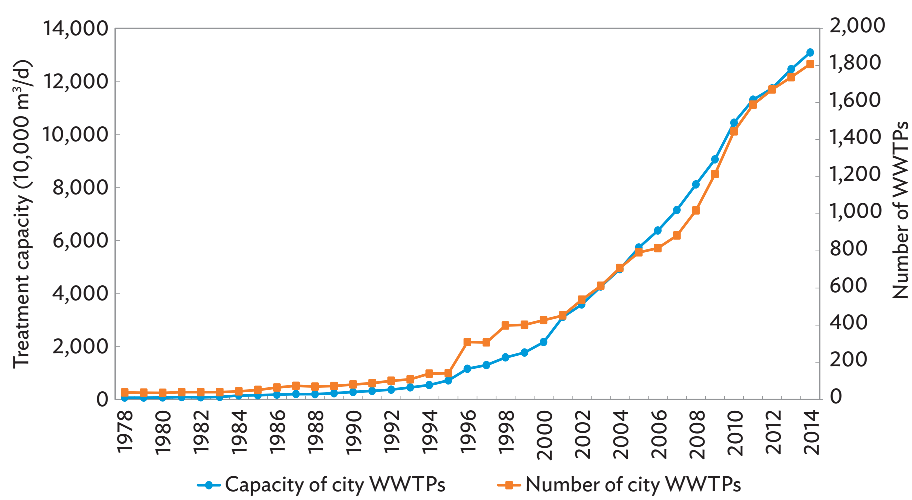
Three scenarios (low, medium, and high) of pollution discharge forecasting, based on level of water pollution reduction or treatment measures undertaken, were developed for 2020 and 2030 to assess the optimal future pathway for effective water pollution reduction in the PRC (Table 18). The medium treatment scenario emerged as the most appropriate under the current circumstances, with COD reaching 12.4 million tons in 2030 (a reduction of 43% from the 2014 level) and NH_3-N reaching 0.99 million tons in 2030 (a reduction of more than half). More importantly, implementation of the medium scenario would control wastewater and pollutants discharged into water bodies within allowable assimilative capacity of water bodies and would, therefore, mark the beginning of a genuine inflection of the country's pollution discharge.

Figure 18: Underground Water Quality Trends, 2011–2014



Sources: Ministry of Environmental Protection (now Ministry of Ecology and Environment), People's Republic of China. Various years. *Report on the State of the Environment in China, 2011–2014*. Beijing; Ministry of Geology and Mineral Resources, People's Republic of China. 1993. *National Groundwater Environmental Quality Standards (GB/T 14848-93)*. State Bureau of Technical Supervision. https://www.chinesestandard.net/PDF.aspx/GBT14848-1993 (translated into English).

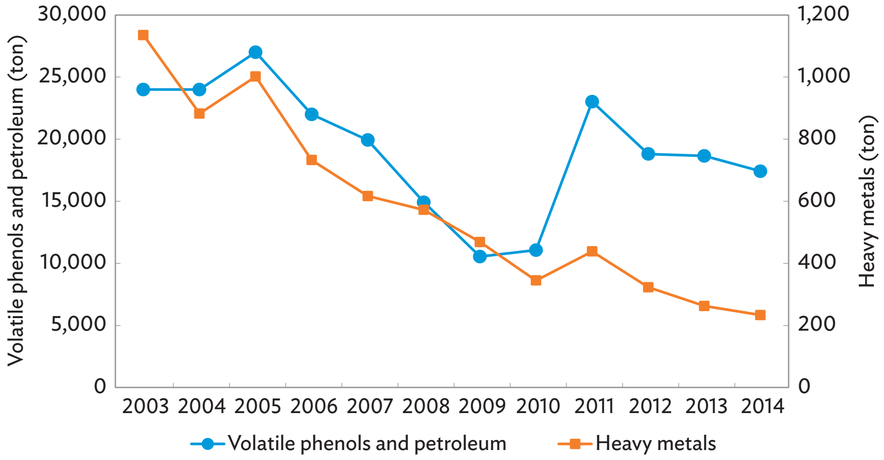
Figure 19: Number and Treatment Capacity of City Wastewater Treatment Plants, 1978–2014



m^3/d = cubic meter per day, WWTP = wastewater treatment plant.

Source: Ministry of Housing and Urban-Rural Development, People's Republic of China. 2015. *China Urban–Rural Construction Statistical Yearbook 2014*. Beijing.

Figure 20: Volatile Phenols, Petroleum, and Heavy Metal Effluents from Key Industry Categories, 2003–2014



Note: The sudden rise from 2010 to 2011 is due to the 35% increase in investigation number for key industry enterprises.

Source: China Environmental Science Press. Various years. *Annual Statistical Report on Environment in China, 2003–2014*. Beijing.

Table 15: Total Point and Nonpoint Source Pollution Effluent and Discharge
('000 tons)

Item	Pollutant Effluent		Pollutant Discharge into Water Bodies	
	COD	NH_3-N	COD	NH_3-N
Total (PSP + NPSP)	**84,118**	**9,397**	**21,709**	**2,078**
Industry	7,042	607	5,466	426
Urban	13,328	1,381	9,305	941
Rural	63,749	7,409	6,939	711

COD = chemical oxygen demand, NH_3-N = ammonia nitrogen, NPSP = nonpoint source pollution, PSP = point source pollution.

Note: Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 16: Main Point Source Pollution Effluent and Discharge by Region and River Basin, 2014
('000 tons)

Region/River Basin		Pollutant Effluent						Pollutant Discharge into Water Bodies	
		COD			NH_3-N				
		Total	Industry	Urban Domestic	Total	Industry	Urban Domestic	COD	NH_3-N
National Total		**15,676**	**7,042**	**8,635**	**1,988**	**607**	**1,381**	**12,106**	**1,367**
Region	Northeast	1,360	524	835	190	42	148	956	111
	North	2,010	655	1,355	311	55	256	1,454	203
	Southeast Coast	4,450	1,783	2,667	565	120	446	3,417	389
	Central	3,366	1,549	1,817	450	207	242	2,692	315
	Southwest	2,848	1,513	1,335	260	78	183	2,299	190
	Northwest	1,643	1,017	626	212	106	106	1,288	159
River Basin	Songhua River	850	376	474	102	26	76	557	54
	Liao River	543	193	350	90	17	73	424	59
	Hai River	868	307	561	136	26	109	611	89
	Yellow River	1,206	578	627	173	67	106	943	125
	Huai River	1,542	424	1,118	222	41	181	1,164	140
	Yangtze River	5,597	2,521	3,075	727	267	460	4,435	511
	Southeast Rivers	1,167	518	649	141	35	106	854	93
	Pearl River	2,640	1,208	1,432	295	75	220	2,115	218
	Southwest Rivers	631	447	185	31	11	19	518	23
	Northwest Rivers	634	469	164	71	41	30	484	55

COD = chemical oxygen demand, NH_3-N = ammonia nitrogen.

Note: Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 17: Main Nonpoint Source Pollution Effluent and Discharge, 2014
('000 tons)

Pollutant	Pollutant Effluent						Pollutant Discharge into Water Bodies
	Total	Agriculture Runoff	Rural Domestic Life	Urban Runoff	Soil and Water Erosion	Livestock and Poultry Husbandry	
COD	68,442	...	11,108	4,693	...	52,641	9,603
NH_3-N	7,409	529	711	...	...	6,168	711
TN	19,270	5,294	1,811	235	425	11,505	2,673
TP	5,647	1,434	697	35	245	3,236	549

... = data not available, COD = chemical oxygen demand, NH_3-N = ammonia nitrogen, TN = total nitrogen, TP = total phosphorus.

Note: Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 18: Forecasting of Water Pollutants Discharge under Three Treatment Scenarios
('000 tons)

Component		COD Discharge			NH_3-N Discharge		
		Low	Medium	High	Low	Medium	High
2014	PSP	...	12,106	...	...	1,367	...
	NPSP	...	9,603	...	...	711	...
	Total	...	**21,709**	...	...	**2,078**	...
2020	PSP	11,189	7,999	6,504	974	686	555
	NPSP	9,002	7,381	6,079	715	541	400
	Total	**20,191**	**15,380**	**12,583**	**1,689**	**1,227**	**955**
2030	PSP	9,687	6,297	4,032	745	519	269
	NPSP	8,234	6,118	4,105	699	470	250
	Total	**17,921**	**12,415**	**8,137**	**1,444**	**988**	**519**

... = data not available, COD = chemical oxygen demand, NH_3-N = ammonia nitrogen, NPSP = nonpoint source pollution, PSP = point source pollution.

Notes:

1. The scenarios correspond to the level of water pollution reduction or treatment measures employed (low, medium, high) to address pollution discharge.
2. Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Freshwater Ecology

According to the *Bulletin of the First National Census for Water* (2011), the total number of rivers with a basin area of at least 50 square kilometers (km^2) was 45,203 nationwide, the combined length of which spans about 1.51 million km.[13] The quantity of lakes with perennial water surface area greater than 1 km^2 was 2,865, including large lakes such as the Dongting Lake, Poyang Lake, Qinghai Lake, and Taihu Lake. The total water area of natural lakes reached about 78,000 km^2.

It is estimated that the PRC has about 10% of the global wetlands including rivers, lakes, marshes, coastal wetlands, and others. According to the *Second National Wetland Resources Survey* (2009–2013), the marshes area in the PRC covered around 0.22 million km^2, and the proportion of which against national territorial area was 2%.[14]

Aquatic Ecological Space

In the CWA study, aquatic ecological space includes water body areas, protection zones of drinking water sources, key prevention areas for soil and water erosion, and floodplain and flood retention areas.

[13] Ministry of Water Resources, People's Republic of China. *Water Resources in China*. http://www.mwr.gov.cn/english/mainsubjects/201604/P020160406508110938538.pdf.

[14] State Forestry Administration (now State Forestry and Grassland Administration), People's Republic of China. 2014. *Second National Wetland Resources Survey*. Beijing.

(i) **Water body areas.** These refer to surface water body areas of rivers, lakes, reservoirs, and ponds. According to the 2011 *China Statistical Yearbook*,[15] the PRC inland water area is about 175,000 km^2.

(ii) **Protection zones of drinking water sources.** Surface water and groundwater protection zones include primary, secondary, and quasi protection zones involving land areas and water areas.

(iii) **Key prevention areas for soil and water erosion.** According to the Review Division Results of National Key Prevention Areas and Key Control Areas in the National Water and Soil Conservation Plan, national key prevention areas for soil and water erosion cover around 439,000 km^2.

(iv) **Floodplain and flood retention areas.** Floodplain areas refer to inundation areas without any engineering facility protection. The floodplain areas in the middle and lower reaches of seven large rivers are 25,000 km^2, and the flood retention areas are 38,000 km^2. In addition, flood retention areas that are less than 10 years, with recurrence interval, cover about 4,000 km^2.

Aquatic Biodiversity

The PRC is home to a rich biodiversity of aquatic species, including 4,220 species of aquatic plants and 2,312 species of vertebrates. About 500 species of freshwater fish and 31 out of the 57 endangered water birds are threatened by disappearing wetlands.

According to statistics from the State Forestry and Grassland Administration (formerly State Forestry Administration) and the Ministry of Ecology and Environment, the PRC already has 46 international important wetlands and 173 national important wetlands. By 2013, about 577 natural wetland reserves had been established, with a total area of 232,400 km^2. Since 2005, the number of wetland reserves has increased by 279, of which national and provincial-level reserves increased by 23 and 144, respectively. The conservation ratio reached 45% of total natural wetlands.

Environmental Flow

Environmental flow is the volume of flow left in river channels after water abstraction for socioeconomic development. According to the National Water Resources Master Plan, the PRC's target required environmental flow is 1,918 bcm, with a maximum of 703 bcm in the Yangtze River and a minimum of 11 bcm in the Hai River.

Flood and Drought Disasters

Flood

The PRC has suffered from flood disasters frequently throughout its long history. Since its founding in 1949, more than 50 extraordinary basin-wide floods have hit the country. Impacted by terrain conditions and economic concentration, flood-risk areas are mainly located in the lower reaches of large rivers and coastal areas.

[15] National Bureau of Statistics of China. 2012. *China Statistical Yearbook 2011*. Beijing: China Statistics Press.

Since the 1990s, the direct economic losses of flood disaster have increased variably. During the periods 1990–1998, 1999–2009, and 2010–2014, the annual average losses were recorded at CNY124.58 billion, CNY100.33 billion, and CNY249.03 billion, respectively, showing a generally significant increasing trend during the past 25 years. While the total direct economic losses have increased, the proportions of annual losses to the corresponding gross domestic product have declined in general, reaching around 0.5% in recent years.

The major disaster risks from floods occur with small river floods and urban floods. The number of cities that suffer from floods and waterlogging also shows increasing trends. The annual average number of cities that were affected by floods and waterlogging increased from 120 during 2006–2009 to 189 during 2010–2014.

With rapid urbanization and increase in extreme precipitation events, coupled with the fact that construction of drainage networks lags behind the development of cities, the number of affected populations and the extent of loss and damages have intensified in cities.

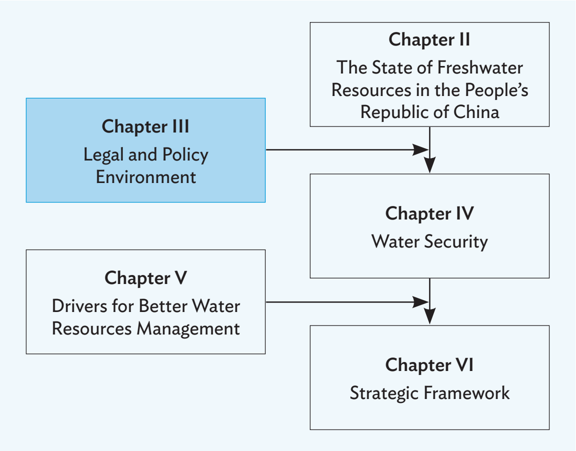
Drought

The PRC is historically a drought-hit country. In the country's historical documents from 1766 BC to AD 1937, the number of droughts recorded reached 1,074, with a frequency of once every 3 years and 4 months. The northern PRC is the most vulnerable to drought.

Drought disasters showed an overall decreasing trend in 1978–2014. The damaged farmland area reached roughly 267,830 km^2 in the severe drought disaster of 2000, but declined significantly to an average of 65,160 km^2 during 2010–2014.

In general, the total area affected by drought in the PRC's northern regions exhibited declining trends. Conversely, drought disasters in the southwest regions such as Guizhou, Sichuan, and Yunnan provinces showed increasing trends and frequency. In fact, during the past decades, many provinces suffered from severe drought such as the 2010 extreme drought in the southwest regions.

CHAPTER III
Legal and Policy Environment



The dichotomy between economic development and water security is evident in the structure of the 13th Five-Year Plan (2016–2020) of the People's Republic of China (PRC). The plan presses all sectors to grow—urbanization, industry upgrades, foreign investment, and the economy in general—while other parts of the plan are dedicated to a recovery from the past imbalanced growth and mitigating further losses—reducing emissions, water consumption, water pollutants, land reclamation, and deforestation. Finding a balance is a challenge and requires a coordinated effort to develop new legislation, policies, and institutional arrangements.

The 12th Five-Year Plan (2011–2015) was a period of heavy investment in infrastructure for flood control, water supply, irrigation, and wastewater treatment. Yet, the ecological health and sustainability of the country's water resources remained in critical condition. Political awareness and efforts to reverse environmentally unproductive development are growing, but the pace of water management reforms is no match for the PRC government's determination to urbanize and achieve the country's maximum growth potential.

This chapter outlines the elements identified by the country water assessment (CWA) that comprise the country's enabling environment for water resources management: the legal framework, policy developments and macrostrategies, market-based instruments, and the institutional arrangement going into the 13th Five-Year Plan period.

Legal Framework and Reforms

The PRC has made remarkable progress in improving its legal framework and institutional reforms in water management. A series of laws have been put in place, including the Water Law, Water Pollution Prevention and Control Law, Soil and Water Conservation Law, Flood Control Law, and other laws relating to the management of the environment, forests, and land resources. These laws are implemented with secondary legislation and regulations and are supported by State Council decrees and sector administrative regulations. Each province and their local governments have adopted these reforms as part of provincial legislation and regulations.

In 2011, the State Council issued the country's first national regulation on the management of a particular river basin, the Taihu Lake Basin. It aims to strengthen water resources protection and water pollution prevention; support flood control, drought relief, and ecological use; and improve the basin's ecological environment. The government is actively studying similar regulations or laws for the basins of Yangtze River and Yellow River.

In 2012, the central government implemented the Strictest Water Resources Management System; and, in 2013, the State Council decree on *Assessment Methods on Practicing the Strictest Water Resources Management System* established the "three red lines," which set compulsory targets for (i) controlling total water use, (ii) improving water use efficiency, and (iii) capping total water pollution discharge loads.

In July 2016, the State Council's legislation, *Regulations on Irrigation and Water Conservancy*, became effective, which aims to improve farmland engineering and water efficiency in order to enhance agriculture productivity and national food safety. The regulation specifies that no one is allowed to divert irrigation water for other uses without permission from the irrigation water users; and that any project that needs to use irrigation water or facilities for other purposes should negotiate with those in charge and seek the approval of related government departments.

Since 2011, the government has attached great significance to law enforcement. The legislative body (the National People's Congress), relevant authorities, and local governments check and monitor the implementation and enforcement of laws and regulations on a more regular basis and report their findings to the National People's Congress and the public. Public participation and supervision have also been strengthened for law formulation and enforcement.

For a more comprehensive and historical perspective, Table 19 summarizes the major state-level laws, regulations, and rulings related to water governance.

Policy Developments and Macrostrategies Related to Water

The 2015 Fifth Plenary Session of the 18th Central Committee of the Communist Party of China reiterated the government's commitment to economic restructuring, inclusive growth, and sustainable natural resources management. The session highlighted five development principles for the 13th Five-Year Plan (2016–2020): innovation, coordination, green development, opening-up, and sharing. A new water management policy of water saving, spatial balance, and systematic management was proposed, with more nongovernment sector and/or private sector involvement in the management of water. This refers to the widespread water conservation and development approach that requires cities, industries, and other economic growth sectors to factor in water resource limits.

At the dawn of the 13th Five-Year Plan, newly developed water-related action plans target the greatest challenges facing the economy and the public health. Water quality gets much needed attention in the 2015 Action Plan on Water Pollution Prevention and Control (also known as the *Water Ten Plan*), with projected total investment of CNY2,000 billion ($304 billion). The plan aims to control industry and municipal point sources as well as nonpoint sources from agriculture and stormwater. It also targets to reduce the number of lakes and rivers with a water quality standard of

Table 19: Major State-Level Laws, Regulations, and Rules on Water Governance in the People's Republic of China

Category	Name	Promulgating Organization	Provisions
Laws	Water Law	National People's Congress (Revised in 2016)	Provisions on the rational use, protection, and management of water
	Flood Control Law	National People's Congress (1998)	Provisions for flood control and water safety
	Soil and Water Conservation Control Law	National People's Congress (2010)	Provisions for soil erosion control
	Water Pollution Prevention and Control Law	National People's Congress (Revised in 2017)	Provisions on the prevention and control of water pollution, and protection of aquatic ecology
	Law on the Appraisal of Environment Impacts	National People's Congress (2002)	Appraisal of water impacts
Regulations	Regulation on the Administration of the License for Water Abstraction and the Levy of Water Resources Fees	State Council Decree No. 460 (2006)	Provisions on the application for and justification, approval, inspection, and supervision of water abstraction permit
	Detailed Rules of Implementation of Water Pollution Prevention and Control Law	State Council Decree No. 284 (2000)	Responsibilities, supervision, and rewards for water pollution prevention and control; and penalties for water pollution
	River Channel Management Regulation	National People's Congress (1988)	Provisions for river channel use control, construction, protection, and obstacle clearing
	Interim Regulation of Water Pollution Prevention and Control of Huai River Basin	State Council Decree No. 183 (1995)	Pollution prevention and control of the Huai River Basin
	Management Regulation of the Taihu Lake Basin	State Council Decree No. 604 (2011)	Protection of water resources in the Taihu Lake Basin
	Regulation for the Prevention and Control of Geological Disasters	State Council Decree No. 394 (2003)	Prevention and control of disasters such as settlement resulting from overexploitation of groundwater
	Opinions on Practicing the Strictest Water Resources Management System	GUO-FA No. 3 (2012)	Identifies the "three red lines," implements the strictest water resources management, and defines administrative responsibilities
Rules and Regulatory Documents	Management Procedures for Water Resources Justification of Construction Projects	Ministry of Water Resources and National Development and Reform Commission (2002)	Requirements for the procedure, contents, and methodology of water resources justification
	Administrative Measures on the Water Abstraction Permit	Ministry of Water Resources (2008)	Policies issued by water administrations for the management of water abstraction permit

continued on next page

Table 19 *continued*

Category	Name	Promulgating Organization	Provisions
Rules and Regulatory Documents	Administrative Measures on the Levy and Use of Water Resources Fees	Ministry of Finance, National Development and Reform Commission, and Ministry of Water Resources (2008)	Procedures for paying the water resources fees by organizations and individuals directly drawing water resources from rivers, lakes, or groundwater bodies, except for cases where water permits are exempted as per Article 4 of the Regulation
	Management Regulations for the Prevention and Control of Pollution in Water Source Protection Zones of Drinking Water	Ministry of Ecology and Environment (formerly Ministry of Environmental Protection) (Revised in 2010)	Regulations on zoning and management of water source protection zones
	Opinion on the Enhancement of Groundwater Management in Overexploited Areas	Ministry of Water Resources (2003)	Objectives governing the overexploitation of groundwater and requirements for actions

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Class V and worse. The preventive aspects of the plan are noteworthy, considering that the typical approach to water crisis and disasters in the developing world is reactive and limited to management and containment rather than reduction of future risks to disasters (or at least minimizing their scope and impacts) and prevention of water stress. The plan's effective implementation would result in desired improvements of water quality and the ecosystems during the 13th Five-Year Plan period.

The 2011 No. 1 Central Policy Document gave water security top place in the political agenda. As a result, several top-level central government policy papers and initiatives highlighted the importance of water security and ecosystem health. Some of the most recent policies and programs are discussed below.

The Three Water Resources Red Lines

In 2011, to address the serious and complex issues and challenges confronting the PRC's water resources, the central government launched key reforms to facilitate the implementation of the country's strictest water resources management system and the establishment of the three red lines on water use regulation, water use efficiency, and water pollution control. The government's National Urbanization Plan (2014–2020) urges urban master planning to draw red lines to protect surface and underground waters during future urbanization. Table 20 lists the targets for the three red lines.

The red line for total water use applies for both surface water and groundwater, and is the total limit for all users combined. It determines the carrying capacity of water resources needed to ensure sustainable socioeconomic development, and it differs across administrative levels (county, city, province, river basin).

The red line for water efficiency aims to promote the rational and efficient use of water. It is measured based on the water used by area or by enterprise and the level of socioeconomic development.

Table 20: Targets for the Three Water Resources Red Lines, 2015, 2020, and 2030

Target	2015	2020	2030
1. Total water use			
Total water use shall not be in excess of:	635 bcm	670 bcm	700 bcm
2. Water use efficiency			
Water use per CNY10,000 ($1,600) of industry added value shall be reduced to:	30% below 2010 figures	65 m^3	40 m^3
Irrigation efficiency shall exceed:	53%	55%	60%
3. Water quality			
Proportion of the number of water function zones meeting water quality standard shall exceed:	60%	80%	95%
All sources of drinking water for both rural and urban areas shall meet set standards		Yes	Yes
All water functions shall fully comply with water quality standards			Yes

bcm = billion cubic meter, CNY = yuan, m^3 = cubic meter.

Source: State Council of the People's Republic of China. 2013. *Assessment Methods on Practicing the Strictest Water Resources Management System*. Beijing.

There are two indicators set for the water efficiency red line: (i) the water used per CNY10,000 ($1,600) industry added value, which is applied to industries with the highest water consumption—e.g., thermal power, oil refinery, iron and steel, textile, paper making, chemical, and food; and (ii) the irrigation efficiency.

The red line for controlling pollution specifies the number of water function zones meeting water quality standard as percentage of the total number of water function zones by river basin and/or province. Several indicators are used to evaluate and monitor status of pollution control. As designated by the State Council, water quality within the water function zones of major lakes and rivers will be measured.

Ecological Red Line Policy

The principle of the ecological red line policy (ERP) was incorporated into the PRC's Environmental Protection Law in 2014. Its primary objective is ecosystem protection, particularly safeguarding the spatially well-defined ecological red line areas. The ERP's overall target is the protection of the integrity of essential ecosystems to secure the delivery of diverse yet interconnected ecosystem services required to meet the needs of various stakeholders in the ecological red line areas. The ERP aims to achieve the following main goals:[16]

(i) To protect vital ecosystem service areas (eco-function hotpots); to deliver basic water and environmental services, such as clean and safe drinking water, improved water storage, and carbon sequestration; and to maintain ecological well-being to support national and local socioeconomic development.

[16] Y. Bai et al. 2016. New Ecological Redline Policy (ERP) to Secure Ecosystem Services in China. *Land Use Policy*. 55. pp. 348–351.

(ii) To safeguard ecologically fragile areas (eco-fragile hotspots); to control land degradation, desertification, and soil erosion; and to uphold the safety of human habitats (with focus on local-scale living environment).

(iii) To provide and protect living environments and habitats, especially for important species; and to maintain biodiversity (biodiversity hotspots) on both national and global scales.

These goals will bolster the PRC's national ecological security network to support living environments and economic development. The ERP will provide better awareness as to where ecosystem services and supplies are, who provide them, and who the target beneficiaries are.

In 2018, the PRC government has approved plans of 15 provincial-level regions to draw their ecological red lines. The State Council authorized the red line plans from the cities of Beijing and Tianjin, Hebei Province, Ningxia Hui Autonomous Region, and the 11 regions along the Yangtze River Economic Belt (YREB). The red-line demarcated zones of these 15 provincial-level regions have a combined area of 610,000 km^2, or about a quarter of the total land area of said regions. They cover various nature reserves, scenic areas, forest parks, geological parks, and wetlands. The country's 16 remaining provincial-level regions should complete the demarcation of their ecological red lines by the end of 2018. Human activities will not be banned in the red line zones, but they will be under stringent regulation. The zones can be rationally developed, but their areas should not be reduced and their ecological functions should not be harmed.

Rural Vitalization

The PRC's rural areas play a vital role in water management. Not only are they the source of water, but they are also the biggest user of water in agriculture. Nonpoint source pollution (NPSP) from agriculture—in particular, nutrients, pesticides, and herbicides—comes from rural areas. Improving water management at the rural level will contribute significantly to improving the country's overall water management.

In early 2018, the government launched a package of policies, charting the road map for rural vitalization and aiming to develop a strong agriculture, a healthy environment, and well-off farmers. The policy should close the urban–rural development gap due mostly to poor quality and lack of efficiency in agriculture. The package of policies includes higher-quality agriculture development, protection of natural and cultural resources, and improvement of quality of poverty reduction. It also aims for better rural governance, strengthened leadership of the Communist Party, better health and education services, improved infrastructure and basic facilities (e.g., toilets), reforms on collective property rights and land use, and more training and incentives to build capacity needed to support rural development. Specific timetable and targets have been set and explained for the rural vitalization strategy:

(i) By 2020, an institutional framework and policy system shall be established for the strategy. By that time, there shall be no people living below the prevailing poverty line, and rural and agriculture productivity shall have markedly improved.

(ii) By 2035, basic rural and agriculture modernization shall have made decisive progress. All residents, both in urban and rural areas, shall have equal access to basic services; likewise, urban–rural integration shall have improved.

(iii) By 2050, rural areas shall see all-around vitalization.

The Sponge City Concept

During the rapid phase of urbanization in the last few decades, some development and construction-related behavior (especially cutting of mountains, covering of rivers, and deforestation) have seriously damaged the environment and drastically changed the state of water resources. As a result, increase in impervious surface, decrease of infiltration, and increase of volume and peak flow of rainfall runoff have been observed.

The "sponge city" concept aims to address increased flood risk resulting from rapid urbanization (and aggravated by the effects of climate change). It offers a holistic approach that mainstreams urban water resources management into urban planning designs and sustainable development policies. The sponge city concept, a joint initiative by the Ministry of Housing and Urban–Rural Development, the Ministry of Finance, and the Ministry of Water Resources, was launched in 2015. It aims to

(i) adopt and develop low-impact development initiatives to more effectively control urban peak runoff and temporarily store, recycle, and filter rainwater;

(ii) utilize more flood-resilient infrastructure to upgrade the conventional drainage systems (e.g., tunnels for underground water storage); and improve current standards of drainage protection (through low-impact development systems) to lessen excess stormwater and counter peak discharges; and

(iii) incorporate lakes, wetlands, and other natural water bodies into drainage design, while promoting multifunctional objectives (e.g., improving ecosystem services) and providing more blue spaces (artificial water bodies) and green spaces (parks, gardens) that help appreciate amenity values.

The sponge city program initially selected 16 cities for the conduct of pilot projects, and later added 14 more cities. The *Guideline of Sponge City Construction* enumerates the program's targets as follows: (i) to increase by 20% the surface area of urban land that can absorb surface water discharges, (ii) to retain and/or reuse urban stormwater up to about 70% by 2020, and (iii) to recycle stormwater further by approximately 80% in 2030. Hence, the sponge city initiative would not only combat urban flooding but would also take a proactive approach to collecting, purifying, and reusing urban stormwater in the PRC's cities and address extreme climate events (e.g., floods and droughts) in the future.

The sponge city concept is not unique. It is similar to concepts practiced in other countries and cities such as the Water Sensitive Urban Design approach in Australia and the methodology framework of the 100 Resilient Cities project.[17] The added value of the concept is that it forces cities to integrate urban land-use planning with water resource management.

The River Chief System

In 2007, the PRC assigned local government officials as "river chiefs." They were tasked to address the blue algae outbreak in Taihu Lake of Jiangsu Province. A number of regions with abundant water resources later adopted the river chief system to ensure the strict enforcement of environmental

[17] R. Brown, N. Keath, and T. Wong. 2009. Urban Water Management in Cities: Historical, Current and Future Regimes. *Water Science and Technology*. 59 (5). pp. 847-855; Rockefeller Foundation. 100 Resilient Cities. https://www.100resilientcities.org/.

policies and to enhance coordination of different government bodies. Based on the experience gained from these pilots, the central government released in December 2016 a document ordering the system, which is linked to the performance evaluation of top officials, to be established nationwide by the end of 2018.

In July 2018, this new measure aimed at improving the PRC's water governance has been successfully implemented across most provinces. The river chief mechanism places responsibility for protecting bodies of water squarely on the shoulders of government officials. More than 300,000 officials have been designated as river chiefs around the country, operating at the provincial, city, county, and township levels; and another 760,000 have been appointed at the village level. This basic concept incentivizes officials to pay more attention to water resources management within their district and to balance economic and environmental policies.

National Strategies for International and Regional Development and Integration

A visionary proposal for the 13th Five-Year Plan sets the government's bid for "vertical and horizontal economic axes primarily consisting of economic belts along sea, river, and border based on the overall strategy of regional development and led by the Three National Strategies—namely, the construction of the 'One Belt and One Road' initiative; the coordinated development of Beijing, Tianjin, and Hebei; and the development of the Yangtze River Economic Belt." The proposal needs to be carefully examined to understand the implications on water resources.

The change from "economic belts" to "economic axes" means that the PRC's regional development will focus on integration and coordination. Several growth poles will drive coordinated regional development. The growth poles will serve as centers for regional development and keep the economy growing at medium to high speed. The Three National Strategies will guide and steer the integration of the PRC's eastern, central, western, and northeastern regions. National integration will lead to a comprehensive opening up along sea, river, and border transport routes to new domestic, regional, and international markets.

Regional development will depend on green agriculture product processing, cultural tourism, and other characteristic and competitive industries in the western PRC region. The proposal acknowledges that efficient utilization of water resources will need to be strengthened, and eco-environmental protection needs to be intensified to improve the barrier function of ecological safety.

The Belt and Road Initiative

In 2013, during a state trip throughout Central Asia and Southeast Asia, PRC President Xi Jinping put forward a world-recognized major joint initiative called the Silk Road Economic Belt and the 21st-Century Maritime Silk Road (or otherwise known as *The Belt and Road Initiative*).[18]

[18] National Development and Reform Commission, Ministry of Foreign Affairs, and Ministry of Commerce, People's Republic of China. 2015. Vision and Actions on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road. http://en.ndrc.gov.cn/newsrelease/201503/t20150330_669367.html.

The Silk Road Economic Belt runs inland from the PRC to Europe through Central Asia and Russia; to the Persian Gulf and the Mediterranean Sea through Central Asia and West Asia; and to Southeast Asia, South Asia, and the Indian Ocean. The 21st-Century Maritime Silk Road mainly extends from the PRC's coastal ports in two directions—one to the Indian Ocean and then to Europe, and the other through the South Pacific.

This important medium- to long-term strategy calls for the PRC's water sector to engage in water diplomacy by strengthening bilateral and multilateral cooperation with countries along the new silk belt and road; to take advantage of the PRC's planning, survey, design, construction, and technology of water infrastructure projects; and to participate in international water affairs.

The Beijing–Tianjin–Hebei Region

As the PRC's center of politics, economy, culture, science and technology, the Beijing–Tianjin–Hebei region is an important growth pole in the eastern PRC and a major driver of the country's economic development. After years of developing major water infrastructure, the flood control and water supply systems are well established in Beijing, Tianjin, and Hebei. But the highly concentrated population and industries, along with the seriously overloaded water resources and water environment in these regions, have led to evident water-related problems—e.g., water shortage, aquatic ecosystem degradation, severe water pollution, and frequent water conflicts.

The current pattern of water use and structure of water resources in the Beijing–Tianjin–Hebei region are not sustainable. For example, water supply depends heavily on the overexploitation of groundwater. The proportion of agriculture water use is relatively high. Service industry water use and eco-environment water use are relatively low in the metro areas of Beijing, but more so in the city of Tianjin.

In 2014, agriculture water use in Tianjin accounted for 45% of the city's total water use, and its service industry accounted for only 4.6%. The proportion of supply coming from groundwater sources is high in Tianjin (up to 66%). Groundwater is used for nearly 75% of Hebei Province's water supply. Nonconventional water sources (such as reclaimed, brackish, or desalinated water) are underutilized.

As the PRC rolls out its major strategy of coordinated development in the region, the noncapital functions of Beijing will become smaller, and the regional layout and approach of socioeconomic development will be transformed. This will lead to shifts in demand, changed means, and readjusted structure of water use. Moreover, as the South-to-North Water Diversion Project begins to supply water, the layout and deployment of water sources will change as well. New types of agriculture, industry, and commerce are needed to be developed in this region. This would mean developing low water-intensive industries, mainly high-tech and high-value industries, and low water-use agriculture. All high-polluting industries will need to be closed or transferred to other regions in the PRC.

Water use and efficiency across industries and regions will need to be improved in order to take away the bottlenecks in water resources, control the overexploitation of groundwater, restore the river and lake ecological systems, and effectively increase regional water security.

The South-to-North Water Diversion Project is still incomplete, which is seriously restricting the benefits of water supply from the diverted water. Overexploitation of groundwater resources continues in the Beijing–Tianjin–Hebei region. Once the diversion project is completed, the region will have to contend with the long-term accumulated issues of having encroached upon environmental flows and overexploiting groundwater resources.

The Yangtze River Economic Belt

The YREB is centrally located in the PRC between the south and the north, with an extremely important ecological position. It receives an abundant allocation of sunlight, heat, water, and soil, thus breeding abundant fauna and flora. It is the most important conservation area of water sources and a key ecological protective barrier system. Having the longest development history in the PRC, it also has high population and industrial density.

The past problems of water resources and water environment have not been adequately addressed, and new problems from rapid development will become more prominent and will constrain the YREB's regional socioeconomic growth even more seriously. The Yangtze River is one of the important sources of drinking water supply to the cities in the middle and lower reaches, and is the single drinking water source for some of these cities. Yet, the security of drinking water has been threatened in recent years, as the total pollutant load continues to increase annually. Overdevelopment of water use is further degrading the aquatic ecology and water environment. Moreover, new eco-environmental problems are emerging, which include the shrinking of lakes and wetlands and the drying up of some sections of the tributaries, thereby seriously endangering rare aquatic animals. Many chemical industrial parks and hazardous chemical terminals are situated along the Yangtze River, making it even more difficult to eliminate the risks of major water pollution incidents. Stringent rules for the protection of water resources and aquatic ecology in the middle and lower reaches of the Yangtze River must be implemented with utmost urgency.

In 2017, the PRC government released an environmental plan for the YREB, which stretches more than 2,000,000 km^2 over nine provinces and two municipalities. Forty percent of the PRC population lives within this economic belt. The national promotion of the YREB intends to recharge the country's slowing economy, and the environmental plan will limit usage of the river, ensure environmental flow levels, and impose rigorous protection measures.

Current Water Management System

In the PRC, water is a public natural resource owned by the state. Therefore, governments at different levels take leading responsibilities for the control and management of water resources based on the demand for socioeconomic development and for ecological protection. The management system generally covers the whole process from water allocation, supply, use, and consumption to drainage, disaster mitigation, effluent control, and wastewater treatment and reuse.

Total Water Use Cap

Based on the National Water Resources Master Plan, which has an integrated socioeconomic demand and ecosystem protection provision, the PRC has a national total water use cap. Present water use reaches 610 billion cubic meters (bcm). By 2020, water use will be strictly regulated to under 670 bcm and, by 2030, the water use cap will be under 700 bcm. This is the red line for total water use.

Interbasin Water Resource Reallocation

Distribution of water resources is very uneven in the PRC, with apparent spatial and temporal variations. An effective and sustainable system of water allocation is therefore important to support socioeconomic development. For instance, the PRC's northern region is short of water, hence water diversion from the Yangtze River has been done to reallocate water. In 2014, the amount of water diverted among the 10 Class-I river basins in the PRC reached 19.1 bcm, covering 3% of total water supply.

Water Resource Allocation in Basins

Besides interbasin water reallocation, local water resources are sometimes also allocated in some river basins in the PRC. An example is the water allocation for the Yellow River as regulated by the State Council in 1987 (called the 1987 Yellow River Water Allocation Scheme), which determined the amount of water available for the provinces and cities in the Yellow River Basin. Water allocation for ecosystem purposes was taken into account in this water allocation scheme. In the arid northwest of the Yellow River Basin, at least 40% of the water should be allocated to wetlands and natural oases, according to the PRC standard. The Yellow River water allocation plan also reserves 21 bcm per year for balancing the sediment and for ecosystem preservation in the Yellow River Delta.

Water Use and Discharge Permits

Based on the water allocation to the river basins, affected regions and relevant governments control the use of water through a permit system within the allocated amounts. At present, water use caps have been set for all the provinces for 2020 and 2030. Water use permits are constrained by the water use red lines. However, most permits are only for big industries, urban domestic users, and some big irrigation schemes. Most small users are not covered and controlled under the permit system, such as farmers with groundwater well irrigation.

Water saving is highly emphasized in the water-scarce country, and water-use efficiencies are listed as major constraints and targets in water resources planning and management. At present, the State Council has set irrigation efficiency targets for all the provinces for 2020 and 2030; targets for water use per CNY10,000 industry added value are also being formulated, as water saving has become the first priority in both national and local water management.

Wastewater discharge is permitted according to the water quality protection requirements. The State Council has set the targets for percentage of water function zones meeting water quality standards at 80% and 95% for 2020 and 2030, respectively (Table 21).

Water and Pollution Discharge Trading

At present, all provinces are allocating water use amounts (red lines) to each region under their management. Water use rights trading practices have been applied in the last 10 years in Ningxia Hui and Inner Mongolia autonomous regions, allowing for water rights transfer from agriculture use to industry use. The Ministry of Water Resources initiated water rights trading pilots in seven provinces in 2014. The management of water use rights trading needs an effective control measure such as a smart metering system, which involves high operation and maintenance cost.

Table 21: Key Water Function Zones of Rivers and Lakes in the People's Republic of China Meeting Provincial Water Quality Targets
(%)

Region	2015	2020	2030
Beijing	50	77	95
Tianjin	27	61	95
Hebei	55	75	95
Shanxi	53	73	95
Inner Mongolia Autonomous Region	52	71	95
Liaoning	50	78	95
Jilin	41	69	95
Heilongjiang	38	70	95
Shanghai	53	78	95
Jiangsu	62	82	95
Zhejiang	62	78	95
Anhui	71	80	95
Fujian	81	86	95
Jiangxi	88	91	95
Shandong	59	78	95
Henan	56	75	95
Hubei	78	85	95
Hunan	85	91	95
Guangdong	68	83	95
Guangxi Zhuang Autonomous Region	86	90	95
Hainan	89	95	95
Chongqing	78	85	95
Sichuan	77	83	95
Guizhou	77	85	95
Yunnan	75	87	95
Xizang (Tibet Autonomous Region)	90	95	95
Shaanxi	69	82	95
Gansu	65	82	95
Qinghai	74	88	95
Ningxia Hui Autonomous Region	62	79	95
Xinjiang Uygur Autonomous Region	85	90	95
National Average	**60**	**80**	**95**

Source: State Council of the People's Republic of China. 2013. *Assessment Methods on Practicing the Strictest Water Resources Management System*. Beijing.

Discharges of wastewater and pollutants are inevitable for most areas, and discharge permit systems are implemented for most basins. The discharge permits are generally based on water flow regimes, water quality targets, and impacts of pollutants. However, the discharge permit system does not cover most pollutants in the PRC, except chemical oxygen demand (COD) and ammonia nitrogen (NH_3-N). The Ministry of Environmental Protection (now Ministry of Ecology and Environment) has explored pollution discharge rights trading in 11 provinces since 2007, and promoted this trading in recent years.

Water Monitoring and Metering

The water allocation and use permit system and the water rights trading system need more monitoring and metering for accountability. In the PRC, monitoring and metering are lagging and cannot meet water management demands. A national water resources monitoring network is currently under construction. Phase 1 has been completed, while Phase 2 is ongoing. In addition, a national groundwater monitoring network project is also underway and an information center is being established, setting up 20,000 monitoring wells. Water use metering system is being expanded to include the coverage of smaller users.

There is also a plan to undertake an evaluation of how actual water management is being done, taking into account set water allocations, water abstraction permits, the three red-line targets for water resources management, and data monitoring. This evaluation aims to determine the effectiveness of present water management practices. A series of regulations has been implemented to encourage good management or punish violations of established restrictions, such as overdevelopment of water use or pollution discharges that exceed the set targets.

Governance

Under current circumstances, the PRC needs to upgrade its traditional water management approach and develop a modern water governance system that will address not only the new challenges brought by rapid urbanization and modernized agriculture development but also the adverse impacts of global climate change (Box 1). With water infrastructure building now largely in progress, new water management constraints need to be addressed such as the limitation of available water supply and the pollution of water resources. Pollution is increasing the competition between water users for the remaining clean water resources. Balancing the allocation of water resources between socioeconomic development and ecosystem protection has become the most important priority for the management of water affairs. The protection of the integrity of rivers and other water bodies is now regarded as a major target in the national strategy.

International Good Governance Attributes

Traditional thinking and approaches to water governance in the PRC need to conform to the following international good governance attributes.

(i) **Support from legislation.** Traditional water governance in the PRC relies too much on government and administrative measures. Following the reform trends of social governance projected for the next 10–20 years, a law supporting water governance should be expected. In this process, improved water-related laws, policies, regulation, accountability, transparency, public participation, oversight, and enforcement are expected to win prominence.

Box 1: Beyond Water Management, Building Water Governance

Governance is a relatively new term, and so is water governance. According to the definition of the Organisation for Economic Co-operation and Development (OECD), water governance is a set of rules, practices, and process in water management policy formulation, implementation, and auditing. A similar term exists in environmental protection called environmental governance. According to the United Nations Environmental Program, environmental governance is a combination of rules, best management practices, policies, and institutions to address the interacting relations between human and the environment.

Governance is different from traditional management. The main differences concern three aspects. First, management primarily refers to government functions and responsibilities, while governance refers also to the need for dialogue and participation of stakeholders, including enterprises, nongovernment organizations, and even individuals. Second, management is essentially a top–down process based on national laws or regulations. Governance is based on many more rules and also include, beyond laws and regulations, dialogue processes from top to bottom and from bottom to top. Finally, governance functions are wider than for management. The latter focuses mostly on the functions that coordinate the effort of the government to accomplish goals and objectives by using available resources efficiently and effectively.

Source: OECD. 2015. OECD Principles on Water Governance. http://www.oecd.org/governance/oecd-principles-on-water-governance.htm.

(ii) **Integrative nature.** More integration is the key to improved water governance in the PRC. A river basin or watershed should be regarded as the fundamental unit of water management and as an integrated system covering natural resources (such as rivers, forests, etc.) and human-made resources (such as farmlands, human settlements, and industries). Both are closely interlinked. Integrated river basin or watershed planning and management systems should be developed so that the demand for water can be better balanced with the need to protect these resources. Although 85% of the PRC's cities have established water affairs management bureaus, some of them are not really integrated. Water resource allocation, water supply, wastewater treatment, flood control, river management, and other water-related affairs often remain separately managed by different departments and bureaus. In the future, more integration should be promoted based on the experience of large cities like Beijing and Shanghai, where water affairs have been more effectively integrated and are managed by a single water affairs bureau.

(iii) **Transparency and participatory involvement.** Given large water works (reservoirs, irrigation, dams, power, flood control, interbasin transfer, etc.), well engaged yet limited availability of water resources and further pressure on water and the environment can lead to more conflicts. To defuse them, additional dialogue among water users and improved public participation in decision-making are needed. Water user associations introduced by the World Bank is a typical successful mode of participation for irrigation management at farm level. Similar participatory governance tools should be developed and expanded to watersheds and urban areas to strengthen dialogue and participation. For instance, river basin commissions can be reformed to attract relevant provinces or users to participate in the development of water allocation and water pollution control measures. Water users should be given water use rights and, ideally, it should be possible to trade those rights on a market platform to optimize the allocation of resources and their protection at the least economic cost.

The PRC central government has already asked for a higher emphasis on market instruments for resource allocations, including for water. Water use rights are being piloted in Hubei and Jiangxi provinces and Ningxia Hui Autonomous Region, where specific water use rights have been defined; as well as in Gansu, Guangdong, and Henan provinces and Inner Mongolia Autonomous Region, where water rights trading solutions are being tested. A National Water Rights Trading Center has been established and has been operational since 2016 in Beijing. The center was approved by the State Council and was jointly established by the Ministry of Water Resources and the Beijing Municipal Government. The center is a platform for water rights trading and will contribute to the development of related policies.

(iv) **Holistic processes.** Two important water cycles need to be covered by water governance in the future. These include the big (overall) hydrological water cycle, and the small water cycle of drinking, municipal and industry water use, and discharge. Regarding the hydrological cycle, more attention should be given to restoring healthy water systems; providing more areas for water; and taking care of the sedimentation balance, diversified river corridors, and estuary biodiversity, among others. The human impacts on this water cycle should be minimized and placed under stricter control, especially in highly developed areas. As to the (small) water use cycle, governance needs to take into account other water sources and recharge of (ground) water systems, water transfer, water treatment, water allocation, end-user water savings, water consumption control, wastewater collection and treatment, reclaiming and discharge into water bodies, etc. To improve water supply security for urban areas, upstream water source protection should be taken into account. Water pollution control should also be better integrated into pollution source identification, in-house pretreatment, centralized treatment to discharge of treated effluent into water bodies, and the subsequent need to keep water bodies free from pollution to secure ecological services.

Ministry-Level Reforms

The PRC government has resolved to deepen the reform of state institutions in order to facilitate the modernization of the country's governance system and capacity from a strategic and long-term perspective.

There is ongoing institutional reform at the central and provincial levels, which is expected to be completed by the end of 2018; and by March 2019 at the local level.[19] In early 2018, the PRC started restructuring its ministries with some adjustments in their respective mandates. The Ministry of Natural Resources was established in April 2018, and absorbed eight former departments (including the Ministry of Land and Resources). It is tasked to oversee the management of the PRC's grasslands, forests, wetlands, water and maritime resources, and urban and township planning. It will develop and protect these natural resources, and establish for them a system of paid use. They will take over some of the tasks of the Ministry of Water Resources, thereby reducing some of the latter's mandate.

Also in April 2018, the Ministry of Emergency Management was formed. It absorbed the functions of 13 relevant departments and agencies under different ministries, including some responsibilities of the Ministry of Water Resources. The primary mandate of the newly formed ministry is the protection of life and property. It has launched a 24-hour emergency response system to handle

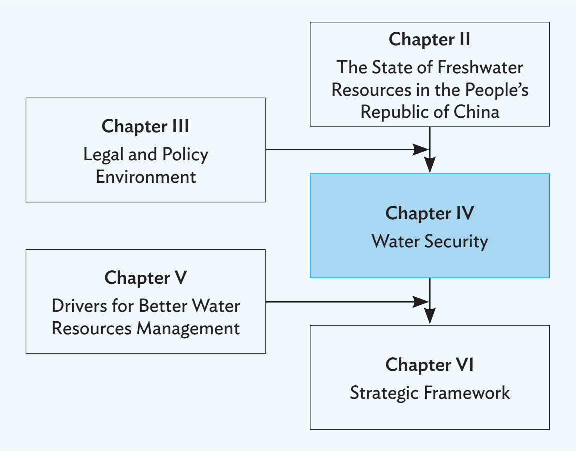
[19] L. He. 2018. Institutional Reform for Better Governance. *China Daily*. 15 March. http://usa.chinadaily.com.cn/a/201803/15/WS5aa9a7e1a3106e7dcc141b27.html.

natural disasters or major workplace accidents. At the same time, the functions of the National Development and Reform Commission has been streamlined to focus on its main role of economic macromanagement.

The Ministry of Ecology and Environment has replaced the now defunct Ministry of Environmental Protection and consolidated some of the functions and personnel of other ministries or agencies. It has embarked on a countrywide campaign to deal with water pollution in cities and repair sewage treatment facilities in towns. Instead of managing air, water, and soil pollution separately, the Ministry of Ecology and Environment will now deal with them as an entire ecological system. This ministry has also been mandated to reduce climate change impacts and carbon emissions; manage surface water, groundwater, and river basins; and protect the coastal and marine environment. It has likewise taken over the regulation of agriculture NPSP from the Ministry of Agriculture and the management of wastewater discharge outlets from the Ministry of Water Resources, thereby managing pollution in both urban and rural areas. To further the reforms at both central and local levels, coordinated actions are essential.

CHAPTER IV

Assessment of Water Security: Providing Water-Related Services



Water security is defined as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."[20]

The Asian Development Bank (ADB) gauges water security in Asia and the Pacific using a methodology it developed for the *Asian Water Development Outlook* (AWDO). Scores are given for five key dimensions: household water security, economic water security, urban water security, environmental water security, and resilience to water-related disasters. The AWDO methodology shows the development over time of water security, and compares levels of water security between countries in the region. Water security indicators are determined at the country level.

The country water assessment (CWA) study developed an index system modeled after ADB's AWDO to determine the national water security level of the People's Republic of China (PRC). This enhanced innovative methodology was developed to suit the specific conditions of the PRC and to make it possible to define scores at the provincial level.

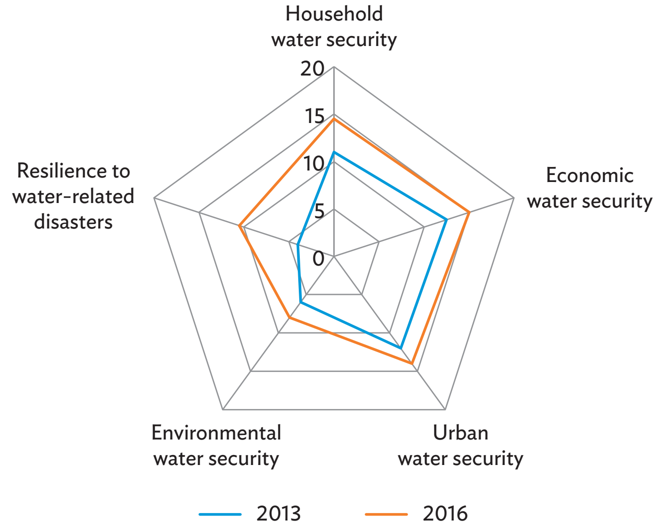
Asian Water Development Outlook

In its 2013 and 2016 editions, the AWDO rated the PRC on the following five key dimensions: household water security, economic water security, urban water security, environmental water security, and resilience to water-related disasters. Expressed in a score range of zero (no security at all) to 100 (perfect), the national water security score of the PRC was 44.3 in 2009 and 61.8 in 2014.[21] The progress in the PRC's water security condition during 2009–2014 is quite impressive. Compared to the other countries assessed under the AWDO 2016, the PRC ranks 17th out of the 48 countries in the Asia and Pacific region, including the advanced economies of Australia, Japan, and New Zealand.

[20] UN-Water Task Force on Water Security. 2013. *Water Security & the Global Water Agenda: A UN-Water Analytical Brief*. Hamilton, Ontario. United Nations University / Institute for Water, Environment & Health (UNU-INWEH). http://www.fao.org/3/a-i2930e.pdf.

[21] The score from the 2013 AWDO reflects the PRC's water security condition as of 2009; the score from the 2016 AWDO reflects the situation in 2014.

Figure 21: Progress of Water Security in the People's Republic of China, 2013 and 2016



Sources: Asian Development Bank. 2013. *Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific*. Manila; Asian Development Bank. 2016. *Asian Water Development Outlook 2016: Strengthening Water Security in Asia and the Pacific*. Manila.

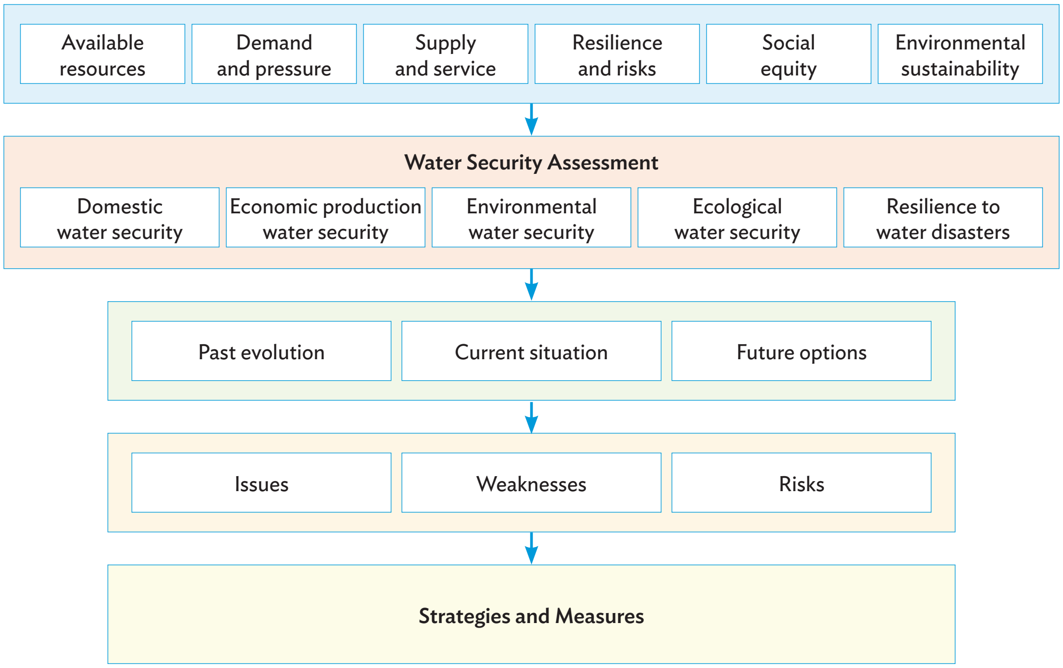
This positive development is also shown in Figure 21, wherein the scores are expressed by key dimension under the 2013 and 2016 AWDO. Progress has been made on all key dimensions, particularly on household water security and resilience against water-related disasters. The environmental key dimension shows that there is room for improvement.

Adaptation of the Water Security Methodology for the People's Republic of China and the Assessment Results

Modeled after ADB's AWDO, the CWA study developed an adapted index system for determining the PRC's national water security level. In this adapted system, water security is also based on five key dimensions, but the AWDO's urban key dimension is replaced by an ecological dimension. The following are the five dimensions used in this CWA: domestic water security, economic production water security, environmental water security, ecological water security, and resilience to water-related disasters.

Embedded in these key water security dimensions are 20 quantifiable indicators that reflect basic functions of water resources, water services, sustainability of usage, and protection of water resources. The indicators are used to score water security according to five scales: insecure, slightly insecure, basically secure, moderately secure, and secure. The scores are aggregated and averaged using equal weights to arrive at a single index value per dimension. The general approach and methodology of the assessment is illustrated in Figure 22. Each of the dimension-focused indexes is aggregated with

Figure 22: General Approach of Water Security Assessment and Strategy Formulation



Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

equal weights into an overall water security index. Each indicator, each security dimension index, and the overall water security index are scored on a scale of 1 to 10, which corresponds to the five security grades as shown in Table 22.

The assessment was done at the provincial level and aggregated at the national level. This approach captures the spatial differences. Most of the data were from 2014, which means that the water security scores represent the water security situation as of 2014 and, hence, are comparable with the results of the 2016 AWDO.

Table 22: Water Security Grade with Index Range

Security Grade	Insecure	Slightly Insecure	Basically Secure	Moderately Secure	Secure
Index Range	0–2	2–4	4–6	6–8	8–10

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Domestic Water Security

Domestic water security is determined by the coverage and standards of urban and rural water supply services and the reliability of those systems to ensure safe drinking water. There are four indicators of domestic water security:

(i) **Urban tap water coverage ratio.** This indicator expresses the ratio of urban population covered by public tap water supply over the total urban population. The estimates are based on statistics about city and county tap water coverage ratios. Most provincial cities scored high, except for Beijing, Henan Province, and Tibet Autonomous Region, which had considerably lower scores. A significant percentage of the Beijing population still relies on self-provided groundwater wells.

(ii) **Ratio of cities with multiple water sources.** This indicator expresses the ratio of cities with multiple water sources over the total number of cities, based on survey and official statistics. Cities with multiple water sources are considered to be more resilient against disruptions in water supply. The provincial-level municipalities of Beijing, Shanghai, and Tianjin stood out as very resilient, with multiple sources of supply that are well established. All other provinces have significantly lower scores.

(iii) **Ratio of urban–rural drinking water sources satisfying designated standards.** This indicator refers to the ratio of urban–rural surface water and groundwater sources that satisfy raw water regulatory standards over the corresponding total number of water sources. Values range between 60% and 100% and show a linear progression across the provinces. Beijing, Tianjin, and Hebei Province score the highest, while the three least endowed provinces are Sichuan Province, Guangxi Zhuang Autonomous Region, and Qinghai Province.

(iv) **Rural tap water coverage ratio.** This indicator refers to the ratio of rural population with access to tap water supply over the total rural population. Values are widely spread and show a linear progression between 40% and 100% across the provinces. Topping the list are Shanghai, Beijing, and Jiangsu Province, which have relatively low rural population and have ensured that peripheral villages have access to tap water. The three lowest-rated provinces are Tibet Autonomous Region, Shaanxi Province, and Anhui Province, which are more remote, underdeveloped, and have large rural population.

Table 23 presents the aggregate values for the four indicators of domestic water security and the resulting index score for the entire dimension. The provincial data underlying these aggregate scores show interesting trends. Domestic water security scored as *moderately secure*, which is a bit optimistic

Table 23: Indicator Scores and Key Dimension Index Score for Domestic Water Security, 2014

Indicator	Indicator Value (%)	Indicator Score	Key Dimension Index Score
Urban tap water coverage ratio	85.6	9	7.3
Ratio of cities with multiple water sources	30.7	4	
Ratio of urban–rural drinking water sources satisfying designated standards	72.3	8	
Rural tap water coverage ratio	74.6	8	

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

considering the disparity in coverage and quality of water services between urban and rural areas. Domestic water was most secure in the provincial-level municipalities of Beijing, Shanghai, and Tianjin. Domestic water was least secure in the remote areas (the autonomous regions of Guangxi Zhuang and Tibet, and Yunnan Province) and in some central underdeveloped provinces with large populations (Anhui, Henan, and Sichuan provinces).

Economic Production Water Security

Economic production water security compares the total amount and intensity of water use against the government's red lines—i.e., the water use efficiency and productivity rates of different sectors to sustain economic growth in food production, industry, energy, and urban development. Water shortage and low water use efficiency can affect a province's or region's capacity for sustainable economic growth.

There are four indicators of economic production water security:

(i) **Percentage of total water use over maximal control target.** The total maximal control targets of water use at the national and provincial levels for 2020 and 2030 are explicitly determined in the State Council document, *Assessment Methods on Practicing the Strictest Water Resources Management System.* Xinjiang Uygur Autonomous Region is already well over its allocated target, while Jiangxi and Gansu provinces are approaching their limit. Majority of the other provinces have values between 80% and 95%. The two districts with a large margin for increase include Shanghai and Qinghai Province.

(ii) **Water shortage rate.** This indicator compares total water shortage to total water demand. Any deficit in supply considers the physical deficit plus the overexploited surface water and groundwater, where applicable. All provinces have shortages; although, for largely half of them, the shortage is only between 1% and 15%. A second tier consists of provinces with bigger shortage rates between 20% and 25%. The largest water shortage is experienced in Hebei Province, which has a shortage rate exceeding 40%.

(iii) **Water use per CNY10,000 of gross domestic product.** This indicator refers to the ratio of total water use needed to generate CNY10,000 of GDP, calculated at 2010 constant prices. This indicator shows the economic water productivity. The three highest scoring areas are Tianjin, Beijing, and Shandong Province. Considering that these areas are also significantly short of water, their relatively good scores indicate that scarcity may not always be an adverse factor. Tianjin, Beijing, and Shandong Province received high scores because the water scarcity they face have forced them to increase their productivity. Nonetheless, they are also partially responsible for the overexploitation of groundwater and for diverting water reserved for environmental flows, which cause stress on other water security dimensions such as environmental and ecological water security. A similar picture emerges for water use efficiency in agriculture.

(iv) **Farmland irrigation efficiency.** This indicator refers to the ratio of net irrigation water use over the total irrigation water distributed to irrigated farmland. The five most efficient regions are Shanghai, Beijing, Tianjin, Hebei Province, and Shandong Province. Since Shanghai, Beijing, and Tianjin have relatively little land for agriculture, these mega-poles use it very efficiently to serve their large population. Hebei and Shandong provinces are seriously short of water and have, therefore, invested significantly in water conservation in agriculture (the main user of water resources) to free water resources for other welfare-generating economic activities. The majority of provinces have irrigation efficiency between 0.45 and 0.60.

Table 24 presents the aggregate values for the four indicators of economic production water security and the resulting index score for the entire dimension. Water security for economic production scored *basically secure* at the national level. The main problem is the overall low water use efficiency in various sectors. Another factor is the excessive water demand over supply in the northern regions due to the limited availability of water resources there. Not surprisingly, water is most secure for economic production in the economically developed coastal regions, which have higher water use efficiency such as Shanghai and Zhejiang Province.

Table 24: Indicator Scores and Key Dimension Index Score for Economic Production Water Security, 2014

Indicator	Indicator Value	Indicator Score	Key Dimension Index Score
Percentage of total water use over maximal control target (%)	90.1	8	5.5
Water shortage rate (%)	8.0	5	
Water use per CNY10,000 of GDP (m^3)	109.4	3	
Farmland irrigation efficiency (no.)	0.5	6	

CNY = yuan, GDP = gross domestic product, m^3 = cubic meter.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Environmental Water Security

Environmental water security is determined by the quality of water resources, the gaps between designated water quality standards, the amount and intensity of pollution loads discharged into water bodies, and the service coverage and standards of wastewater management systems.

There are five indicators of environmental water security:

(i) **Ratio of river length equal to and better than Class III.** This indicator is evaluated annually and refers to the length of river that satisfies Class III and above water quality over the total river length monitored. The ratio of river length equal to or better than Class III varied from 35% to 100% and was spread over the provinces. Chongqing, Tibet Autonomous Region, and Hainan Province have the best water quality. Chongqing tops the list because it is near the confluence of two large rivers, the Yangtze River and the Jialing River, which dilute the pollution discharges; Tibet Autonomous Region because it is less developed; and Hainan Province because it is particularly well endowed with water.

(ii) **Ratio of PSP COD discharge over ceiling control amount.** This indicator refers to the ratio of the yearly point source pollution (PSP) chemical oxygen demand (COD) discharged into water bodies over the maximum PSP COD discharge control amount. Most provinces exceed their respective ceiling control amount by 100% up to 210%. Three provinces are discharging at excessively high rates: Shanxi Province, Shaanxi Province, and Xinjiang Uygur Autonomous Region. These provinces have very limited water resources. Shanghai has the lowest exceedance rate, followed by Qinghai Province and Tibet Autonomous Region. The picture is similar with the ratio of PSP ammonia nitrogen (NH_3-N) discharge over the ceiling control amount.

(iii) **Ratio of PSP NH_3-N discharge over ceiling control amount.** This refers to the ratio of the yearly PSP NH_3-N discharged into water bodies over the corresponding maximum discharge control amount. Again, most provinces are discharging in excessive amounts. Shanxi Province, Inner Mongolia Autonomous Region, and Hebei Province have the largest excess loads, with Shanxi Province reaching close to 700% excess discharge. The best-performing areas are also Shanghai, Qinghai Province, and Tibet Autonomous Region.

(iv) **Industrial wastewater treatment rate.** This indicator refers to the ratio of industrial wastewater being treated before discharging into water bodies over the total industrial wastewater effluents. Values were estimated from the rate of industrial wastewater treatment by key industries surveyed by the Ministry of Environmental Protection (now Ministry of Ecology and Environment). More than half of the provinces have wastewater treatment rates ranging between 70% and 80%. Best performers are Zhejiang Province, Tianjin, Liaoning Province, and Beijing, with rates greater than 75%. The worst performers are Chongqing, Hainan Province, and Gansu Province, with rates around 50%.

(v) **Urban wastewater treatment rate.** This indicator refers to the ratio of urban domestic wastewater from cities and county towns over the total urban domestic wastewater effluents. Nearly all provinces have domestic treatment rates between 60% and 80%. The three best performers are Liaoning Province, Tianjin, and Anhui Province. The worst performer is Tibet Autonomous Region, with less than 20% of domestic wastewater being treated.

Table 25 presents the aggregate values for the five indicators of environmental water security and the resulting index score for the entire dimension. Environmental water security is the least secure of all key dimensions. At the national level, environmental water security sits just at the edge between *slightly insecure* and *basically secure*, indicating a strong need for improvement. The poor environmental security levels are caused by (i) continuing heavy domestic and industrial PSP discharge into water bodies; (ii) insufficient pollution control infrastructure (wastewater sewers and treatment plants) in cities and towns; and (iii) continuous and poorly controlled nonpoint source pollution (NPSP) discharge from agriculture. Environmental water security is least secure in Shanxi, Henan, Shaanxi, and Gansu provinces due to limited water resources, excess pollutant discharge, and absence of efficient wastewater management systems in many cities and townships.

Table 25: Indicator Scores and Key Dimension Index Score for Environmental Water Security, 2014

Indicator	Indicator Value (%)	Indicator Score	Key Dimension Index Score
Ratio of river length equal to and better than Class III	72.8	8	4.0
Ratio of PSP COD discharge over ceiling control amount	191.2	2	
Ratio of PSP NH_3-N discharge over ceiling control amount	243.7	1	
Industrial wastewater treatment rate	71.4	4	
Urban wastewater treatment rate	77.3	5	

COD = chemical oxygen demand, NH_3-N = ammonia nitrogen, PSP = point source pollution.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Ecological Water Security

Ecological water security is determined by the protection capacity of aquatic ecosystems, the degree of sustainable usage of surface water and groundwater, and the capacity to restore and sustain ecological health so as to enable and sustain ecological services.

At the national level, ecological water security was rated as *basically secure*, indicating a need for improvement. Ecological water security is high in areas with rich water resources, less pressure for economic development, and lower incidence rate of soil and water erosion such as Hainan and Hunan provinces, and Shanghai.

Ecological water security is lowest in ecologically fragile provinces—such as the autonomous regions of Xinjiang Uygur and Inner Mongolia, and the provinces of Gansu, Hebei, and Shanxi—where erosion is compounded with water shortage. Water scarcity in a number of provinces is also the main cause of environmental flow water encroachment and groundwater overexploitation.

There are four indicators of ecological water security:

(i) **Ratio of heavy soil and water erosion areas.** This indicator refers to the ratio of heavy soil and water erosion areas by water and wind erosion type to the total territory area. Erosion intensity is divided into five categories: mild, medium, strong, severe, and extreme. Three provinces have an erosion ratio of over 18%: Gansu Province and the autonomous regions of Inner Mongolia and Xinjiang Uygur. More than 70% of the provinces have either no significant erosion or limited to less than 10% of the total area. Shanghai and Hainan Province have negligible water-related erosion issues.

(ii) **Ratio of environmental flows diverted for water supply.** This indicator refers to the ratio of instream environmental flows being diverted for water supply over the total surface water supply; both ratios were taken as 10-year rolling averages. Half of the provinces (mostly in the northern PRC) are abusing the quantity of water that should be reserved for environmental flows; whereas, all others do not encroach upon the minimum level of water needed for environmental support and integrity. Hebei and Shanxi provinces and Xinjiang Uygur Autonomous Region are diverting 25%–40% of their environmental flows. The environmental offenders are also found in the provinces that are overexploiting groundwater.

(iii) **Ratio of overexploited groundwater supply.** This indicator refers to the ratio of the total amount of groundwater overexploitation in plain, hills, and mountain areas over the corresponding total groundwater supply; the ratios were taken as 10-year rolling averages. More than half of the PRC provinces are overexploiting groundwater resources. Xinjiang Uygur Autonomous Region, Tianjin, and Hebei Province are the worst offenders and have been overexploiting groundwater in ratios exceeding 35%.

(iv) **Ratio of protected freshwater wetland.** This indicator refers to the surface ratio of estimated protected inland freshwater wetland areas (following the *National Principles for Categories and Grades of Natural Reserves*) over the total natural freshwater wetland areas. Ratios show a linear progressive trend over all provinces. The five best performers are Shanghai, Tianjin, Hainan Province, Chongqing, and Heilongjiang Province, which have protection ratios higher than 73%. The least protective areas include Shanxi Province, with a protection ratio of about 10%, as well as Xinjiang Uygur Autonomous Region and Hebei Province, with protection ratios of about 20%.

Table 26 presents the aggregate values for the four indicators of ecological water security and the resulting index score for the entire dimension. Due to lack of statistically relevant quantitative indicators for biodiversity and ecological health of water bodies, the calculated scores for ecological water security is likely to be optimistic. Aquatic ecology in most water bodies (rivers and lakes) is in a desolate state, and the deterioration rate does not seem to have been reversed yet. If not addressed swiftly and forcefully through systematic restoration of aquatic ecosystems and the biological revitalization of deteriorated aquatic habitats, many water bodies may not be able to sustain their delivery of aquatic ecosystem services, which are critically important and economically significant.

Table 26: Indicator Scores and Key Dimension Index Score for Ecological Water Security, 2014

Indicator	Indicator Value (%)	Indicator Score	Key Dimension Index Score
Ratio of heavy soil and water erosion areas	10.4	4	4.8
Ratio of environmental flows diverted for water supply	3.1	6	
Ratio of overexploited groundwater supply	18.0	4	
Ratio of protected freshwater wetland	47.8	5	

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Resilience to Water-Related Disasters

Resilience to water-related disasters determines the scale of influence and impacts that water-related disasters are likely to have on socioeconomic development, the capacity to recover from water-related disasters, and the resilience of water infrastructure to water-related disasters.

There are three indicators of water-related disaster resilience:

(i) **Ratio of economic losses due to flood disasters.** This indicator refers to the ratio of direct economic losses caused by flood disasters over total GDP, considering the average values for the 3-year period (2012–2014). Three provinces have experienced particularly high losses compared to all other provinces: Hainan, Gansu, and Sichuan provinces have all experienced losses of 1%–2.5% or more of GDP. Most other provinces have also experienced losses, but these are less than 1% of GDP.

(ii) **Ratio of economic losses due to drought disasters.** This indicator refers to the ratio of direct economic losses caused by drought disasters over the total GDP, considering the average values for the 3-year period (2012–2014). The estimates are based on affected areas, damaged areas, and areas with crop failure. The ratio of economic losses due to drought disasters shows a similar pattern as the flood-related losses, although the losses range from 0.75% of GDP to negligible levels and are more linear across the provinces. The worst-hit areas are Hunan, Liaoning, and Gansu provinces. Several coastal provinces and municipalities such as Tianjin, Shanghai, and Hainan Province have not experienced any losses due to droughts.

(iii) **Ratio of population impacted by flood and drought disasters.** This indicator refers to the ratio of population affected by flood disasters plus the population with drinking water difficulty due to drought over the total population. Scores show a straight, linear progressive distribution between all provinces. Impacted populations range from as few as 1% to as many as 20%. The population in Guizhou, Sichuan, and Yunnan provinces are the most affected, while the population in Shanghai, Henan Province, and Xinjiang Uygur Autonomous Region are the least affected.

Table 27 presents the aggregate values for the three indicators of water-related disaster resilience and the resulting index score for the entire dimension. The country's resilience to water-related disasters is rated as *moderately secure*, just short of a *secure* status. The high rating may be affected by the low number of serious flood and drought disasters in the past 3 years. Most developed coastal cities and provinces such as Jiangsu Province, Shanghai, and Tianjin show a higher resilience, which is partially because design standards against floods and droughts are based on higher recurrence intervals to protect these important economic regions. Gansu, Sichuan, Guizhou, and Hainan provinces have the least resilience due to the limited development of risk control measures.

Table 27: Indicator Scores and Key Dimension Index Score for Water-Related Disaster Resilience, 2014

Indicator	Indicator Value (%)	Indicator Score	Key Dimension Index Score
Ratio of economic losses due to flood disasters	0.4	8	7.3
Ratio of economic losses due to drought disasters	0.2	9	
Ratio of population impacted by flood and drought disasters	9.2	5	

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Overall Water Security and Recommendations

The overall water security rating for the PRC is *basically secure* (Table 28 and Figure 23). Overall water security has best rating in the centrally administered provincial-level municipalities of Shanghai, Beijing, and Tianjin, as well as in the coastal regions with rich water resources such as Jiangsu, Fujian, and Zhejiang provinces. Overall water security is, however, weak in Gansu Province,

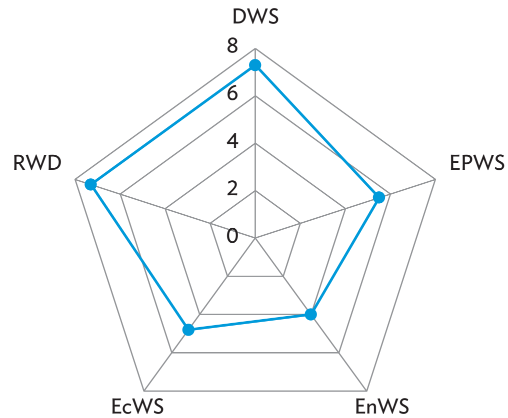
Table 28: Overall Water Security Rating by Key Dimension, 2014

Dimension	2014 Rating	Insecure	Slightly Insecure	Basically Secure	Moderately Secure	Secure
Domestic Water Security	7.3				x	
Economic Production Water Security	5.5			x		
Environmental Water Security	4.0			x		
Ecological Water Security	4.8			x		
Resilience to Water-Related Disasters	7.3				x	
Overall Water Security	**5.8**			**x**		

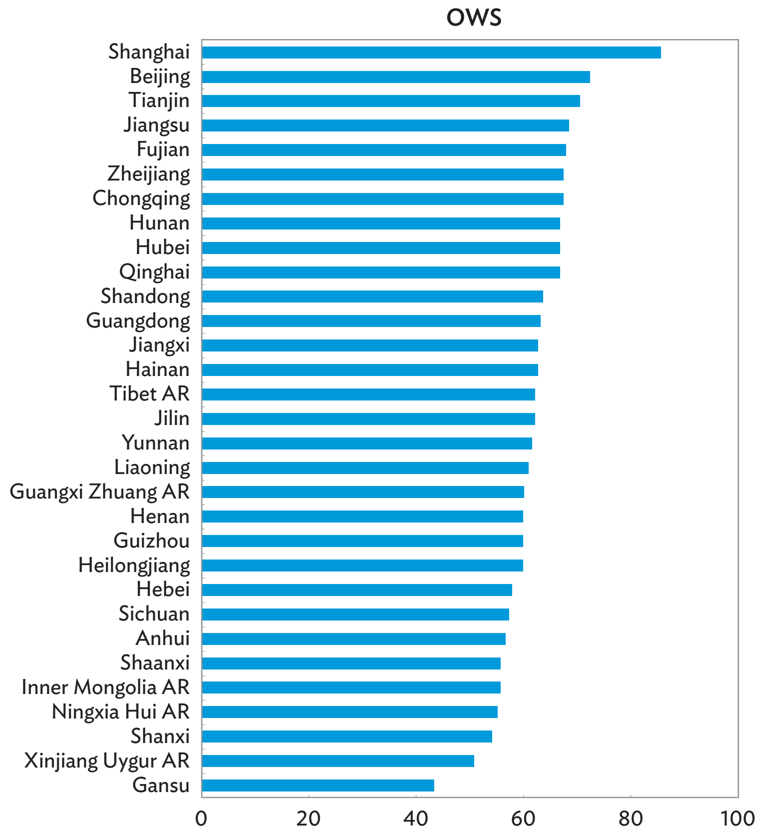
Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Figure 23: Overall Water Security by Key Dimension and by Province, 2014

a. By Key Dimension



b. By Province



AR = Autonomous Region, DWS = domestic water security, EcWS = ecological water security, EnWS = environmental water security, EPWS = economic production water security, OWS = overall water security, RWD = resilience to water-related disaster.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Xinjiang Uygur Autonomous Region, Shanxi Province, Ningxia Hui Autonomous Region, and Shaanxi Province; these are regions with severe water shortage rates and with less developed economies.

Inadequate water management and governance limit overall water security in the PRC. Some indicators already embed facets of water governance, as water resources management and water use management are core elements of water governance. Water management capacity in the PRC is generally weak. The eastern coastal provinces with developed economies have more capacity for monitoring and metering water use and wastewater discharge, compared to the less developed and remote western and border provinces.

The relatively low level of overall water security in the PRC presents opportunities for improvement. The following recommendations are made for the five key dimensions:

(i) **Domestic water security.** The index rating can be improved by (a) prioritizing water supply and service upgrades in urban towns, county towns, and villages; (b) forcefully controlling the discharge of PSP and NPSP into water bodies to protect drinking water sources; and (c) actively preventing water losses, particularly where there is water shortage.

(ii) **Economic production water security.** To enhance this index rating, water shortages should be reduced, if not totally prevented, by improving water use efficiency rates and practicing conservation measures to avoid reaching the control ceilings on water availability. This means reorienting water to high-value economic activities and developing nonconventional water sources (e.g., reclaimed, brackish, or desalinated water).

(iii) **Environmental water security.** Improvement of this index requires upgrading of industry, urban, and rural wastewater collection, treatment, and reuse across the country. There is also a need to reduce PSP in cities and towns, especially from industries. This calls for stronger regulations for integrated water use permits, control, and enforcement. Moreover, the joint treatment of domestic and industrial wastewater in centralized wastewater treatment plants (CWWTPs) should be encouraged. After PSP reduction is managed, the next step is to address NPSP coming from animal husbandry and from the excessive use of fertilizers and pesticides.

(iv) **Ecological water security.** To enhance the qualitative carrying capacity of water bodies, the restoration of aquatic habitats and the promotion of water-related biodiversity should be made mandatory. This requires the development of a national strategy for the restoration of aquatic ecology, which should emphasize the protection of aquatic ecological space and the correction of groundwater overexploitation and use of environmental flows. The identification and definition of simple, quantitative bio-indicators for aquatic ecological health and their systematic tracking should be undertaken. Bio-ecological restoration would also help control soil and water erosion.

(v) **Resilience to water-related disasters.** Ratings for this index can be increased by (a) improving flood risk control infrastructure standards for the upper reaches of main rivers and for major tributaries, and building flood risk protection infrastructure according to the improved standards; (b) improving emergency response planning against drought in vulnerable areas; and (c) building a national operational plan to address climate change risks and establishing a target program of measures at provincial and lower levels to alleviate risks in vulnerable areas.

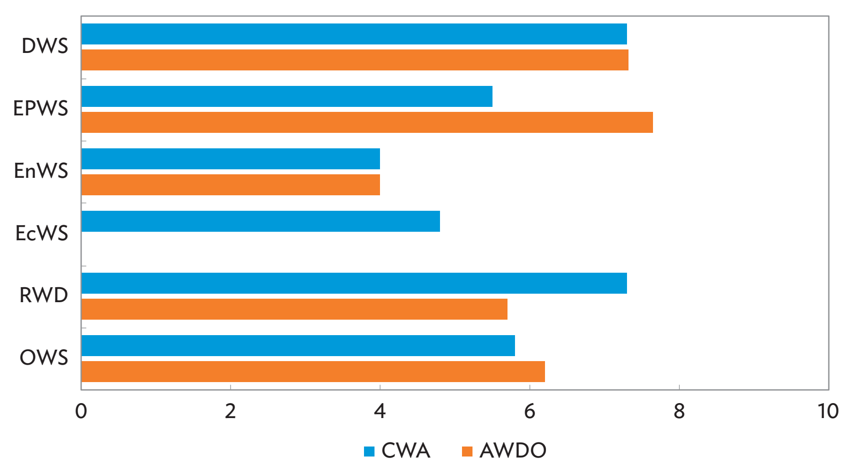
To improve the national water security, water governance must mature to international good practice standards. Future water security assessments may include additional qualitative indicators for water management capacity.

Comparison with the Asian Water Development Outlook for the People's Republic of China

Adopting the AWDO approach and principles, this CWA developed an enhanced water security assessment methodology to suit the local conditions in the PRC, and applied this adapted methodology at the provincial and national levels. A direct comparison of the results of the enhanced CWA methodology with those of the AWDO is not fully possible as the adapted methodology has dropped the urban water security dimension used in the AWDO and replaced it with the ecological water security dimension. Nevertheless, the other four key dimensions are comparable.

The comparison is given in Figure 24, which shows that the overall scores are close—5.8 for the CWA and 6.2 for the AWDO. The scores for domestic water security and environmental water security are the same. However, the scores for economic production water security and resilience to water-related disasters are clearly different, with the CWA giving a more pessimistic score for the economic production water security dimension and a more optimistic rating for the resilience to water-related disasters dimension.

Figure 24: Comparison of Assessment Results on the Water Security of the People's Republic of China, 2014



AWDO = Asian Water Development Outlook, CWA = country water assessment, DWS = domestic water security, EcWS = ecological water security, EnWS = environmental water security, EPWS = economic production water security, OWS = overall water security, RWD = resilience to water-related disaster.

Note: The EcWS is a new key dimension adopted under the CWA as replacement of the AWDO's urban water security dimension.

Sources: Asian Development Bank. 2016. *Asian Water Development Outlook 2016: Strengthening Water Security in Asia and the Pacific*. Manila; Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Water Security in the Yangtze River Economic Belt: A Case Study

The Yangtze River is the PRC's longest river. It traverses the eastern, central, and western regions, joining the coastal areas with the inland districts. The Yangtze River Economic Belt (YREB) covers 11 regions—the nine provinces of Anhui, Guizhou, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan, Yunnan, and Zhejiang; and the two centrally administered provincial-level municipalities of Chongqing and Shanghai. A water profile of the YREB has been drawn based on water resources quantity, quality, development, and ecological status.

Current Status of Water Resources in the Yangtze River Economic Belt

The total water resources and land area in the YREB are 45% and 21%, respectively, of national totals. Its per capita water resources is approximately 3,000 cubic meters (m^3), whereas the national average is only about 2,100 m^3 per capita. These data illustrate that the YREB has relatively abundant water resources (Table 29).

Table 29: Annual Average Water Resources in the Yangtze River Economic Belt, 1956–2000
(bcm)

Region	Surface Water	Groundwater	Overlapping	Total
National Total	**2,738.8**	**821.8**	**719.4**	**2,841.2**
Yangtze River Economic Belt	**1,257.5**	**334.4**	**315.0**	**1,276.9**
Upper Reaches[a]	645.5	174.8	174.7	645.6
Middle Reaches[b]	423.4	106.1	100.5	429.0
Lower Reaches[c]	188.6	53.5	39.8	202.3

bcm = billion cubic meter.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.
[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.
[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Water Supply

About 302,000 infrastructure for surface water supply have been built in the YREB. These include storage, diversion, pumping, and transferring facilities as well as large, medium, and small reservoirs. Total water supply in the YREB reached 260.4 billion cubic meters (bcm) in 2014 (or equivalent to 43% of national total), with surface water accounting for over 95% of supply (Table 30).

Water Quality

Water quality in the YREB is rated as generally good, especially in the upper-reach provinces but not so in the eastern part. The proportion of river length in the YREB meeting Class I-III water quality standards accounted for 74% of the total assessed river length. Water quality indicators exceeding standards include NH_3-N, total phosphorus, biological oxygen demand, COD, and permanganate index.[22]

Water Use

Table 31 presents the distribution and category of water use in the YREB. Water uses per CNY10,000 of GDP in the upper, middle, and lower regions of the YREB are 89.8 m^3, 131.0 m^3, 78.8 m^3, respectively, in 2014. Other indicators of water use efficiency are shown in Table 32.

Table 30: Water Supply in the Yangtze River Economic Belt, 2014
(bcm)

Region	Surface Water	Groundwater	Other Sources	Total
National Total	**492.1**	**111.7**	**5.8**	**609.5**
Yangtze River Economic Belt	**248.2**	**10.6**	**1.6**	**260.4**
Upper Reaches[a]	53.0	2.7	0.5	56.2
Middle Reaches[b]	84.2	3.6	0.2	88.0
Lower Reaches[c]	111.0	4.2	1.0	116.2

bcm = billion cubic meter.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.
[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.
[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Note: Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 31: Water Use in the Yangtze River Economic Belt, 2014
(bcm)

Region	Arable Land Irrigation	Agriculture (except arable land irrigation)	Industry	Urban Domestic	Rural Domestic	Ecology	Total
National Total	**338.6**	**48.3**	**135.6**	**58.3**	**18.4**	**10.3**	**609.5**
YREB	**125.0**	**14.2**	**82.6**	**27.7**	**8.3**	**2.7**	**260.4**
Upper Reaches[a]	28.3	4.0	13.4	6.9	2.9	0.8	56.2
Middle Reaches[b]	48.7	3.8	23.9	8.4	2.6	0.5	88.0
Lower Reaches[c]	48.0	6.4	45.3	12.4	2.9	1.3	116.2

bcm = billion cubic meter, YREB = Yangtze River Economic Belt.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.
[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.
[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Note: Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

[22] ADB. 2016. *Yangtze River Economic Belt (YREB) Environmental Protection and Rehabilitation Project: A Preliminary Study*. Consultant's report. Manila (TA 9044-PRC).

Table 32: Water Use Indicators in the Yangtze River Economic Belt, 2014

Region	Water Use per capita (m^3/year)	Water Use per CNY10,000 GDP (m^3)	Industry Added Value per CNY10,000 (m^3)	Irrigation for Arable Land (m^3/ha)	Coefficient of Effective Irrigation for Arable Land	Urban Domestic (L/d)	Rural Domestic (L/d)
National Total	**447**	**96.0**	**59.5**	**6,030**	**0.53**	**133.0**	**81.0**
YREB	**435**	**99.8**	**75.1**	**6,455**	**0.51**	**147.5**	**87.8**
Upper Reaches[a]	288	89.8	64.6	5,546	0.45	138.3	74.8
Middle Reaches[b]	521	131.0	83.7	7,860	0.49	161.3	85.7
Lower Reaches[c]	495	78.8	76.9	5,959	0.60	143.0	103.0

CNY = yuan, GDP = gross domestic product, ha = hectare, L/d = liter per day, m^3 = cubic meter, YREB = Yangtze River Economic Belt.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.
[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.
[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Note: Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Aquatic Ecological Status

The YREB encompasses the most important areas of water conservation, nature reserves, and ecological barrier (Table 33). According to the National Ecological Function Zoning, there are 17 key water source conservation regions in the PRC, eight of which are located in the YREB.

Table 33: Status of Aquatic Ecology in the Yangtze River Economic Belt, 2014

Region	Water Area (km^2)	Lake Area (km^2)	Area of Soil Erosion (km^2)	Number of Nature Reserves	Area of Nature Reserves (km^2)	Number of Aquatic Germplasm Resources Protection Zone
National Total	**238,697**	**79,058**	**2,932,913**	**2,762**	**14,842**	**431**
YREB	**93,092**	**20,555**	**439,937**	**1,077**	**1,781**	**207**
Upper Reaches[a]	17,260	1,254	317,262	506	1,286	57
Middle Reaches[b]	48,919	13,247	109,587	504	408	115
Lower Reaches[c]	26,913	6,054	13,088	67	87	35

km^2 = square kilometer, YREB = Yangtze River Economic Belt.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.
[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.
[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Water-Related Disasters

Water-related disasters in the YREB in 2014 are presented in Table 34. Although the average number of deaths per flood event has been declining over time, economic damages have always been increasing throughout history.

Table 34: Water-Related Disasters in the Yangtze River Economic Belt, 2014

Region	Economic Losses from Floods (CNY100 million)	Mortality due to Floods	Arable Land Affected by Drought ('000 ha)	People with Drinking Water Difficulty due to Drought (10,000)
National Total	**1,573.6**	**486**	**12,271.7**	**1,783**
Yangtze River Economic Belt	**720.1**	**347**	**2,316.6**	**876**
Upper Reaches[a]	418.6	273	925.9	554
Middle Reaches[b]	244.1	70	916.8	322
Lower Reaches[c]	57.3	4	473.9	0

CNY = yuan, ha = hectare.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.

[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.

[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Dikes, with combined length of about 34,000 kilometers, have been built in the YREB. Moreover, a total of 271 large reservoirs, including the Three Gorges Reservoir and the Danjiangkou Reservoir, have been constructed with an estimated flood control capacity of 60 bcm.

Water Issues and Challenges

Socioeconomic Development Forecast

By 2030, it is estimated that the total GDP of the YREB will range between CNY61.5 trillion and CNY73.7 trillion, and its industry added value will be between CNY25.2 trillion and CNY31.6 trillion (accounting for 41% and 39% of the national total, respectively). Total YREB population is projected to hit 639 million (or approximately 43% of national total) and its urban population will increase to 438 million (or 43% of total national urban population). Irrigation area of cultivated land will expand to 24.6 million hectares, increasing by 3% compared to that in 2014. Table 35 presents a detailed breakdown of the YREB's major demographic and development indicators by regional reach. The Yangtze River is one of the important sources of drinking water supply to its waterfront cities in the middle and lower reaches, and even for cities in the northern PRC that are covered under the ongoing South-to-North Water Diversion Project.

Table 35: Major Demographic and Development Indicators of the Yangtze River Economic Belt, 2014 and 2030

Region	Total Population (10,000 persons)		Urban Population (10,000 persons)		City Population (10,000 persons)	
	2014	2030	2014	2030	2014	2030
National Total	**136,246**	**148,000**	**73,111**	**102,653**	**44,630**	**62,535**
Yangtze River Economic Belt	**58,425**	**63,892**	**31,689**	**43,823**	**17,866**	**25,778**
Upper Reaches[a]	19,353	21,135	8,923	13,591	4,676	7,674
Middle Reaches[b]	17,095	18,628	8,839	12,178	4,326	6,569
Lower Reaches[c]	21,977	24,129	13,927	18,054	8,864	11,535

Region	GDP (CNY trillion)		Industry Added Value (CNY trillion)		Farmland Irrigation Area ('000 ha)	
	2014	2030	2014	2030	2014	2030
National Total	**63.9**	**167.0**	**29.1**	**69.1**	**64,539**	**68,735**
Yangtze River Economic Belt	**26.1**	**68.3**	**11.6**	**28.0**	**23,825**	**24,642**
Upper Reaches[a]	5.8	15.9	2.6	7.0	6,034	7,178
Middle Reaches[b]	6.3	16.8	2.8	7.2	7,959	8,395
Lower Reaches[c]	14.0	35.6	6.2	13.8	9,832	9,069

CNY = yuan, GDP = gross domestic product, ha = hectare.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.

[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.

[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Water Demand Forecast

This CWA study estimated current and projected water demand for the YREB under a medium (moderately intensive) water conservation scenario (Table 36). By 2020 and 2030, total water demand of the YREB will reach 288.4 bcm and 302.9 bcm, respectively, growing by 8% and 13% from 2014 level. The upsurge in water demand is attributed, for the most part, to the increases in domestic and industry water demand.

Water Supply and Water Use Forecast

Under medium growth scenarios (i.e., both medium socioeconomic growth scenario and moderately intensive water conservation scenario), the total water supply in the YREB is projected to reach over 3,000 bcm by 2030, and roughly 85% of which will be coming from surface water (Table 37).

Pollution Forecast

According to estimates of the CWA study, in 2014, point source wastewater volume, COD, and NH_3-N loads discharged into the water bodies of the YREB were 31.0 bcm, 6.0 million tons, and 0.7 million tons, respectively. These figures are about half of the national overall wastewater volume and pollution loads discharged into water bodies across the country. By 2030, wastewater discharge

Table 36: Water Demand in the Yangtze River Economic Belt under a Medium Water Conservation Scenario, 2014, 2020, and 2030 (bcm)

Region	Urban and Rural Domestic			Agriculture			Industry		
	2014	2020	2030	2014	2020	2030	2014	2020	2030
National Total	**76.8**	**100.5**	**118.5**	**398.0**	**411.7**	**406.0**	**135.6**	**145.8**	**164.8**
Yangtze River Economic Belt	**36.1**	**46.2**	**54.8**	**147.1**	**156.6**	**152.7**	**82.6**	**81.1**	**89.8**
Upper Reaches[a]	9.8	13.2	16.0	35.0	44.4	45.1	13.4	16.8	21.2
Middle Reaches[b]	11.0	13.6	16.0	54.1	55.8	54.4	23.9	27.8	31.8
Lower Reaches[c]	15.3	19.5	22.8	58.1	56.4	53.2	45.3	36.5	36.8

Region	Off-Stream Environment			Total Water Demand		
	2014	2020	2030	2014	2020	2030
National Total	**10.3**	**13.5**	**16.6**	**620.5**	**671.6**	**705.9**
Yangtze River Economic Belt	**2.7**	**4.4**	**5.7**	**268.3**	**288.4**	**302.9**
Upper Reaches[a]	0.8	1.7	1.9	58.9	76.1	84.2
Middle Reaches[b]	0.5	1.1	1.5	89.5	98.3	103.6
Lower Reaches[c]	1.3	1.6	2.3	119.9	114.1	115.1

bcm = billion cubic meter.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.

[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.

[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Notes:

1. Medium scenario corresponds to the application of moderately intensive water conservation efforts.
2. Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

into rivers and lakes in the YREB can reach 32.3 bcm under the medium (water pollution reduction or treatment) scenario—this translates to a 4% increase from the 2014 level. During the same period, industry wastewater discharge will decrease to 2.3 bcm, while wastewater from urban domestic life will increase to 3.6 bcm. With the rapid rates of urbanization and industrialization, wastewater discharged into water bodies has increased annually. These wastewater discharges mainly come from outlets located along the lakes of Dongting, Poyang, and Taihu, and the rivers of Han, Mon, and Tuo, which together account for about 80% of total wastewater discharges in whole river basin.

Weak Water Governance

In general, water governance in the YREB is not integrated. Fragmentation of responsibility and absence of accountability lead to inconsistency and inability to effectively enforce regulatory requirements. The Yangtze Water Resources Commission, the river basin authority, has no clear mandate. Therefore, water governance is yet to be improved, particularly in the areas of regional control of total water use, emission rights allocation, integrated operation and management of dams, administration of rivers and lakes development, and eco-compensation between the upper and lower reaches.

Table 37: Water Supply in the Yangtze River Economic Belt under Medium Growth Scenarios, 2030
(bcm)

Region	Total	Surface Water	Groundwater	Others
Yangtze River Economic Belt	**3,001.1**	**2,562.7**	**109.2**	**26.6**
Upper Reaches[a]	815.1	718.5	27.8	11.7
Middle Reaches[b]	993.3	939.1	49.1	4.5
Lower Reaches[c]	1,192.7	905.1	32.3	10.4

bcm = billion cubic meter.

[a] The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.
[b] The middle reaches include Hubei, Hunan, and Jiangxi provinces.
[c] The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Notes:
1. Medium growth scenarios refer to both medium socioeconomic growth scenario and medium (or moderately intensive) water conservation scenario.
2. Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Water Security Assessment

The water security assessment for the YREB indicates that its dimensional water security rating is just above the *basically secure* status, with variations between the upper and lower reaches of the Yangtze River (Figure 25). Domestic water security, economic production water security, ecological water security, and resilience to water-related disasters have all *moderately secure* rating, but generally better than the national status. Environmental water security, on the other hand, clearly has a lower rating—bordering between *slightly insecure* and *basically secure*, which is similar to the national status. The water security level of each dimension varies across reaches, and there is no clear consistency; but, overall water security is relatively better in the middle and lower reaches than in the upper reaches.

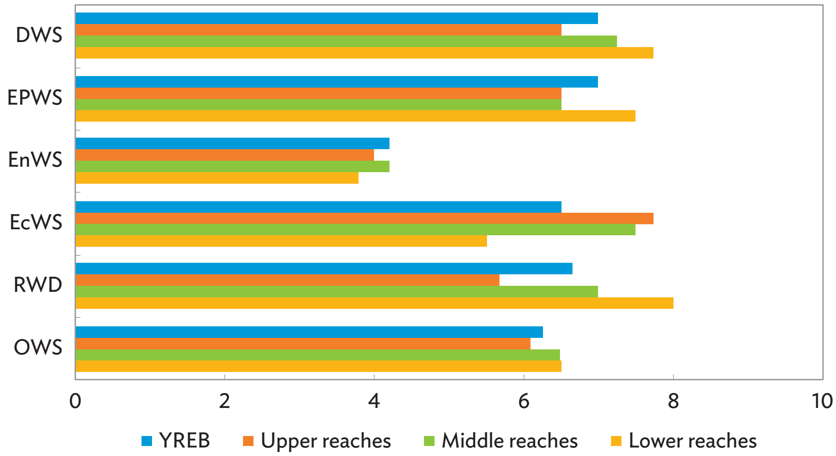
Possible Future Developments in Water Security

Water Security Improvement Scenarios

In Chapter II, different water development and management scenarios for the target years 2020 and 2030 were explored based on expected future socioeconomic development, possible water conservation measures, improved demand-side management, and upgraded wastewater collection and treatment systems. Similarly, the water security assessment developed four scenarios for the different security dimensions based on the level of water security improvement measures undertaken:

(i) **Zero: No-action scenario.** This assumes that no improvement measures will be undertaken during the expected growth trends in population and urbanization and the unabated industrial development. This scenario is important for estimating the additional investments and services needed to achieve the objectives and targets defined in the other scenarios.

Figure 25: Water Security Assessment Results of the Yangtze River Economic Belt by Key Dimension, 2014



DWS = domestic water security, EcWS = ecological water security, EnWS = environmental water security, EPWS = economic production water security, OWS = overall water security, RWD = resilience to water-related disaster, YREB = Yangtze River Economic Belt.

Notes:

1. The upper reaches include Chongqing and the provinces of Guizhou, Sichuan, and Yunnan.
2. The middle reaches include Hubei, Hunan, and Jiangxi provinces.
3. The lower reaches include Shanghai and the provinces of Anhui, Jiangsu, and Zhejiang.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

(ii) **Low: Business-as-usual scenario.** This assumes low improvements between 2015 and 2030, following the same trajectory as experienced since 2000.

(iii) **Medium: Accelerated-improvement scenario.** This assumes moderate improvement by accelerating measures for water conservation, water reclamation, PSP and NPSP control, and ecological restoration.

(iv) **High: Faster and intensified-improvement scenario.** This assumes high-speed and highly intensive improvement scenario by building on measures included in the accelerated improvement scenario but with faster mobilization of large investments in infrastructure, which may strain central and local budgets for several years.

Possible Trends in Water Security Improvement

Estimated target values for the 20 water assessment indicators were based on recommended improvement measures and were scored using the same water security index methods. Figure 26, Table 38, and Table 39 provide an overview of trends of the expected water security improvement for the five key dimensions and the overall national water security status. Table 40 shows the projected scores of the 20 water security indicators by 2030 under different water security improvement scenarios.

Figure 26: Prospective Water Security Index Scores under Different Water Security Improvement Scenarios, 2014, 2020, and 2030

DWS = domestic water security, EcWS = ecological water security, EnWS = environmental water security, EPWS = economic production water security, OWS = overall water security, RWD = resilience to water-related disaster.

Note: Zero scenario means no water security improvement measures will be undertaken; low scenario is business-as-usual or following low improvements similar to those undertaken since 2000; medium scenario assumes moderate improvements in water security measures; and high scenario refers to faster and intensified improvements.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 38: Water Security Index Scores by Key Dimension under Different Water Security Improvement Scenarios, 2020 and 2030

Dimension	2014 (base year)	Scenario							
		Zero		Low		Medium		High	
		2020	2030	2020	2030	2020	2030	2020	2030
Domestic Water Security	7.3	7.0	7.0	7.3	8.8	8.3	9.3	8.5	9.5
Economic Production Water Security	5.5	4.5	5.0	5.0	6.0	6.3	7.5	7.8	9.0
Environmental Water Security	4.0	3.2	3.0	4.8	5.6	5.6	7.4	6.8	9.8
Ecological Water Security	4.8	4.8	4.5	6.0	6.8	6.5	9.0	7.5	9.3
Resilience to Water-Related Disasters	7.3	6.7	6.7	6.3	7.3	7.3	8.3	7.7	9.0
Overall Water Security	**5.8**	**5.2**	**5.2**	**5.9**	**6.9**	**6.8**	**8.3**	**7.6**	**9.3**

Note: Zero scenario means no water security improvement measures will be undertaken; low scenario is business-as-usual or following low improvements similar to those undertaken since 2000; medium scenario assumes moderate improvements in water security measures; and high scenario refers to faster and intensified improvements.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 39: Projected Water Security Status by Key Dimension under Different Water Security Improvement Scenarios, 2030

Dimension	2014 (base year)	Scenario			
		Zero	Low	Medium	High
Domestic Water Security	Moderately secure	Moderately secure	Secure	Secure	Secure
Economic Production Water Security	Basically secure	Basically secure	Moderately secure	Moderately secure	Secure
Environmental Water Security	Basically secure	Slightly insecure	Basically secure	Moderately secure	Secure
Ecological Water Security	Basically secure	Basically secure	Moderately secure	Secure	Secure
Resilience to Water-Related Disasters	Moderately secure	Moderately secure	Moderately secure	Secure	Secure
Overall Water Security	**Basically secure**	**Basically secure**	**Moderately secure**	**Secure**	**Secure**

Note: Zero scenario means no water security improvement measures will be undertaken; low scenario is business-as-usual or following low improvements similar to those undertaken since 2000; medium scenario assumes moderate improvements in water security measures; and high scenario refers to faster and intensified improvements.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Table 40: Projected Scores of Water Security Indicators under Different Water Security Improvement Scenarios, 2030

Dimension	Indicator	2014 (base year)	Scenario			
			Zero	Low	Medium	High
Domestic Water Security	1. Urban tap water coverage ratio (%)	9	9	10	10	10
	2. Ratio of cities with multiple water sources (%)	4	4	6	7	8
	3. Ratio of urban–rural drinking water sources satisfying designated standards (%)	8	7	10	10	10
	4. Rural tap water coverage ratio (%)	8	8	9	10	10
Economic Production Water Security	5. Percentage of total water use over maximal control target (%)	8	4	5	7	8
	6. Water shortage rate (%)	5	4	6	8	10
	7. Water use per CNY10,000 of GDP (m^3)	3	5	6	7	9
	8. Farmland irrigation efficiency (no.)	6	7	7	8	9
Environmental Water Security	9. Ratio of river length equal to and better than Class III (%)	8	6	8	8	9
	10. Ratio of PSP COD discharge over ceiling control amount (%)	2	1	2	5	10
	11. Ratio of PSP NH_3-N discharge over ceiling control amount (%)	1	1	3	6	10
	12. Industrial wastewater treatment rate (%)	4	3	8	10	10
	13. Urban wastewater treatment rate (%)	5	4	7	8	10
Ecological Water Security	14. Ratio of heavy soil and water erosion areas (%)	4	4	6	6	7
	15. Ratio of environmental flows diverted for water supply (%)	6	6	8	10	10
	16. Ratio of overexploited groundwater supply (%)	4	3	5	10	10
	17. Ratio of protected freshwater wetland (%)	5	5	8	10	10
Resilience to Water-Related Disasters	18. Ratio of economic losses due to flood disasters (%)	8	8	8	9	9
	19. Ratio of economic losses due to drought disasters (%)	9	8	8	8	9
	20. Ratio of population impacted by flood and drought disasters (%)	5	4	6	8	9

CNY = yuan, COD = chemical oxygen demand, GDP = gross domestic product, m^3 = cubic meter, NH_3-N = ammonia nitrogen, PSP = point source pollution.

Note: Zero scenario means no water security improvement measures will be undertaken; low scenario is business-as-usual or following low improvements similar to those undertaken since 2000; medium scenario assumes moderate improvements in water security measures; and high scenario refers to faster and intensified improvements.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

The zero (no-action) scenario is taken as baseline for examining existing gaps and tasks to be accomplished in the future. Under the zero scenario, (i) improvements in water efficiency would be low, while demand for water would continue to grow rapidly, thereby expanding the supply–demand gap; (ii) wastewater pollution load would continue to increase; (iii) overuse of surface water would continue to further encroach on environmental flows because of the rapid increase in water demand; and (iv) capacity development for disaster mitigation may not meet the increase in fixed assets, urbanization, as well as the higher rural living standards. The overall water security situation would continue to worsen, particularly for the key dimensions on economic production water security, environmental water security, and water-related disaster resilience.

Measures taken under the low (business-as-usual) scenario would lead to some progress. Domestic, economic, and ecological water security dimensions would improve. However, no significant changes are foreseen in environmental water security and water-related disaster resilience dimensions. Overall water security rating would improve from *slightly insecure* to *basically secure*.

Under the medium (accelerated-improvement) scenario, there would be evident improvements in the key dimensions for domestic water security, economic water security, environmental water security, and resilience to water-related disasters. Actions taken under this scenario would also ensure security of ecological water.

Measures under the high (faster and intensified-improvement) scenario would upgrade the water security rating of the economic and environmental dimensions by a notch, while ratings of the other dimensions would hardly experience any change.

The medium or accelerated-improvement scenario is recommended as the most responsive scenario for the PRC in the next 15 years. Figure 27 reflects the overall security rating by key dimension for the years 2014, 2020, and 2030 under the medium (accelerated-improvement) scenario.

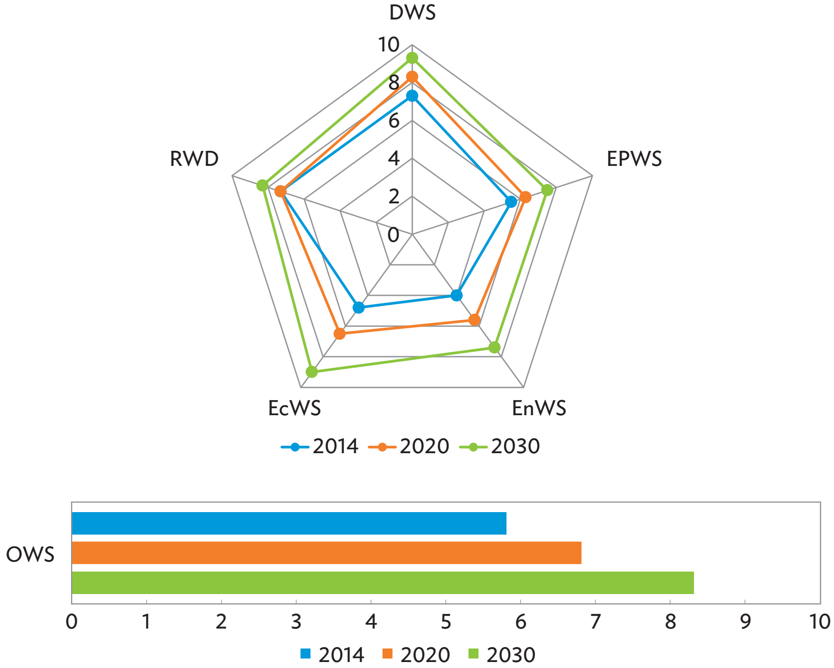
Sustainable Development Goals

The United Nations adopted on 25 September 2015 the 2030 Agenda for Sustainable Development, and its Sustainable Development Goals (SDGs).[23] The SDGs provide a universal and integrated guide for countries to eradicate poverty and achieve sustainable development globally by 2030. Its core content covers 17 goals and 169 specific targets covering the three aspects of sustainable development—economy, social affairs, and environment. Goal 6 (or SDG 6) is specifically oriented to water.

As the largest developing country in the world, the PRC insists on taking development as a top priority and has fully initiated the implementation of the 2030 Agenda for Sustainable Development. In April 2016, the PRC released its *Position Paper on the Implementation of the 2030 Agenda for Sustainable Development*. In September 2016, the National Plan on the Implementation of the Sustainable Development Goals was adopted. The national plan consists of five parts: (i) achievements and experience in the PRC's implementation of the Millennium Development Goals, (ii) opportunities and challenges in the PRC's implementation of the 2030 Agenda for Sustainable Development,

[23] United Nations. 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development*. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf.

Figure 27: Overall Water Security Index Scores by Key Dimension under a Medium Water Security Improvement Scenario, 2014, 2020, and 2030



DWS = domestic water security, EcWS = ecological water security, EnWS = environmental water security, EPWS = economic production water security, OWS = overall water security, RWD = resilience to water-related disaster.

Note: A medium water security improvement scenario assumes moderate improvement by accelerating measures for water conservation, water reclamation, pollution control, and ecological restoration.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

(iii) guiding thoughts and general principles for the PRC's implementation of the SDGs, (iv) overall approaches for the PRC's implementation of the 2030 Agenda for Sustainable Development, and (v) implementation plan for the 17 SDGs.

The national plan will act as guide for the PRC in carrying out the concept of innovative, coordinated, green, open, and shared development; accelerating the implementation of the 2030 Agenda for Sustainable Development; providing references to other countries, especially the developing countries, on advancing such implementation; and, within its capacity, making contributions to the cause of global development.

Sustainable Development Goal on Water: SDG 6

The most relevant SDG for the PRC's CWA is SDG 6 on water. SDG 6 has set six targets (6.1–6.6) and two implementation means (6.a and 6.b). The PRC's national plan has translated these targets into specific actions, as described in Table 41.

Table 41: Targets for Sustainable Development Goal 6 and Related Actions by the People's Republic of China

SDG Target	PRC's Action Plan
Goal 6. Ensure availability and sustainable management of water and sanitation for all	
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Launch the project of consolidating and improving the safety of rural drinking water. By 2020, centralized water supply rate will exceed 85% and tap water coverage rate will exceed 80% in rural areas. By 2030, achieve universal and equitable access to safe and affordable drinking water for all.
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all; and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	Work toward full coverage of water hygiene infrastructure. By 2030, complete revamping of rural household toilets and achieve access to adequate and equitable sanitation and hygiene for all.
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally	Implement the Water Pollution Prevention and Control Action Plan to increase the proportions of good quality water in key river basins and coastal water areas and qualified treatment of sewage water. Intensify monitoring of key functional water zones and sewage discharge outlets, and strengthen categorized and tiered management of functional water zones.
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	Build a water-saving society in a holistic manner by enforcing the strictest water resources management system, strengthening water demand and water consumption management, and exercising dual control of total volume and intensity of water resource consumption. Establish water efficiency assessment systems such as the water consumption quantity per CNY10,000 of GDP, and continuously improve water efficiency across all sectors. By 2020, increase the effective use of irrigation water to above 0.55 nationwide, and reduce water consumption per CNY10,000 of GDP and per CNY10,000 of industry added value by 23% and 20%, respectively.
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	Improve the water resources management system that combines river basin management and administrative area management, and enhance the role of comprehensive river basin management in water governance.
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes	Build a national ecological security framework to protect and restore water-related ecosystems by managing the overuse of groundwater in some areas. By 2030, endeavor to improve the national overall water quality and generally restore functions of water ecosystems.
6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling, and reuse technologies	Actively advance the South–South Cooperation on water- and environment-related areas; help other developing countries strengthen the capacity building for resource conservation, climate change mitigation, and green, low-carbon development; and provide them with assistance and support within the PRC's capacity.
6.b Support and strengthen the participation of local communities in improving water and sanitation management	Continue to exercise working mechanism that involves water users' participation and support; strengthen and urge the participation of water users and local communities in improving water and sanitation management.

CNY = yuan, GDP = gross domestic product, PRC = People's Republic of China, SDG = Sustainable Development Goal.

Source: Government of the People's Republic of China. 2016. *China's National Plan on Implementation of the 2030 Agenda for Sustainable Development*. Beijing.

Other Water-Related Sustainable Development Goals

Besides SDG 6, several other SDGs and targets relate to water and to the actions described in this CWA study. These relate to health (SDG 3); inclusive and sustainable economic growth (SDG 8); safe, resilient, and sustainable settlements and cities (SDG 11); sustainable consumption and production patterns (SDG 12); climate change (SDG 13); and terrestrial ecosystems (SDG 15). The specific water-related targets of these other SDGs are listed in Table 42.

The introduction of the SDG targets is rather recent. It is expected that, in due time, programs of the PRC government will include the SDG targets in their objectives and activities, and start monitoring the progress of their programs in meeting these targets. The AWDO is working on linking the SDGs with their key water security dimensions. Similarly, the adapted methodology of this CWA study is expected to make this link as well.

Table 42: Other Water-Related Sustainable Development Goal Targets

SDG Target	PRC's Action Plan
Goal 3. Ensure healthy lives and promote well-being for all at all ages	
3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases; and combat hepatitis, water-borne diseases, and other communicable diseases	By 2020, the proportion of people living with HIV/AIDS who are diagnosed and aware of their infection will exceed 90%; the proportion of people living with HIV/AIDS and with treatable conditions who have received anti-virus treatment will exceed 90%; and the treatment success rate for people living with HIV/AIDS who have received anti-virus treatment will exceed 90%. By 2020, the nationwide tuberculosis incidence will drop to 58 per 100,000; malaria will be eradicated; and the prevention rate of maternal-neonatal transmission of hepatitis B will exceed 95%. By 2030, continue to maintain a high rate of hepatitis B vaccination.
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production, and endeavor to decouple economic growth from environmental degradation in accordance with the 10-Year Framework of Programs on Sustainable Consumption and Production, with developed countries taking the lead	Implement the 10-Year Framework of Programs on Sustainable Consumption and Production, and improve resource efficiency. By 2020, reduce the ratio of water consumption per CNY10,000 of GDP by 23% compared with 2015. Continue to improve environmental quality, and endeavor to decouple economic growth from environmental degradation while maintaining moderate and high-speed economic growth.
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	
11.5 By 2030, significantly reduce the number of deaths and the number of people affected, and substantially decrease the direct economic losses relative to global GDP, caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	Reduce disaster impact and offer special protection for affected vulnerable groups in accordance with laws and regulations—such as the Emergency Response Law, Regulations on the Prevention and Control of Geological Disasters, the Meteorology Law, Regulations on Forest Fire Prevention, and Road Traffic Safety Law. Prevent and control floods; and reduce death tolls, number of affected people, and economic losses from floods.

continued on next page

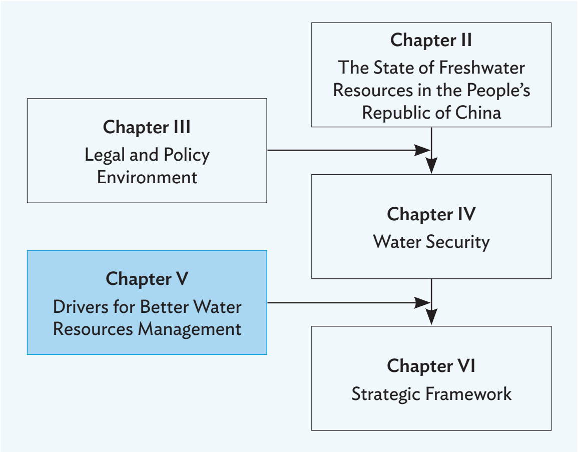
Table 42 *continued*

SDG Target	PRC's Action Plan
Goal 12. Ensure sustainable consumption and production patterns	
12.2 By 2030, achieve the sustainable management and efficient use of natural resources	Control the total volume of energy and resource consumption, optimize the structure of utilization, and substantially increase secondary utilization of energy and resources. Accelerate the establishment of a natural resources property rights system and an assessment and compensation system for ecological damages. Substantially improve energy and resource efficiency. Fully implement the strictest water resource control system to keep the total volume of national water consumption below 700 bcm by 2030.
Goal 13. Take urgent action to combat climate change and its impacts	
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	Actively adapt to climate change and strengthen resistance capacity to climate risks in agriculture, forestry, water resources, and other key fields, as well as cities, coastal regions, and ecologically vulnerable areas. Gradually establish a forecast, warning, and disaster prevention and reduction system; accelerate the full coverage of meteorological early warning system; and strengthen climate resilience.
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	
15.1 By 2020, ensure the conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems and their services—in particular, forests, wetlands, mountains, and drylands—are in line with obligations under international agreements	Maintain ecological water levels in key wetlands and estuaries. Protect and restore the biological systems in wetlands, rivers, and lakes. Establish a protection system for wetlands, and a protection and restoration system for degraded wetlands; and promote the rational use of wetlands. Advance the establishment of a legal system for land natural reserves, and improve the protective utilization of natural resources including forests. Assess the soundness of rivers and lakes to protect the water ecosystem.

bcm = billion cubic meter, CNY = yuan, GDP = gross domestic product, PRC = People's Republic of China, SDG = Sustainable Development Goal.

Source: Government of the People's Republic of China. 2016. *China's National Plan on Implementation of the 2030 Agenda for Sustainable Development*. Beijing.

CHAPTER V
Drivers for Better Water Resources Management



More than 500 million Chinese have worked their way out of poverty with jobs and industries that have supported factories and exports of Chinese-made products. The People's Republic of China (PRC) is the second-largest economy in the world and is classified as upper-middle-income. Since the opening-up policies of the late 1970s shifted the country from a centrally planned economy to a market-based one, its rapid economic ascendance has brought on rapid urbanization, overexploitation of natural resources, and environmental degradation. Both Chinese and international experts are concerned that the country may take longer to recover its natural resources than it did to damage them.

This chapter explores the macro socioeconomic policies and trends that are driving water scarcity, pollution, environmental decline, and climate change, and have complicated the production of energy and food. The pressure points are numerous. The causes as well as the effects are interconnected, and integrated solutions and management are essential. To relieve pressure in one may cause pressure in another. More investments are needed. Sophisticated systems of planning and management are required, which has come of age in an era that now requires as much attention to data, good governance, and technology as to investments, engineering, and construction.

Rapid Growth in Population and Urbanization

Population Growth

The PRC population is likely to maintain its recent slower pace, but high growth will continue.[24] The country water assessment (CWA) developed three population growth scenarios—high, medium, and low—based on the new population growth policy, 2014 age structure, birth rate, death rate, and migration rate, among other factors. Using the medium growth scenario, the national population will peak at about 1.45 billion by 2030 and then slowly decline (Table 43).

[24] Congressional-Executive Commission on China. 2007. *Research Report on National Population Development Strategy of China.* http://www.cecc.gov/resources/legal-provisions/research-report-on-national-population-development-strategy-chinese-text.

Table 43: Estimated Population in the People's Republic of China by Region under a Medium Population Growth Scenario, 2014, 2020, and 2030
(million persons)

Region	Total Population			Urban Population			City Population		
	2014	2020	2030	2014	2020	2030	2014	2020	2030
National Total	**1,361**	**1,425**	**1,450**	**749**	**855**	**1,015**	**445**	**556**	**711**
Northeast	110	112	112	67	74	83	48	50	60
North	337	351	359	184	208	252	108	132	177
Southeast Coast	359	378	386	233	262	297	149	193	226
Central	230	242	246	118	135	162	58	78	105
Southwest	196	207	210	90	109	136	47	60	87
Northwest	123	130	132	63	72	88	35	42	57

Notes:
1. The medium population growth scenario is based on the new population growth policy and other factors such as the 2014 age structure, birth rate, death rate, migration rate, etc.
2. "City" refers to the older, downtown, or more built-up urban area; "urban" covers both the older cities and the new development in the outskirts of cities.
3. Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

The population will mainly migrate from the central and western regions to the east and southeast coastal regions, where the economy is more developed, especially in the three strong population-absorbing zones: the Pearl River Delta, the Yangtze River Delta, and the Beijing–Tianjin–Hebei region. Figure 28 shows the trend of the PRC's total population, including urban and city population from 1980 to 2030.

Among all river basins, 36% of the newly increased population in the PRC will occur in the Yangtze River Delta, 12% in the Pearl River Delta, and 18% in the Hai River. With nearly 40 million additional people in the six major river basins in northern PRC, this will make the total population in the northern region reach 603 million by 2030, where water resources per capita is far less than what is needed, causing greater distress on water resources and supply.

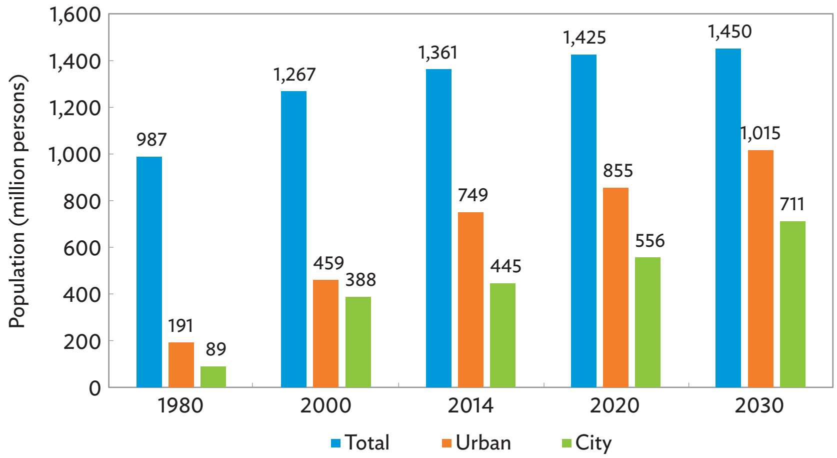
Rapid Urbanization

Since 1995, with the gradual relaxation of the household registration system known as the *hukou* system, the rural population has entered cities at massive rates and has become the main force of urbanization. The *hukou* system limits population flow across internal borders and makes it difficult for citizens (especially those in the rural *hukou*) to change residence into a more developed area or to an urban *hukou*.

In 2014, the PRC urbanization rate of permanent residents was 54.8% (Figure 29). Meanwhile, the urbanization rate of household registration residents (with urban *hukou*) was only about 36%—far less than the 80% average for developed countries and the 60% average for developing countries with per capita income similar to that of the PRC .

International experience shows that the PRC's urbanization is accelerating, with rates between 30% and 70%. Urbanization will continue rapidly until it reaches 70% to 80%. Continuous urbanization will

Figure 28: Population Trend under a Medium Population Growth Scenario, 1980–2030

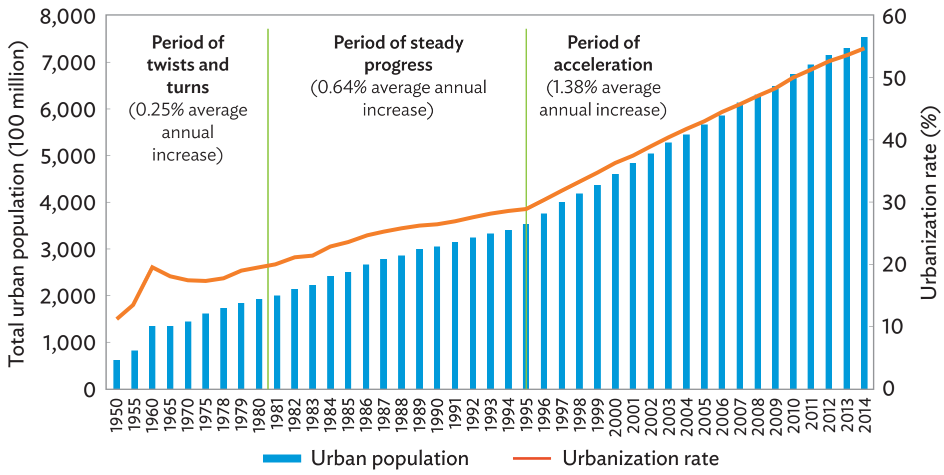


Notes:

1. The medium population growth scenario is based on the new population growth policy and other factors such as the 2014 age structure, birth rate, death rate, migration rate, etc.
2. "City" refers to the older and more developed urban area; "urban" covers not only the older cities but also newer development in the outskirts of cities.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Figure 29: Urbanization in the People's Republic of China, 1950–2014



Source: World Bank and the Development Research Center of the State Council of the People's Republic of China. 2013. *China 2030: Building a Modern, Harmonious, and Creative Society*. Washington, DC: World Bank.

enable more farmers to shift to higher-income city jobs and enjoy better public services, which will fuel growth in the domestic consumer base and lead toward structural changes in urban economies. Growing urbanization and higher spendable income will also generate demand for investments in urban infrastructure, public service utilities, residential buildings, and convenience services—ultimately injecting sustained power for economic development.

Urban planners should understand and mitigate the risks that urbanization poses to water resources. More people in more urban spaces means more water demand, more intense water use, higher water pollution loads, and more risks induced by people and on people—such as the increase in impervious surface that may aggravate city waterlogging and increase potential property loss. Urbanization will lead to higher standards for water security and significantly larger per capita water use than in rural areas. Water service standards and reliability will need to be improved over current service performance.

The 10 Class-I river basins of the PRC will experience increased population and urbanization between 2014 and 2030. During this period, three of these 10 regions—the Pearl River, the southeast rivers, and the Hai River—will undergo rapid population migration and urbanization that may exceed 70% by 2030. The Yellow River, northwest rivers, and southwest rivers will maintain fast natural population increases but relatively slow urbanization. The region of the southwest rivers will experience only 56% urbanization by 2030, the lowest of the 10 regions.

By 2030, more than 70% of the PRC population will live in urban areas. The total water demand by 2030 of urban and cities will reach 267.5 billion cubic meters (bcm) and 112.5 bcm, respectively, or a growth of 32.8% in urban demand and 54.3% in city demand compared to 2014 levels (Table 44). While most cities in the PRC rely on stable water sources, such as reservoirs and large rivers with sufficient water as water supply sources, future urban water supply security will face severe challenges under the development pressure of population growth and urbanization.

Table 44: Regional Water Demand under a Medium Water Conservation Scenario, 2014 and 2030
(bcm)

Region	Urban Water Demand		City Water Demand	
	2014	2030	2014	2030
National Total	**201.4**	**267.5**	**72.9**	**112.5**
Northeast	12.8	19.7	7.1	10.9
North	24.4	40.1	11.5	18.9
Southeast Coast	87.1	93.7	22.1	34.0
Central	44.9	57.1	18.7	27.9
Southwest	21.3	34.6	8.3	12.8
Northwest	11.1	22.6	5.1	8.1

bcm = billion cubic meter.

Notes:
1. Medium scenario corresponds to the application of moderately intensive water conservation efforts.
2. “City” refers to the older, downtown, or more built-up urban area; “urban” covers both the older cities and the new development in the outskirts of cities.
3. Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People’s Republic of China: Country Water Assessment*. Consultant’s report. Manila (TA 8715-PRC).

Economic Development

Economic Growth and Structure

Based on 2010 comparable prices, the water used per CNY10,000 of gross domestic product (GDP) in 2014 was 109 cubic meters (m^3). This value must be reduced to 49 m^3 by 2030 to overcome water shortages and enhance water productivity. This will be a challenge given the rapid increase of the economic aggregates, which will consequently increase the total amount of water used in the PRC.

To quantitatively estimate the development scale of the PRC's future economy, the CWA study developed a production function model of GDP and determined the added value of the three sectors—agriculture (primary), manufacturing industry (secondary), and domestic and/or services (tertiary)—based on econometric model method using data from 1990 to 2014. Three economic development scenarios (low, medium, and high) estimate GDP and the added value of the three sectors by different regions and river basins in the PRC for 2020 and 2030 (Table 45).

Table 45: Estimated Gross Domestic Product under Different Economic Growth Scenarios, 2020 and 2030
(CNY trillion)

Region/River Basin		2014 (base year)	Low		Medium		High		Growth Rate (%)		
			2020	2030	2020	2030	2020	2030	Low	Medium	High
National Total		**63.8**	**88.1**	**150.7**	**91.7**	**167.5**	**94.3**	**180.6**	**5.4**	**6.1**	**6.6**
Region	Northeast	6.0	8.1	13.7	8.5	15.2	8.7	16.4	5.3	6.0	6.5
	North	16.6	23.0	39.3	23.9	43.7	24.6	47.1	5.5	6.2	6.7
	Southeast Coast	22.3	30.5	51.3	31.7	57.0	32.6	61.5	5.3	6.0	6.5
	Central	8.2	11.4	19.8	11.9	22.0	12.2	23.7	5.7	6.4	6.9
	Southwest	6.1	8.6	15.1	8.9	16.8	9.2	18.1	5.8	6.5	7.0
	Northwest	4.6	6.5	11.5	6.8	12.8	7.0	13.8	5.9	6.6	7.1
River Basin	Songhua River	2.8	3.8	6.4	4.0	7.1	4.1	7.7	5.3	6.0	6.5
	Liao River	3.3	4.5	7.6	4.7	8.4	4.8	9.1	5.4	6.0	6.5
	Hai River	8.1	11.3	19.3	11.7	21.5	12.0	23.2	5.6	6.3	6.8
	Yellow River	5.4	7.7	13.7	8.0	15.2	8.2	16.4	6.0	6.7	7.2
	Huai River	8.9	12.2	20.5	12.7	22.8	13.0	24.6	5.4	6.1	6.6
	Yangtze River	20.1	27.8	47.7	28.9	53.0	29.7	57.1	5.5	6.2	6.7
	Southeast Rivers	5.0	6.8	11.2	7.1	12.5	7.3	13.5	5.2	5.9	6.4
	Pearl River	8.4	11.6	19.8	12.0	22.0	12.4	23.8	5.5	6.2	6.7
	Southwest Rivers	0.5	0.6	1.0	0.7	1.1	0.7	1.2	4.4	5.1	5.6
	Northwest Rivers	1.4	1.9	3.4	2.0	3.7	2.1	4.0	5.7	6.3	6.8

CNY = yuan.

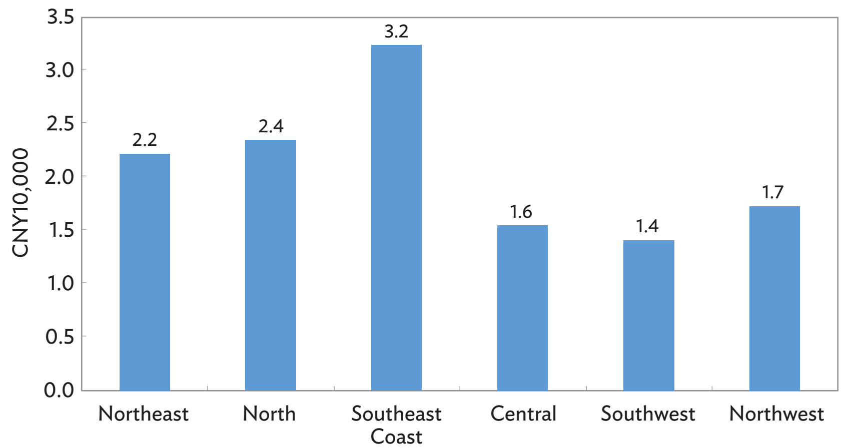
Notes:

1. As indicated in the table, estimated average growth rates of gross domestic product for the three scenarios differ across regions and river basins. For the national total, growth rates of 5.4%, 6.1%, and 6.6% are used for low, medium, and high, respectively.
2. Numbers may not sum precisely because of rounding.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

The economic outlook for the services or tertiary sector illustrates the economy's water supply dilemma. The PRC's services sector has rapidly developed, with the ratio of its added value to GDP increasing sharply to exceed primary and secondary sectors to become the driving force of national economic development. The 2014 per capita added values of the tertiary sector in the six geo-economic regions demonstrate the difference between the more developed and urbanized eastern regions versus the lesser developed and primarily rural western regions, which likewise reflect the water use difference among these regions (Figure 30).

Figure 30: Per Capita Services Sector Added Value by Region, 2014



CNY = yuan.

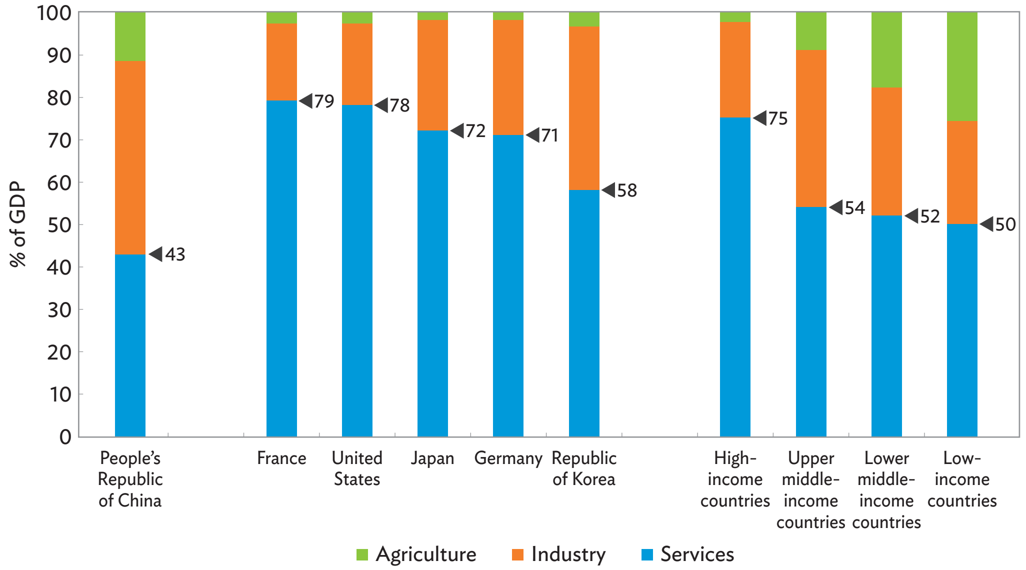
Source: World Bank and the Development Research Center of the State Council of the People's Republic of China. 2013. *China 2030: Building a Modern, Harmonious, and Creative Society*. Washington, DC: World Bank.

Figure 31 shows the difference in the PRC's economic structure compared to other countries. The contribution of the services sector in the PRC is comparably still very low at 43% of GDP, while the services sector in high-income countries accounts for up to 70% of GDP. According to the social development pattern of developed countries, the PRC can expect its industry share to continually decrease, while the share of its services sector will continually increase. As household incomes and living standards increase, so will demand for commodities and services. The water supply guarantee rate for the services sector is high. Gradually increasing the proportion of the services sector will alter the water supply structure and total water supply required, bringing about large pressure on urban water supply.

Industrialization

Global economic and technology trends and the PRC's industrialization plans point to slower industry development rates. The country's industry growth rate will be slightly slower than the national GDP growth, and the share of industry to the national economy will decline by 2030 to about 36%. The CWA study found that the PRC's industry added value would be CNY52 trillion under the medium economic growth scenario by 2030.

Figure 31: Services Added Value as a Share of Gross Domestic Product, 2010



GDP = gross domestic product.

Source: World Bank and the Development Research Center of the State Council of the People's Republic of China. 2013. *China 2030: Building a Modern, Harmonious, and Creative Society*. Washington, DC: World Bank.

The PRC's economic growth is characterized by regional differences, resulting in different characteristics of industry development between the eastern, central, and western regions. In the eastern region, the development pace and trend are at par with the national average. In the central and western regions, where industrialization is underdeveloped, industry will grow at a faster pace and will contribute more to the regional economy, while the growth rate in the central region will be higher than that in the eastern region.

The main task of national economic development is to improve industrialization. The PRC will generally fulfill its goal of industrialization by around 2030 as a result of the manufacturing sector becoming more creative and green, and information technology integrating with industrialization. Water-saving technology will also usher in an era of reduced industry water use. Industry water use and wastewater discharge account for a large proportion of the national total. In the future, the progress of industrialization will put immense pressure on the PRC's water supply as well as its water conservation and restoration efforts. On the other hand, the closing of heavy industries will release large volumes of water. The challenge is to transfer water from the heavy industry sector to the services sector, which is located in wider areas. In addition, not all the water used by heavy industries is clean water, which will require treatment.

Climate Change

Climate change will likely lead to three key water-related consequences in the PRC: an increase in temperature, a change in water distribution geographically and seasonally, and a rise in sea levels.[25] Temperature rise could trigger greater glacier melting, which can critically affect river runoff and flooding.[26] In the coming decades, global warming will continually increase glacial runoff, especially during the spring and early summer.[27]

In the short term, climate change could be beneficial for irrigated agriculture in the arid regions, although runoff may be reduced in the late summer and autumn.[28] In the long term, if a large fraction of glacier melts, water shortage may return and become the norm. Rising sea levels would impact cities and coastal zones. Cities that are facing land subsidence due to overpumping of groundwater will probably notice higher water levels and perhaps even saltwater intrusion into freshwater aquifers. Storm surge and sea level rise can also cause massive flooding of coastal zones and low-lying areas.

The risk of disasters is one of the most serious threats to inclusive and sustainable socioeconomic development. Climate change scenarios for the PRC show an increased likelihood of more severe storms, flooding, and droughts in many provinces. In 2014, natural disasters cost the PRC about CNY581 billion—1% of GDP. Many of the natural disasters that the PRC experienced are water-related, which are closely linked to climate change and environmental degradation.[29]

The CWA study was informed by a special thematic report on the country's risks to water-related disasters, the policies in place to reduce and manage those risks, and the opportunities to strengthen integrated disaster risk management in the country. The likelihood of occurrence of many types of water-related disasters increases with changes in temperature, precipitation, and other climate variables. Loss of vegetation cover magnifies the risk of landslides and downstream flood disasters.[30] Vulnerability or the possible exposure of people, property, and infrastructure to harm or damage because of a water-related hazard creates a water-related risk. Greater population density and higher growth worsen vulnerability in hazardous areas.

Water-related disasters have affected a growing number of people and infrastructure as climate events have gained in frequency and intensity. The consequences of water-related disasters are both direct (e.g., damages to buildings, crops, and infrastructure; and loss of life and property) and indirect (e.g., losses in productivity and livelihoods, greater investment risk, indebtedness, and impacts on human health). In the PRC, continuing development in hazard-prone areas amplifies exposure to such hazards and places the population and the country's capital assets at much greater risks, especially as weather-related events become more frequent and intense because of climate change.

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[25] X. Li, G. Turner, and L. Jiang. 2012. *Grow in Concert with Nature: Sustaining East Asia's Water Resources through Green Water Defense*. A World Bank Study. Washington, DC: World Bank.

[26] S. Piao, et al. 2010. The Impacts of Climate Change on Water Resources and Agriculture in China. *Nature*. 467 (7311). pp. 43–51.

[27] T. P. Barnett, J. C. Adam, and D. P. Lettenmaier. 2005. Potential Impacts of a Warming Climate on Water Availability in Snow-Dominated Regions. *Nature*. 438 (7066). pp. 303–309.

[28] S. Y. Liu, Y. Zhang, Y. S. Zhang, and Y. J. Ding. 2009. Estimation of Glacier Runoff and Future Trends in the Yangtze River Source Region, China. *Journal of Glaciology*. 55 (190). pp. 353–362.

[29] L. J. Henderson. 2004. Emergency and Disaster: Pervasive Risk and Public Bureaucracy in Developing Nations. *Public Organization Review*. 4 (2). pp. 103–119.

[30] H. Yin, F. Liu, and L. Du. 2010. Probability of Loess Landslide Based on Terrain and Vegetation Distribution in Loess Plateau. *Geoscience*. 24 (5). pp. 1016–1021 (in Chinese).

Energy Development

As energy development is the foundation and engine of modernization, its supply and security dominate how the PRC can generally perform to become a modernized state. At present, the water consumed by the PRC's thermal and nuclear power generation is about 47.8 bcm, accounting for 35% of the country's total industry water use. The PRC's Energy Development Strategy Action Plan (2014–2020) specifies that the total primary energy consumption will be controlled within 4.8 billion tons of standard coal, and the total primary energy production will reach 4.2 billion tons of standard coal by 2020, representing a self-sufficient capacity of about 85%. Moreover, the reserve–production ratio of petroleum will increase to 14%–15%. An energy reserve system for emergency response will be in place. By 2020, the share of nonfossil energy and natural gas in primary energy consumption will be 15% and more than 10%, respectively, while the share of coal consumption will be controlled within 62%.[31]

In the PRC's main function zoning plan, five areas and 17 major energy bases are identified, which has more than 70% of the national total reserves of coal, oil, and gas resources as well as primary energy production capacity. The amount of energy exported from these 17 major energy bases accounts for 90% of the national interprovincial transportation amount. With the gradual exhaustion of energy resources in the mid-eastern region of the PRC, the characteristics of the PRC's energy development strategy to the west is becoming more and more obvious. However, of the 17 energy bases, 15 bases (such as Ordos Basin, Shanxi Province, Xinjiang Uygur Autonomous Region, etc.) are located in the Hai River, Yellow River, and the northwest inland river basins, which have the most severe problems of water shortage or with fragile ecosystem. Energy industry layout and water resources and environmental carrying capacity do not match, which will exacerbate regional water supply and demand imbalance.

In the distant future, coal will still dominate the PRC's energy production and consumption structures. At present, 13 large coal bases are under construction, eight of which are located in water-insufficient areas. Meanwhile, the country's inland oil and gas production bases are mostly located in arid and semi-arid regions like the northwest and northern PRC. The exploitation of oil and gas resources as well as development of heavy chemical industries will bring about large pressure on local water resources.

As a key energy industry, electricity is an important condition for national socioeconomic development. Since 1949, with the PRC's rapid economic growth, the requirement for electricity development has increased dramatically. By the end of 1949, the total installed capacity of power generation in the PRC was only 1,850 megawatts (MW), and the annual power generation capacity was 4.3 billion kilowatt per hour (kW/h). By 2008, the PRC's power generation installed capacity increased to 792,530 MW, and the annual generating capacity increased to 3,426.8 billion kW/h.

By 2020, total installed capacity of the PRC's power generation will be about 2.0 million MW. Installed capacity of thermal power generation, nuclear power generation, hydropower generation, wind power generation, and photovoltaic generation will be about 1.2 million MW; 6,100 MW; 35,000 MW; 20,000 MW; and 10,000 MW, respectively. By 2030, the installed capacity of thermal and nuclear power generation will additionally increase by more than 1.3 million kilowatts, according to a conservative prediction that took into consideration the requirements for energy conservation and emission reduction.

[31] State Council of the People's Republic of China. 2014. *Energy Development Strategy Action Plan (2014–2020)*. http://www.gov.cn/zhengce/content/2014-11/19/content_9222.htm (in Chinese).

The power generation sector is the main water user in the energy industries, with its proportion of water use accounting for more than 80% of total energy water use. The water used in power generation process is much more than the water used in oil exploration and coal mining. In the future, thermal power will still be the main source of power generation. Even if the total amount of industry water use decreases, the construction of energy bases and the development of the energy industry (especially the electric power sector) will further aggravate the water supply security of the energy bases and increase the energy industry's water use.

Rural Development

The agriculture and rural development environment of the PRC is undergoing major changes. On the one hand, with the acceleration of new-type urbanization and the upgrade of urban and rural residential consumption structures, several rural reforms are launched comprehensively and have created sustained motivation for rural and agriculture modernization. On the other hand, there is a historical task that has to be fulfilled under the background of the "new normal" economic development—i.e., to help farmers increase their income at a steady or fast pace, thereby narrowing the gap between urban and rural areas and ensuring the complete realization of a moderately well-off society as scheduled.

Agriculture is the basis to complete the building of a "moderately prosperous society in all aspects" and to achieve modernization. Improvement of regional rural residential areas and farmland irrigation and drainage conditions, improvement of urban and rural water services equalization, as well as enhancement of rural and agriculture capabilities to cope with extreme disaster events are all relying on the construction of water conservancy projects. The PRC should continue to intensively push forward the construction of high-profile farms and water conservancy works, tackle the difficult tasks of poverty alleviation, optimize the structure and regional layout of agriculture production, foster new type of professional farmers at a faster pace, improve public service in villages, and enhance the protection and restoration of agriculture ecology.

Pressure on Production: Water–Food–Energy Nexus

People will feel the impacts of water scarcity, pollution, and climate change in more and more personal ways—from food safety and affordability, to the cost of heating and cooling their homes, to losses and damages from water-related disasters and serious illnesses from poor water quality.

Water is caught in the crosshairs of food and energy production. A shortage of 25 bcm of water lost to pollution leaves 7 million hectares without irrigation; another 20 million hectares are suffering from water deficiency.[32] Combined, they make up 50% of the country's 55 million hectares of irrigated land, which produce 80% of the total grain output.

A thematic paper on the water–food–energy nexus produced for the CWA attributes the agriculture dilemma to limited water resources, a deteriorating water environment, and rapid urbanization and

[32] Food and Agriculture Organization of the United Nations (FAO). Annex 3: Agricultural Policy and Food Security in China. http://www.fao.org/docrep/004/ab981e/ab981e0c.htm; FAO. 2016. China. AQUASTAT. http://www.fao.org/nr/water/aquastat/countries_regions/CHN/ (accessed 29 September 2017).

industrialization. Because of climate change, rainfall patterns are erratic, groundwater recharge rates are lower, soil moisture deficits are higher, and droughts (as well as floods) are more severe and more frequent. At the same time, the changing lifestyle of the emerging middle-income class is pushing up demand for food, and particularly for water-intensive products such as dairy and meat.

If the water–food–energy security nexus is not managed well and in an integrated way, unsustainable water use in the energy sector could seriously impair the water system. The adverse impact on the entire economy—particularly on the socioeconomic development in the western PRC, which is rich in coal resources but is already facing serious water stress—would be great. The PRC's capital-intensive, industry-led, energy- and resource-intensive growth strategy is likewise unsustainable. The coal-dominated energy sector contributes to critical water pollution and reduced availability of water.

The changing demand for and supply of water resources in the PRC highlight the importance of water for any development and growth agenda. The country's ability to make more water available for domestic, agriculture, industry, and environmental uses will depend on sector reforms and improved strategy development and planning, including better management and allocation of water resources, more cross-sector planning, restoration of water ecological services, deeper reform of the water rights and pricing system, and creation of water services market.

Poverty: Cumulative Cause and Effect

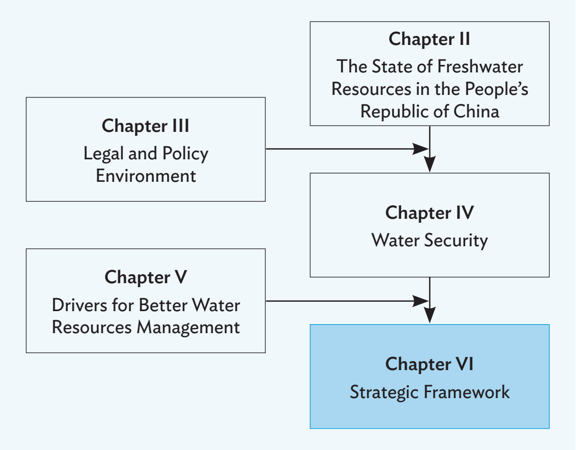
The PRC has 14 designated special poverty regions, which account for nearly one-fifth of the country's land area. In 2014, urbanization rate in these poverty regions was only 24%, far less than the national average of nearly 55%. Poverty rate in these regions averaged 35%, accounting for about 80 million people. The poverty regions generated one-tenth of the country's total GDP in 2014; per capita GDP was 37% of the national average; and per capita income was one-tenth of the national average. Agriculture is the major economic contributor, supplying about 28% of the country's grain supply.

The level of water services is relatively low in the poverty regions. Per capita water supply is 75% of the national average, per capita rural residential water use is 60% of the national average, and the average irrigation rate of cultivated land is 10% below the national average. Flood protection standards are quite low compared to other more developed areas.

The distribution of the PRC's impoverished areas is highly related to the endowment of water resources, and the poverty regions lag far behind in the development of water infrastructure. Water infrastructure in the poverty regions cannot protect against flood or ensure water supply and irrigation; the service level and coverage ratio of public water services are far less than national average; and the capacity to regulate and deploy water resources is too low to achieve efficient water use. Unreasonable development and utilization beyond resource and environmental capacity have resulted in serious ecological degradation in some regions. Therefore, developing the water infrastructure in the country's 14 poverty regions is essential to the country's vision of a moderately prosperous society in all aspects.

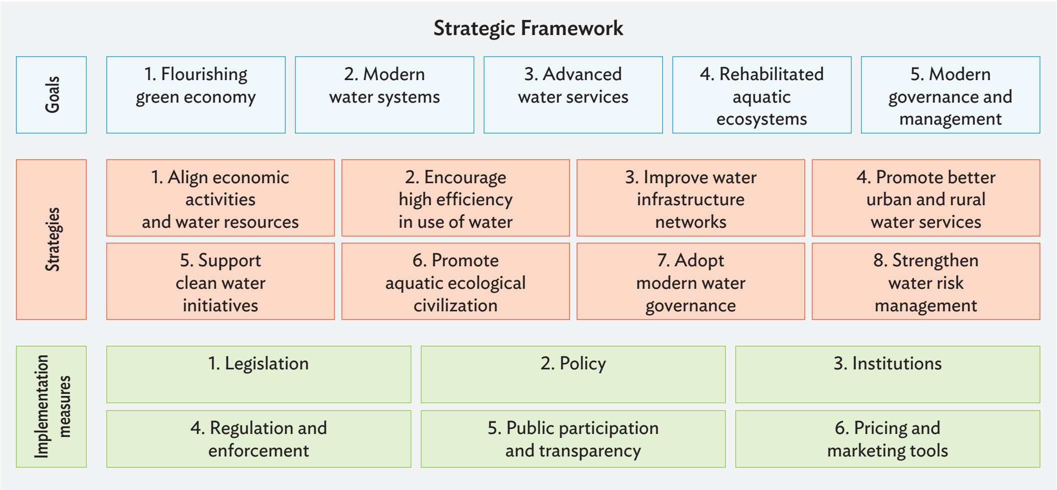
CHAPTER VI
Strategic Framework for Water Resources Management

The ultimate output of this country water assessment (CWA) is a strategy for increasing overall water security. The government of the People's Republic of China (PRC) regards water security as a critical dimension of national security. Many recent national policies have raised expectations for water management, water protection, and sustainable use. The 13th Five-Year Plan confirms the country's commitment to mitigating water risks, especially water pollution, availability, and ecological deterioration.



This chapter links the water resources state (Chapter II) with the water security assessment (Chapter IV) and translates these into concrete actions to achieve the government goals for water resources development. Figure 32 illustrates the elements involved, which will be described in this chapter: five goals, eight strategies, and six implementation measures.

Figure 32: Overview of the Strategic Framework for Water Resources Management with Goals, Strategies, and Implementation Measures



Source: Asian Development Bank.

The strategic framework is grounded in five broad issues that threaten sustainable socioeconomic development, which reflect policy gaps and capacity levels:

(i) **water shortage**, either from a lack of natural water resources, unsustainable demand, or the lack of storage infrastructure;

(ii) **water pollution**, from industry and agriculture sources;

(iii) **degradation of aquatic ecosystems**, resulting from lack of political and institutional coordination to implement, monitor, and address (possibly punitively) or redress overexploitation, pollution, and overdevelopment of infrastructure within lakes and wetlands that have disconnected important resources from each other;

(iv) **weak water governance**, as typified by the ineffective water legislation, poor enforcement of existing laws and regulations, a fragmented institutional setup, limited public involvement in water affairs, and inadequate mobilization of market and economic instruments; and

(v) **water-related disasters**, due to climate change, soil erosion, and other ecological degradation, supply–demand imbalances, and poorly drained cities.

The problems and causes were assessed according to their influence on any of the five key dimensions of water security. Improving the country's state of water security, which should be viewed as an indicator of the country's growth potential, requires top-down, bottom-up, and across-the-board coordination between economic and eco-environmental policies—water resource availability being a major determining factor of both.

Goals for Water Resources Development

Based on the present state of the PRC's water resources, the targets for water security, and the conditional legal and policy factors, five goals for water resources development have been set. Each of these goals involves a total reorientation of some policies and practices before results can be expected.

Goal 1. The green economy is flourishing. Carbon economies have been transformed into sustainable, environmentally viable economies because economic policy and development investments view the sustainable use of water resources as the bottom line. This will require patient yet strategic and gradual achievement of efficient and sustainable use and reuse of water resources. The capacity of individual water bodies to carry pollution loads and extraction rates must be acknowledged, and economic strategies must be aligned with these natural limitations.

Goal 2. Water systems are modern. The limitations of water resources are respected, and water systems are developed and managed for total water security.

Goal 3. Water services are advanced. Water quality meets international standards, and supply is available to all users—urban and rural; domestic, industry, and agriculture.

Goal 4. Aquatic ecosystems are rehabilitated and protected. The ecological services that aquatic ecosystems provide to local and national economies, human health, and environmental integrity are valued and invested in by means of rehabilitation, protection, and sustainable use.

Goal 5. Water governance and management systems are modern. Legal and institutional frameworks, service providers, and the associated human resources have sufficient information and holistic capacity to manage the diverse risks confronting water resources.

To achieve these five goals, eight strategies for better management have been identified for their ability to support the economy while bringing policies and development (especially urbanization) into alignment with the capacity of water resources and the environment. The eight strategies involve major philosophical shifts in how progress and resources are viewed, and require major political determination to reign in unsustainable development, growth, and patterns of urbanization. The strategies are also cross-cutting and contribute to the achievement of the five goals.

Strategies for Better Water Management

Based on the policy directions discussed in Chapter III, the issues described in Chapter IV, and the driving factors for development examined in Chapter V—and as enlightened by the CWA-adapted indexes for determining the PRC's national water security level—eight strategies for better water management are developed and recommended.

Strategy for Harmony between Human Activities and Water

Better harmony between human activities and water resources can be supported through the following measures:

(i) **Align economies, planning, and development investments with local ecological capacities.** This is fundamental to growing a green economy. The following set of recommendations would force alignment of local economic ambitions and ecological limitations. The recommendations are especially practical for new and planned cities as well as those in economic transition.

(ii) **Establish a warning system for water resources that are nearing their carrying capacity.** Water use, pollution discharges, and future development—not excluding urban and industrial development—should be limited to the availability and limitations of water resources (including groundwater) and the environment. Carrying capacities should be determined at the county level, based on local availability and bearing capacity of water resources and the environment. Critically overstressed zones in each county should be identified. A warning system should be developed that will signal to monitoring and enforcement agencies when water resources and the environment are at risk of reaching their capacity. The warning system would alert agencies to activate demand management and pollution control measures.

(iii) **Optimize the layout of socioeconomic development.** Understand the relationship between land and water. What happens to either, happens to both. Planning is integral to the sustainability of economic activity and the natural resources that support it.

(iv) **Plan according to the land-carrying capacity.** Land development has to be based on the water and environmental carrying capacities as these pose risks to the land. Planning models must be based on the scientific knowledge of water, environment, and land-carrying capacities in order to know the risks and effectively use resources. Measures of effective utilization of land resources can be combined with the regional land resource evaluation results. Some exemplary factors for land-carrying capacity are listed in Box 2.

(v) **Optimize the layouts of economic zones and cities.** To avoid excessive development in areas with limited carrying capacity, choose development models that favor quality and efficiency of growth without compromising environmental integrity. Large-scale and high industrialization and urbanization should not be developed in regions designated for their ecological functions.

Box 2: Recommended Factors for Land-Carrying Capacity

1. Coverage of green area: 35%
2. Coverage of forest area: 12%, in addition to green areas
3. Per capita construction area for large cities: more than or equal to 80 square meters (m^2)
4. Per capita construction area for medium and small cities: more than or equal to 100 m^2
5. Green area per capita: 10 m^2
6. Per capita water resources: more than or equal to 1,000 cubic meters (m^3)
7. Per capita water resources in water-scarce areas: more than or equal to 500 m^3
8. Per capita water availability for residential city: 40-45 m^3
9. Per capita water availability for residential city in water-scarce areas: 35-40 m^3
10. Per capita water availability for nonresidential and/or business city: 30–35 m^3
11. Per capita water availability for nonresidential and/or business city in water-scarce areas: 25–30 m^3
12. Industry water recycling: 90%-95%
13. Ecological water needs: 1–2 m^3 per capita
14. Power needs should be factored in
15. Energy needs should be factored in
16. Water pollution treatment capacity and sewerage coverage should be strengthened for all areas of the city
17. Industrial waste and wastewater should be integrated with domestic sources, and treatment should be fully integrated
18. Class II air pollution should not be violated for more than 2 days per month

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

(vi) **Constrain land use.** Land use and layout should consider the water-carrying capacity as a key constraint. Cities should become more compact. Industrial parks should prioritize enterprises with high output per unit of land, low energy consumption, and low pollution emissions. Minimum standards should be established for building density and floor area ratio of land per type of industry. National policy has already determined land use goals for land space development to follow (Table 46).

Table 46: Land Use Goals in the National Main Functional Area Plan of the People's Republic of China

Index	2008	2020
Development intensity (%)	3.5	3.9
Urban space (1,000 km^2)	82.1	106.5
Rural residential area (1,000 km^2)	165.3	160.0
Amount of cultivated land (1,000 km^2)	1,217.2	1,203.3
Amount of forest land (1,000 km^2)	3,037.8	3,120.0
Forest coverage (%)	20.4	23.0

km^2 = square kilometer.

Source: The State Council of the People's Republic of China. 2010. *Planning of Major Function Regions Zoning*. http://www.gov.cn/zwgk/2011-06/08/content_1879180.htm (in Chinese).

(vii) **Promote compact cities.** Cities should be required to redesign their core areas into low-carbon transit hubs with mixed land use. New plans should incorporate existing roads, sites, local culture, and regulations.

(viii) **Continue economic restructuring.** Where there is water shortage, fragile ecosystems, and high consumption rates of water resources, economies should be restructured. This means reducing coal mining, iron and steel production, petrochemical production, cement factories, housing industry, paper mills, and others that consume relatively more water with lower economic output and higher pollution discharge. The traditional overdependence on exports and sectors that are intensive users of natural resources needs to be replaced with innovative, value-adding technological sectors and the tertiary services sector.

(ix) **Strengthen watershed-based planning.** A river basin or watershed is an integrated social, economic, and ecological system. River corridors have limited capacity to absorb the impacts from human activities. Integrated planning is needed in every watershed to ensure sustainable, holistic, and mutually beneficial development in the areas of land use, water supply, pollution control, disaster mitigation, industrialization, and urbanization. Urban industries and economic zones may need to relocate in order to rehabilitate and protect local water resources and ecological conditions.

Strategy for High Water Use Efficiency

Water use efficiency should be encouraged and supported, particularly in terms of water-saving measures in agriculture, urban and commercial areas, and industry.

Agriculture water savings. Opportunities for improving the water efficiency of agriculture in the PRC can be found in the following ways:

(i) **Rationally utilize water resources.** Surface water and groundwater should be rationally allocated and natural precipitation taken full advantage of. For regions that use canal irrigation, engineering systems should combine water storage, diversion, and lifting. For regions that use well irrigation, conjunctive use of surface water and groundwater should be implemented. In regions that lack conventional irrigation conditions, local water cellars and ponds should be utilized to store precipitation, and nonconventional water-saving irrigation should be developed.

(ii) **Use water-saving irrigation systems.** Technology to monitor, detect, and control canal seepage should be adopted. Sprinkling irrigation and micro-irrigation should be used to improve irrigation water use efficiency, especially for regions employing wells for irrigation, water-scarce areas, economic crop planting areas, and large-scale agriculture development regions.

(iii) **Apply agronomic water-saving techniques.** High-quality, drought-resistant, and high-yield crop varieties that utilize natural precipitation should be selected and promoted. In areas prone to drought or soil erosion, conservation tillage technology should be applied.

(iv) **Improve agriculture management.** Cropping patterns in certain areas may need to change and new types of agriculture developed to reduce water usage and soil erosion and retain soil moisture.

Urban and commercial water savings. In urban and commercial areas, water-saving measures can be promoted through a number of approaches.

(i) **Support application of efficiency codes for water-using devices.** All water-using devices (e.g., toilets, showers, dishwashers, washing machines, and faucets) manufactured, imported, and sold in the PRC should comply with strict water and energy efficiency standards.

(ii) **Encourage residential water savings.** Government could subsidize the installation of water-efficient devices (e.g., low-volume toilet, low-flow showerheads, water-saving dishwashers and washing machines, faucet aerators) and sponsor educational programs to teach the public water-saving methods and behaviors.

(iii) **Promote commercial and public water savings.** Conservation specialists should visit and inspect businesses for commercial and industry water audits to identify opportunities to save water. Incentives can be provided for businesses to adopt the water-saving measures identified in these audits.

(iv) **Adopt leakage control program.** Water companies should systematically operate leakage detection and repair, and reduce unnecessary high-pressure areas in the water supply system. Other approaches to save water include improving response time to main breaks and leaks, improving flow metering, and tracking water system losses so that water companies are well informed of the extent of their problems.

(v) **Reform water conservation tariffs.** Water tariffs should be reformed to recover the full cost of water services while providing an appropriate price signal to all users to encourage wise use of water. Water should remain affordable to low-income households. This can be done through block tariffs, discounts, or exemptions for qualifying customers.

Industry water savings. Strategies for relocating and restructuring industries can enhance industry water savings.

(i) **Optimize spatial layouts.** High water-consumption enterprises should be relocated and concentrated in industrial parks, where tandem-type water recycling arrangement with other industries is encouraged. All newly built power plants in the northwest and northern regions of the PRC should prioritize use of nonconventional water resources and adopt air-cooling technology. Enterprises using recycled water, urban sewage treatment plants, and water recycling plants should be situated near each other.

(ii) **Advance structural adjustments.** In regions with overexploited water resources, the industry structure should be adjusted, limiting or prohibiting high-water-consumption industries. New enterprises that use water-saving and environment-friendly technologies and techniques should be promoted. The development of low-water-consumption and low-emissions industries such as the technology sector, high-end manufacturing, and modern services should be expedited.

(iii) **Promote water-saving transformation.** Mandatory water-saving measures and standards should be applied for water-intensive industries. All industries should be encouraged to innovate on their use of water resources, and pursue scientific and technological solutions in advanced water-saving technologies. Water recycling and use of treated wastewater should be enhanced. It is important, though, that the different qualities of recycled water and treated wastewater be clearly demarcated along with their applicable usage. Industries or other sectors with relatively low water quality requirement should strengthen use of treated wastewater.

(iv) **Encourage the engagement of water conservation management services.** Companies that offer professional water conservation services should be encouraged to audit the water use of businesses to guide water-saving measures and innovations in all types of industry sectors.

(v) **Establish and promote water-efficiency champions.** To promote water savings, a directory of water consumption standards for products should be published to guide enterprises toward water-saving products and equipment. Trendsetters in excellent water-saving innovations and measures should be promoted and publicly rewarded.

Strategy for Improved Water Infrastructure Networks

To foster water conservation and efficiency of water use, water infrastructure networks for flood protection, urban and rural water supply, and wastewater services should be improved or optimized.

Flood-protection infrastructure. Improving flood-protection infrastructure is important in strengthening resilience to water-related disasters.

(i) **Accelerate the development of main river control works.** To prevent the risks of flood disasters, the development of flood protection and disaster mitigation systems for the great rivers and lakes must be enhanced and accelerated. Among others, efforts are particularly desirable for the three rivers in the northeast region, the Huai River in the east-central district, and the water environment of the Taihu Lake. In addition, it is important to control the regime of the middle, lower, and upper reaches of the Yangtze River; and to strengthen the construction of flood storage and detention basins for Dongting Lake and Poyang Lake.

(ii) **Address the weaknesses of secondary and tributary flood protection systems.** There should be increased control over the main river tributaries as well as the coastal rivers that flow directly into the sea to achieve an adequate level of flood risk protection. The major tributaries of large rivers (e.g., Han River, Gan River, etc.) as well as the middle and small rivers, especially those traversing through cities and counties, should be harnessed. Flash-flood control in mountain areas should likewise be promoted.

(iii) **Develop a national flood control and drought relief command system.** To improve flood risk control and the mitigation of disaster risks, develop an off-site video network that covers all the important prefecture-level cities and vital counties. The flood control and drought relief system should be expanded to cover all the key reservoirs and hydroelectric power stations. In addition, reservoir flow management systems should be developed to improve flood control and drought relief abilities.

Water supply sources. The following are some of the ways to optimize water supply networks:

(i) **Develop new water supply sources and water allocation projects.** New water source mobilization projects should be developed to increase the water security capacity in urban areas, cities, and the main grain production areas.

(ii) **Develop interconnectivity of waterways and waterworks.** The interconnectivity of rivers, lakes, and reservoirs will greatly improve pollution control and environmental protection in water bodies, as well as enhance water supply resilience.

(iii) **Encourage nonconventional water use.** To address water shortage in water-stressed areas, development of nonconventional uses of water should be accelerated through, for example, rainfall harvesting, flood retention, desalination of sea or brackish water, and reuse of reclaimed treated wastewater. In addition, the sponge-city solutions should be promoted and implemented in all urban areas with acute water shortage.

(iv) **Develop contingency water sources.** Drought-relief water sources need to be developed to alleviate drought risks. In areas with single water supply or with low capacity for emergency water supply, drought-relief solutions involving large or medium-scale reservoirs and water-diversion projects should be promoted.

Urban water infrastructure. Given the continued growth of urban areas, it is necessary to strengthen urban water infrastructure, specifically in the following areas:

(i) **Strengthen urban water source and water supply networks.** Highly reliable water supply sources with high-regulation ability need to be built for urban areas, and multisource water supply systems need to be established for cities. Emergency and reserve water sources should be enhanced, and the emergency reserve function of groundwater restored. The resilience of cities at prefecture level and above with single water supply sources can be improved through the development of alternate water sources. In cities with groundwater overextraction or using water sources from lakes with deteriorated aquatic ecology, alternative water sources should also be developed.

(ii) **Improve flood control and waterlogging prevention.** The construction of flood control and waterlogging prevention projects should be fast-tracked by coordinating requirements such as flood prevention, drainage in cities, urban construction, environmental control, ecological protection and restoration, and urban water culture. This will also facilitate the accelerated network construction of separate collection systems for sewage and stormwater. To improve emergency response for flood risk control, the development of meteorological and hydrological information monitoring and early warning systems in cities should be improved.

(iii) **Promote sponge-city solutions.** Increasing the in-situ absorption of rainwater before it reaches the urban stormwater drainage network can significantly lower polluted urban runoff in cities. Technical solutions are needed to enhance the water absorption and water-storage capacity of urban lands. The interflow of natural water systems including rivers, lakes, depressions, and wetlands originally existing in urban areas has to be revitalized to restore the aquatic ecosystems of cities.

(iv) **Optimize water system for urban and industry uses.** Linkage between urban areas and industries needs to be rationalized. In large, concentrated, and populated areas, a new approach has to be taken to restrict industrial zones to areas outside the cities, but within the urban areas so that industry water use and domestic wastewater reuse can be linked.

Rural water infrastructure. Strengthening of rural water infrastructure can focus on developing efficient water-saving irrigation system and improving the quality of rural drinking water.

(i) **Develop water-saving irrigation systems.** To save irrigation water, efficient water-saving irrigation projects could be built especially in large and medium irrigation districts. The emphasis should be on rehabilitating and upgrading existing irrigation regions. In addition, the transformation into water-saving irrigation regions of the major grain production areas, as well as of areas with fragile ecological environments where water resources are overexploited, should be promoted.

(ii) **Develop new irrigation districts rationally.** To strengthen the PRC's agriculture production capability and food security, new large irrigation regions in the Northeast Plain, in the upstream and midstream of the Yangtze River, and in other areas with better water and soil resources should be developed. These irrigation projects should make extensive use of advanced water-saving optimization techniques compatible with ecological protection and restoration.

(iii) **Improve quality and efficiency of rural drinking water.** The development of public rural water supply systems capable of delivering safe and quality-controlled water supply should be intensified. Whenever possible, urban and rural water supply should be integrated. This can be achieved by connecting surrounding areas to main urban water systems and by promoting connection of pipe transmission mains from large municipalities to rural villages. In addition, protection of drinking water sources in rural areas should be increased.

Domestic wastewater services. At the infrastructure development level, investments on domestic wastewater services should prioritize and focus on projects that have the highest environmental water quality improvement impacts on water bodies. Specific measures for cities and towns to strengthen industry and domestic pollution control include the following:

(i) progressively abolish the use of combined sewers systems and stormwater overflows,

(ii) maximize the possibility of direct clean rainwater infiltration into the ground,

(iii) increase the coverage of sewerage system in cities and towns equipped with centralized wastewater treatment plants (CWWTPs) to ensure all concerned urban residents are connected to urban sewers and CWWTPs,

(iv) expand the sewerage system to surrounding industrial areas to ensure all pretreated industry discharges of polluting enterprises are connected to municipal CWWTPs,

(v) develop sewage sludge treatment facilities at the CWWTPs that are not equipped, and

(vi) enforce continuous monitoring and reporting to competent authorities of the treated wastewater discharges of CWWTPs into receiving waters.

Strategy for Better Water Services

Measures to promote better water services can essentially focus on improving urban water supply, rural water supply, and domestic wastewater services.

Urban water supply. Improving water services in urban areas entails the following:

(i) develop coordination and long-term planning of water supply and wastewater management system to ensure sustainability,

(ii) improve the technical capacity of water utility companies for sustainable operation and maintenance of components,

(iii) mobilize funding resources for necessary system extension to keep pace with population growth and to support low-income household connection to networks,

(iv) increase coverage of tap water supply in cities and in county towns,

(v) increase reliability of city water supply through the development of alternative water sources, and

(vi) develop water safety plans for urban water systems to warrant water safety from source to tap.

Rural water supply. As the PRC population increases, it is crucial to increase safe and quality-controlled rural water supply services to cover 70% of the rural population by 2030. Of utmost priority are avoidance of polluted water as a water source; adequacy of disinfection of tap water in treatment plants; availability of service storage tanks; and management structure for operation and maintenance, as well as water quality control monitoring. Particular attention should be given to the rural population having geology-based high arsenic or fluoride content in their water sources. This population needs small, self-contained, and advanced reverse osmosis plants, which can safely supply water to village-size populations.

Domestic wastewater services. Improving domestic wastewater services involves strengthening of the policy framework and acceleration of technical measures to increase the proportion of urban and rural populations connected to sewers and wastewater treatment facilities. Full cost pricing of wastewater management services—including operation, maintenance, and reinvestment of wastewater collection and treatment of domestic wastewater as well as sewage sludge treatment and disposal—should be introduced through the establishment of tariffs adapted to the population mix of the served area.

Strategy for Clean Water Initiatives

Cleaning up rivers and lakes is a crucial precondition to enable the rehabilitation and restoration of aquatic ecology in surface water.

Water protection areas. The objective of water protected areas (WPAs) is to avoid quality deterioration and promote the necessary protection of areas where water bodies are at risk of water quality deterioration. WPAs are necessary to

(i) prevent the abstraction of water intended for human consumption;

(ii) protect economically significant aquatic species;

(iii) safeguard the demand for recreational waters, including bathing waters;

(iv) protect nutrient-sensitive areas and zones designated as vulnerable due to agriculture or industrial activities; and

(v) protect habitats or species needed to establish a good ecological status of water bodies.

The designation of WPAs will cover whole water bodies based on characteristics of registered water functional zones and embed the actual abstraction zones (safeguard zones) and other zones of potential abstraction. Protection measures in WPAs should focus on safeguard zones linked to existing drinking water abstractions that are at risk of deterioration. WPAs will be designated and registered, and will include defined compliance points for monitoring. In principle, safeguard zones will be risk-based so that any necessary measures applied are most effective in reducing the impacts of human activities on the quality of the abstracted water.

Industrial pollution control. To strengthen industrial pollution control, it is recommended to introduce a strengthened integrated (water abstraction and wastewater discharge) water permit for polluting sites exceeding defined levels of production and wastewater discharge. An even higher level of permitting and control for industrial sites handling dangerous and hazardous substances will complement this. The recommended approaches for industrial pollution control include the following:

(i) maximize opportunity for frequent improvement of industrial processes that favor the use of cleaner production;

(ii) establish an industrial culture of water pollution prevention and regulation through strengthened water pollution control and enforcement, and incentives for cleaner production technologies;

(iii) enforce the separate collection of pollutants at source and the onsite maximization of waste stream separation before dilution, including the opportunity for resource recovery and reuse at source prior to follow-up treatment and discharge;

(iv) implement systematic and thoroughly controlled onsite pretreatment of industrial wastewater to eliminate toxic materials;

(v) expand the sewerage system to surrounding industrial areas to ensure all pretreated industrial discharges of polluting enterprises become connected to municipal CWWTPs, which maximizes industrial wastewater discharge into municipal sewers and facilitates the joint centralized wastewater treatment of sewage with industrial wastewater;

(vi) prohibit direct discharge of treated industrial wastewater into receiving water;

(vii) enforce continuous monitoring and reporting to competent authorities of all treated wastewater discharges of main pollutants into receiving water, as defined in the strengthened water permit; and

(viii) enforce the “polluter pays principle” compelling polluters to cover the full cost of water pollution control.

Domestic pollution control. The measures for improving domestic pollution control in cities and county towns are to

(i) include domestic CWWTP into sites that require a strengthened integrated water permit;

(ii) introduce full cost pricing of wastewater management services—including operation, maintenance, reinvestment of domestic wastewater collection and treatment, and sewage sludge treatment and disposal—through the establishment of tariffs adapted to the population mix of the served area;

(iii) strengthen the collection and calculation of water pollution discharge fees and link it to the real pollution load and pollutants released into water bodies;

(iv) connect all existing households to the sewer system, and enforce the payment of wastewater tariff as soon as the sewers are completed and connected to a CWWTP to increase the sewerage system’s coverage in cities and towns equipped with CWWTPs—this will ensure connection of all concerned urban population to urban sewers and CWWTPs;

(v) ensure that city and town governments construct tertiary branch sewers to connect housing units;

(vi) maximize direct infiltration of clean rainwater into the ground for green and nonplastered build-up areas of cities such as parks, public alleys, public lawns, public wetlands, parking lots with semi-permeable plastering, and other green areas;

(vii) progressively abolish the use of combined sewers systems and stormwater overflows;

(viii) develop sewage sludge treatment facilities at the CWWTPs that are not yet adequately equipped; and

(ix) enforce continuous monitoring and reporting to competent authorities of the treated wastewater discharges of CWWTPs into receiving water.

Nonpoint source pollution. Nonpoint sources principally cover agriculture runoff from fertilizer and pesticide use, animal waste, rural domestic waste, urban runoff, as well as soil and water erosion.

(i) **Address pollution from fertilizers, pesticides, and animal waste.** The proposed strategy is to identify and designate vulnerable agriculture areas subject to severe nonpoint source pollution (NPSP), and develop for each area action plans and targets for progressive NPSP mitigation. For these vulnerable areas, a monitoring program should be established to track pollution prevalence and trend over time toward progressive improvement. Fertilizer and pesticide use should be limited, codes of good agriculture practices should be established, and farmers should be trained on how to apply them. For dispersed animal farms generating manure, technical guidelines for anaerobic sludge digestion of manure and safe disposal of residual wastewater away from water bodies need to be prepared and promoted to farmers. Also, standard technical solutions for the safe collection, stabilization, treatment, and disposal of manure in animal husbandry farms should be developed to avoid any release of residual pollution into water bodies. For larger farms, the use of manure digesters and the recovery of methane gas for electrical and heat recovery should be supported and promoted.

(ii) **Address pollution from rural domestic waste.** Wastewater collection drainage systems and affordable wastewater treatment measures (such as artificially constructed wetland systems starting with larger villages that are riparian to water bodies) should be built for rural areas. Solid waste collection treatment and disposal should be improved in rural areas, particularly avoiding the location of solid waste dumps along riverbanks.

(iii) **Address pollution from urban runoff.** The discharge of urban runoff directly into water bodies needs to be gradually prohibited or prevented. Rainwater should be collected and stored, and then progressively released into a nearby wastewater treatment plant.

(iv) **Address pollution from erosion.** Soil erosion control measures should be undertaken in natural areas, agriculture settings, or urban environments. Good practices against soil and water erosion should be applied such as planting vegetated buffer strips as bioshields along the edges of farmlands to prevent soil erosion and nutrient leaching.

Wastewater treatment and reuse. Reclamation and reuse of treated wastewater should be regulated by providing ordinances for the safe use of various applications. It is also important to define environmental and health standards and guidelines for treated wastewater reclamation and use. In the industry sector, opportunities for in-house industrial reuse of treated wastewater as cooling water, boiler feed, and processed water should be promoted and incentivized. In water-stressed urban areas near CWWTPs, a dual-process water distribution system for nonhuman consumption of water (such as for industry use, toilet flushing, garden and landscape watering, and agriculture irrigation) should be developed, utilizing treated wastewater whenever possible. In the agriculture sector, capacity development for agriculture irrigation and crop irrigation with treated wastewater needs to be promoted and facilitated. By 2030, the ratio for treated urban wastewater should reach 93%, while the ratio for treated rural wastewater should be 50%.

Strategy for Aquatic Ecological Civilization

The overall goal of aquatic ecological restoration is to ensure the healthy ecological functioning of ecosystems involving aquatic and semi-aquatic biodiversity. The proposed strategy primarily involves protecting the natural aquatic habitats and their biodiversity and restoring degraded aquatic ecosystems.

Watershed control and management. Watershed control and management are essential in protecting the aquatic ecosystems.

(i) **Control erosion and siltation.** Eco-friendly land-use practices should be employed in agriculture, forestry, and infrastructure construction on a catchment basis. This is to avoid soil erosion that could cause siltation of water bodies, loss of water storage or channel flow capacity, and destruction of benthic habitats critical as feeding sites and spawning grounds. Water and soil conservation measures should be implemented in severely eroded areas like the black soil region in northeast PRC, the Loess Plateau, and the purple soil region of southwest PRC.

(ii) **Convert reclaimed land.** Reclaimed land should be transformed through the conversion of farmland back to wetlands. Eco-transformation should be pursued, including the removal of concrete embankments and channels to regain critical shorelines, riparian and littoral zones and benthic surfaces for land–water ecological functions, and surface water–groundwater hyporheic functions. It is a priority to convert reclaimed lands in regions where overexploitation of water development and utilization occurs, or where fragile and important aquatic ecosystems are threatened, or where demand for improving water quality is high.

(iii) **Enhance groundwater recharge.** Permeable construction materials should be used for roads, car parks, etc.; and open spaces and sloping lands should be revegetated (grassed over) to prevent soil erosion. More importantly, groundwater recharge (for hyporheic functions) and water purification should be promoted. Criteria and areas for groundwater recharge should be established to sustain shallow aquifers and to prevent land subsidence and saltwater intrusion in coastal areas. The implementation of effective control measures against groundwater overexploitation is also a key aspect in enhancing groundwater recharge.

(iv) **Implement ex-situ pollution control.** Strictly enforce the red line for water pollution control and water quality limits, especially for the water functional zones, to enable strategic planning on a catchment basis to foster the recovery of aquatic ecosystems to their natural state over several generations.

(v) **Formulate checklists of prohibited or restricted zones.** For different zones in the eco-environment field, comprehensive and exhaustive criteria and checklists of prohibited or restricted areas, sites, activities, substances, or behaviors are very useful in practically and precisely guiding the actions of operators to minimize negative impacts. To facilitate the protection and restoration of aquatic ecological systems, the use of exhaustive checklists that precisely define the boundaries of prohibited, restricted, or required actions should be promoted.

(vi) **Promote watershed and catchment-based integration.** This will be developed through the promotion of integrated watershed planning and management of land use for erosion and siltation control, and of pollution discharge and control. Moreover, shoreline or riparian and littoral corridors for buffering human impacts will be established, which would allow for the movement of mammals and birds associated with water in response to climate change impacts.

Aquatic ecological functions, resilience, and protection. There are mainly four types of aquatic ecological space: water bodies, drinking water source protection areas, floodplains and flood retention areas, and soil and water erosion control areas. They are considered important and sensitive regions for the protection of the eco-environment, preservation of aquatic biodiversity, and control of aquatic ecosystem risks. To ensure water security, it is necessary to maintain and improve the ecological functions of these aquatic ecological spaces through the following steps:

(i) **Delineate aquatic ecological space.** The delineation of aquatic ecological space will be based on the national main functional zoning, water sources protection zones, and regional soil and water conservation zones, with due consideration of regional characteristics and functions such as flood control, soil erosion control, clean drinking water supply, and others. Strict regulations and control will be issued for altering the delineation.

(ii) **Establish management mechanism.** Specific rules and standards of protection and restoration will be established and improved. Considering that protection of aquatic ecological space, especially flood retention areas and soil erosion control areas, generate public welfare benefits, investments will come primarily from the government, with supplemental investments from enterprises, private organizations, and others. Meanwhile, market-based incentives and stakeholder participatory mechanisms should be established. Process supervision of various management measures should be strengthened to ensure protection effectiveness.

(iii) **Return aquatic ecological space.** It is necessary to return aquatic ecological space through the adoption and gradual implementation of programs for returning reclaimed farmlands into restoration sites for lakes, wetlands, and rivers. A compensation policy with clear standards and methods of compensation for restoring protected aquatic ecosystems will be formulated. Furthermore, a list of prohibited activities potentially infringing the protection of designated protected areas will be developed.

(iv) **Restore aquatic species.** Restoring aquatic species in rivers, wetlands, and lake-protected areas is important, along with assessing the nature and area of occupation and inhabitation, and its historical suitability and capability. This will similarly be achieved by returning reclaimed farmlands for the restoration of lakes, wetlands, and rivers; as well as by developing clear standards and methods for compensating efforts to restore protected aquatic ecosystems.

Environmental flows and connectivity of aquatic ecosystems. The key measures for ensuring environmental flows (ecological flows) include, among others, water-saving methods and water allocation systems through dams and sluices at watershed scale. It is crucial to identify the flow requirements of critical habitats and biota of aquatic ecosystems, especially in the dry season; and to increase environmental flows to restore aquatic ecosystems, especially in regions with serious ecological problems. This will enhance the connectivity between rivers and lakes, combining natural with artificial connectivity, which will especially be implemented in key urbanized regions. The analytical assessment of the functioning of dams and barriers in relation to the loss of aquatic ecosystems is required, and so is the removal of barriers to promote ecological connectivity for the provision of ecological services.

(i) **Control ecosystem abuse.** Water conservancy projects need to be implemented and corrective actions taken to enhance ecological services and ensure control of water pollution from aquaculture and shipping, habitat destruction by fishing gear, invasive species introduction, and habitat fragmentation.

(ii) **Restore ecological habitats.** There should be strategic planning to restore aquatic habitats in flowing and standing waters and wetlands, after ensuring control of in-situ abuse. Aquatic ecosystems can be restored by improving geomorphology (e.g., riffle and pool channels, benthic and littoral habitats, and meanders and flood basins); wetlands; riparian and littoral fringes and corridors; and hyporheic functions of groundwater. This will require access to and culture of critical biota from similar protected natural water bodies for introduction in degraded sites.

(iii) **Assess river ecosystem health.** A national aquatic ecosystem investigation should be conducted on a watershed or catchment basis to assess its health. Assessments would include biotic types, key biota abundance and distribution, water pollution and toxicity, environmental flows, water and land resources exploitation, and water area protection and restoration. Healthy ecosystem assessment reports of rivers need to be released regularly to the public, especially for critical rivers like the Hai River, Huai River, and Yangtze River.

(iv) **Develop standards for ecological restoration.** In view of the serious conditions of the aquatic ecosystems (combined with heavy metal pollution, eutrophication, environmental flows, and riparian reclamation), comprehensive and strict standards and criteria for ecological rehabilitation and restoration should be developed. Given the great variations in aquatic ecological characteristics across the PRC, it is likewise important to adapt standards and criteria for ecological restoration based on local conditions—e.g., in the cold areas of the northeast, the semi-arid regions of the northwest, the urban areas, etc.

(v) **Restore degraded aquatic ecosystems.** Restoration of ecologically vulnerable rivers, overexploited aquatic ecosystems and littoral zones, and excessively polluted waters will be implemented first—particularly, the aquatic ecosystem in the northeast and northern regions, the middle and lower reaches of the Yangtze River, and the plateau lakes in the southwest region. A rational and step-by-step restoration plan for these rivers needs to be undertaken, employing both engineering and non-engineering measures. The restoration of degraded rivers should be implemented through pilot and demonstration projects, and successful technologies that may be mainstreamed for restoring remaining degraded rivers should be adopted.

Strategy for Modern Water Governance

Modernizing water governance is important in strengthening the enabling environment for the effective management, protection, and sustainable development of water resources and water services.

Water-related legislation and regulations. The PRC urgently needs to strengthen the roles of laws and regulations in routine water management and the supervision of water quality protection.

(i) **Review water-related laws.** The new requirements of water governance call for integration, greater accountability of competent authorities and operators, greater transparency and public involvement in water decision-making, and greater use of market and economic instruments to efficiently regulate water-use behavior. It is therefore essential to review and revise the Water Law, the Water Pollution Prevention and Control Law, the Flood Control Law, and other water-related laws at the national level to make them consistent with these governance requirements. Besides the revision of existing laws and regulations, some additional regulations need to be introduced and enforced for source water protection, groundwater management, water saving, water rights and water trading, river corridor control and protection, and many more.

(ii) **Clearly identify and strictly enforce restrictions on water use and pollution discharge.** The revised laws and regulations should introduce and clearly spell out precise and exhaustive lists of prohibited behaviors or substances that are strictly enforced for all, as well as lists of restricted behaviors or substances that require special regulatory action by operators and authorities such as the need to register, report, and monitor water use and pollution released into water bodies. Of particular importance is also the need to raise penalties to levels that would successfully deter operators from choosing wrongdoing over respecting the rules in managing water use and pollution discharge.

Institutional reforms. Given the importance of water for the continued advancement of the socioeconomic development of the PRC and the need for an integrated approach to water resources management, the integration and coordination of all sector administrations with water-related responsibilities should be strengthened.

(i) **Establish a national water security leadership committee.** This committee, headed by a vice premier minister, could be set up as an independent new committee, which would signal the all-encompassing importance given by the central government to matters pertaining to national water security.

(ii) **Reform the ministries tasked with water affairs.** The tasks between the Ministry of Water Resources (water resources and aquatic ecology) and the Ministry of Ecology and Environment (pollution control) should be reviewed to reduce overlapping functions, optimize coordination of tasks and responsibilities, and ensure that there is no management lacuna. An interministerial water security coordination committee for the supervision and arbitration of water affairs should be formed, led by a state leader and comprising all the ministries and state agencies that have roles and responsibilities pertaining to water resources, aquatic ecology, and water environment.

(iii) **Strengthen integrated water resources management.** Two types of water integration need to be strengthened in the PRC—watershed management integration and urban water affairs integration. In each river basin, an integrated watershed management commission should be set up, which includes all important water stakeholders (administration, human settlements, industry, agriculture, and others) and will take over the direct water allocation process and the arbitration of water-related matters among concerned stakeholders. The integrated watershed management commission would be attached to the existing river basin water commission.

Water management and regulation. Strengthening water management and the enforcement of regulation—including designating WPAs and managing the permit and postpermit processes for water abstraction, wastewater pollution discharge, and environmental flows—are part of water governance.

(i) **Enforce water body protection.** For every water body, including rivers, lakes, and their riparian areas, three types of protection areas are delineated and designated to prevent land use and urban development from encroaching or occupying water spaces through permanent structures: (a) blue lines, which cover potentially inundated areas or boundaries;

(b) green lines for buffer zones with prohibited or restricted development; and (c) gray lines for controlled land use of areas that can impact or be impacted by water.

(ii) **Enhance water resource use management.** Allocation for water resources development and utilization will be strictly based on the sustainable availability of water resources and the guarantee of environmental flows. These will be defined for every watershed and detailed to different river reaches as well as to different water sources. Water rights should be underpinned by water permits that specify water-use rights and duties as well as conditions of water use with strict emission limit value.

(iii) **Enhance water pollution control.** Water pollution control will focus on water quality improvement by implementing a "safe, clean, and healthy" water protection policy. Particularly important aspects include (a) the reduction of pollutant load and the strict control of pollutant load discharged into water bodies, according to water environmental and ecological carrying capacity; and (b) the strengthening of wastewater treatment design standards, and the strict enforcement of treated wastewater effluent quality to reduce the pollution load.

(iv) **Strengthen water-related risk management.** The comprehensive development plan and/or the sector development plan will consider water-related risks and the requirement for flood control. The development of flood-prone areas in the middle and lower reaches of rivers, and of reserved flood retention areas, will be strictly prohibited.

(v) **Enforce laws and regulation.** There is a need for greater accountability of competent authorities supervising water affairs and operators of water services. Indicators and targets for improved water governance will be defined and set for all levels of water management and water services operation. Performance will then be periodically checked against these indicators and targets, and corrective actions will be defined, organized, and enforced when performance falls behind targets.

Transparency and stakeholder participation. The efficient management of water resources in the PRC requires the strengthening and development of a comprehensive, standardized water information system to document all the different dimensions of integrated water resources management issued from the local levels to the central level. Except for national security reasons and confidential trade secrets of businesses, all data monitored by public finance that have potential impacts on human welfare should be disclosed and freely shared on public websites and networks to promote transparency. Moreover, proper water governance requires the active participation of stakeholders. This covers public access to water information and public participation in water-related decisions. It is necessary that the public hearing system for urban water pricing, among other aspects of water allocation, as well as environmental impact assessments be based on standard public participation procedure.

Economic instruments. Economic instruments use price signals to facilitate the optimization of the allocation of resources. This is particularly useful when the resources are scarce, as in the case of water. The use of economic instruments will be reinforced, specifically in connection with water and wastewater services pricing, water abstraction charges, pollution discharge (to water bodies) fees, and compensation mechanisms for resources returned to ecological spaces.

Water monitoring and capacity building. Water monitoring capacity and networks need to be expanded to cover the proposed improved water governance and management framework.

(i) **Establish monitoring and metering systems.** The monitoring system for the whole process of water resources development, water abstraction, water use, water discharge, risk management, ecological condition, and all other aspects related to water will be established. Hydrological and ecological monitoring system will also be strengthened; and metering networks for water abstraction, water use, and water discharge will be expanded to all the major water users.

(ii) **Enhance technical and management capacities.** To address the demand for greater water security, the PRC will improve its technical and managerial capacities especially with regard to monitoring, metering, forecasting, risk management, and decision-making support, among others. The capacity of professionals working in the water sector will be further strengthened through training. Decision-making positions should be filled with professionals having certified competencies that match the ensuing responsibilities.

(iii) **Promote awareness raising.** Awareness building on water security issues and the principles of sound aquatic ecology will be promoted through education, trainings, and outreach programs conducted in schools, in the communities, among enterprises, and within families.

Strategy for Water Risk Management

Water resources face multiple risks—from the impacts of rapid economic and urbanization growth, to the effects of climate change, disasters, and pollution. The following measures will help manage these risks:

(i) **Develop national risk mapping.** On the basis of analyses of water security risk (such as flood and drought risk) and pollution risk and taking into account the heightened risk in connection with climate change and accelerated urbanization and economic development, water risk maps should be developed using geospatial information technology. These maps should present the risk vulnerabilities from major river floods, smaller river floods, flash floods, landslides, droughts, earthquakes, and pollution. It is important that these location-based disaster risk maps be periodically updated and disseminated to decision makers, the general public, and communities at risk of exposure to disaster. The risk maps will be accompanied by risk reduction and mitigation measures and early warning systems at county, city, and national levels.

(ii) **Develop hazards identification and marking.** In addition to natural disaster maps, hazard maps are developed to document hazards in relation to industrial sites that are handling, using, or processing hazardous and dangerous substances. These maps should be linked to water risk vulnerability maps to mark additional levels of risks that can affect water resources.

(iii) **Establish and strengthen risk management and regulation system.** Risk management of the processes of disaster control including multi-hazard early warning systems, preparedness, response, recovery, rehabilitation, and reconstruction will be enhanced. Disaster risk monitoring, identification, and assessment should be strengthened to facilitate prevention and mitigation; and implementation guidance for appropriate preparedness and effective response to disasters should be developed. For the different types of risks, different measures that are adapted to the groups at risk should be developed, approved, and implemented. By regulating water-related human behavior, there will be a reduction in human-made hazards and related environmental, technological, and biological hazards and risks.

(iv) **Strengthen postdisaster recovery and rehabilitation.** To promote the incorporation of disaster risk management into postdisaster recovery and rehabilitation, it is necessary to facilitate the link between relief, rehabilitation, and development. Opportunities to develop capacities and development measures that reduce disaster risk in the short, medium, and long term should be tapped during the recovery phase. Development measures include land-use planning; structural standards improvement; and the sharing of expertise, knowledge, postdisaster reviews, and lessons learned. Postdisaster reconstruction should be integrated into the socioeconomic sustainable development of affected areas.

(v) **Secure financial protection from disaster.** Mechanisms for disaster risk transfer and insurance, risk sharing and retention, as well as financial protection should be promoted to reduce the financial impacts of disasters on governments and societies in urban and rural areas.

(vi) **Strengthen early warning and emergency response systems.** To develop, maintain, and strengthen people-centered response to water-related hazards, it is necessary to implement and utilize forecasting and early warning systems for disaster risk and emergency communication. Such mechanisms include social technologies and hazard-monitoring telecommunications systems. Weather forecasting for flood control and drought relief should be strengthened in the short, medium, and long term. The availability of and access to multi-hazard early warning systems should be substantially increased, and disaster risk information and assessment findings should be promptly disseminated to the public.

(vii) **Increase climate change resilience.** With global warming, occurrence of extreme climate and weather events will increase in regional or local scales. Extreme weather events such as storms, which often cause floods, will increase in frequency. It is necessary to strengthen local capacity to mitigate the impacts of water-related disasters. It is also necessary to strengthen the resources and capacities of local authorities to monitor, identify, and assess the hazards risks; disseminate accurate disaster risk information in close cooperation with national authorities; and make decisions such as evacuating persons living in disaster-prone areas. More focus is needed to address flash floods and landslides, which have become more frequent and devastating in small and medium-sized river basins across the country.

Implementing the Strategies: Governance for Green Growth

As described by the Organisation for Economic Co-operation and Development, the goal of water governance is to promote the effectiveness, efficiency, trust, and engagement of stakeholders of the water sector.[33] There is no generalized mode of good governance applicable to all countries due to diversity in natural endowments and differences in social settings. The PRC is a special country, with unique water endowment and regimes, socioeconomic development history, and culture.

The PRC government is pushing forward social governance reform that focuses on community-based management, government responsibilities and market-dominated roles, sector coordination, public participation, and legislation-based governance. Considering existing and potential water issues and weaknesses in the country's water sector, the overall goal of water governance should be to promote accountability, transparency, effectiveness, fairness, efficiency, and stakeholder engagement.

[33] Organisation for Economic Co-operation and Development. 2015. *OECD Principles on Water Governance.* http://www.oecd.org/governance/oecd-principles-on-water-governance.htm.

Water governance is essential in the improvement of water security. The present governance framework should be reformed to make policies and institutions more adaptable to the changing environment and the evolving challenges that confront the water sector. Water governance is a complex and multilayered domain, which needs the scientific analysis of possible options for reform in order to effectively address the gaps and weaknesses highlighted in the preceding chapters. Table 47 shows the hierarchical water governance reform framework, which covers the following implementation measures: legislation and policy (discussed separately below), institutional reform, regulation and enforcement, public involvement, and market mechanism.

Table 47: Hierarchical Water Governance Framework

Target	Implementation Measure	Indicator	Action
A Better Water Governance	Legislation and policy	Legal updating and revision	Actions to improve water governance of the People's Republic of China
		New laws	
		Policy coherence and orientation	
	Institutional reform	National leadership and coordination	
		Integrated management	
		Regulators and auditors	
		Service providers	
		Capacity building	
	Regulation and enforcement	Water space protection	
		Water use regulation	
		Pollution discharge management	
		Environmental flow regulation	
		Water risk management	
		Asset management	
		Monitoring and forecasting	
	Public involvement	Transparency and accountability	
		Participation	
		Awareness raising	
	Market mechanism	Economic instruments	
		Water markets	
		Private investment	

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

Legislation

Promoting and updating the legal system. It is necessary that the PRC update and upgrade its national water-related laws and regulation so that water issues can be acted upon in an integrated way. Particularly important is the development or upgrading of local water laws and regulations relating to the water law or the pollution control law so that the responsibilities and accountability of water users and managers at all levels can be improved.

Revising existing laws and regulations. Review and revision of water-related laws and regulations at the national level are needed to make them consistent with integration requirements. For instance, improved coordination between watershed management and urban water management has been tested as an effective mode for water management in Beijing, Shanghai, and other regions. Existing laws and regulations, however, do not give any emphasis to the various dimensions of integration in watershed management or in urban water management. The revision of these laws and regulations should clearly define the functions, responsibilities, and tools used by various actors to holistically plan, manage, and monitor the various aspects of water affairs.

The existing laws on urban planning, land use, and agriculture do not consider in detail important water issues (such as the water carrying capacity) or water-related risks and disasters. These laws and regulations need to be updated to more resolutely confront the water challenges ahead. Similarly, floodplains along rivers, ecological health of water bodies, and biodiversity protection are also not given much attention in the current river management law, which tends to focus more on traditional flood control measures.

Formulating new regulations. Besides the revision of existing laws and regulations, new ones need to be considered for groundwater management, water conservation, river basin or watershed management, and flood risk management.

(i) **Groundwater management.** A groundwater management regulation has been under preparation for over 5 years. Groundwater issues like overexploitation and pollution are becoming worse in many cities and have become a serious cause of concern for the public. This regulation is to be issued as soon as possible to strengthen groundwater management and protection around the country. The regulation needs to cover the entire groundwater cycle process—from source recharge, to scientific investigation and assessment, planning and allocation, development and control of wells, abstraction permits, water saving, pollution prevention, monitoring and metering, water pricing, and legal responsibility and liability.

(ii) **Water conservation.** A water-saving regulation has been completed and issued by the State Council, with effectivity on 15 April 2018. The regulation—which, among others, updates the water-use permits system and the water-consumption charges in agriculture—should significantly advance water-saving efforts around the country in various sectors and for various kinds of water resources, and promote the sustainability of these water resources. In the PRC, it is believed that significant water savings can be achieved by improving water efficiency in the agriculture sector. Water-saving regulation should cover provisions not only for water use management but also for pricing incentives, metering and auditing, supervision, oversight and penalties, etc.

(iii) **River basin or watershed management.** Integrated watershed regulations for major river basins such as the Yellow River and the Yangtze River have become essential as they help incorporate other facets of development (e.g., urban development, industrialization, land use, water resources development, environmental protection, ecosystem preservation, and more) into river basin management. The focus of attention for river basin management should be shifted from development to protection, alongside integration requirements. The Yangtze River has been defined by the central government as a major regional water protection area whose integrated river basin management strategy can serve as model for other river basins across the country.

(iv) **Flood risk management.** In spite of some additional requirements needed for the further protection of secondary rivers, existing flood control infrastructure are now, by and large, considered adequate. The provision of additional protection would bear the risk of generating higher marginal costs than marginal benefits. The focus may need to be shifted instead to flood risk forecasting, flood risk warning systems, flood emergency response planning and exercise, and flood insurance schemes. Also vital are additional intermittent flood retention basins and similar soft management tools, which may be better able to alleviate flood risks in the future.

Policy

Improving policy coherence. Since laws and regulations should play more decisive roles in water governance in the future, there is a need to review and adapt the large number of policy documents issued by water-related sectors to ensure they are coherent and compatible with the new laws and regulations. The main objective of the review should be to give more responsibilities to the lower-level governments and organizations and water users. Central-level support and control should be strengthened especially in the areas of integrated water permitting, water-saving and conservation oversight, pollution control inspection and enforcement, and infrastructure development financing. Development and extension of public pollution control infrastructure, such as sewers and centralized wastewater treatment plants (CWWTPs), require large funding that cannot be mobilized at the local government level.

Improving coordination and consistency between sectors. Water sector management is overseen in the PRC by several ministries, which have overlapping responsibilities that need to be better coordinated and clarified. The Ministry of Water Resources and the Ministry of Land and Resources (now Ministry of Natural Resources) have already established model cooperation and coordination mechanisms regarding standards and policies applied in groundwater management. Similar efforts need to be developed for other overlapping responsibilities by various ministries. A low-impact development initiative for cities is now being piloted in 33 sites under a joint approach approved by the ministries of finance, urban development, and water resources. However, no joint planning and implementation processes have been defined and agreed upon. This may lead to inadequately addressed strategic orientation and misallocation of resources. Coordinated actions in the pilots are focusing on local-level measures, such as improving waterlogged areas or developing smaller green belt within cities, while neglecting the need for protection of the water space at the macro level, particularly in the water-rich southern PRC region where the soil is often water-saturated and groundwater aquifers are shallow.

Promoting new policy orientation. The most comprehensive, overarching, and enabling policy document in the water sector is the 2011 No. 1 Policy Document, which established the three red lines policy (water quantity, water quality, and water use efficiency). Since then, several water-related policy documents have been issued such as on eco-civilization, on the framework for deepening reforms, on water pollution control actions, and on eco-compensation. These need to be reinforced by new policies such as water rights, water pricing, water environmental protection, water resources carrying capacity, water and land use development, and natural resources auditing.

Due to the changing industrial landscape toward cleaner and more productive economic development, many heavy industries that were large users of water (like coal mines, iron and steel, etc.) are facing restructuring and, in several cases, downscaling. Water permits allocated to them should be reassessed and redefined as part of the development of the new proposed integrated water permitting system. This integrated permit will cover the three dimensions of the red lines (quantity, quality, and efficiency). In the assessment of the permit, particular attention and priority should be given to the importance of securing the environmental and ecological flows of surface water. The new integrated water use permit will be marked as "subject to reassessment" and be amended when a user deviates from the range of production process, production volume, or permitted water use, as defined in the permit.

Ensuring proper implementation of policy. The PRC needs to strengthen assessment and audits of water policy implementation to ensure enacted policies are thoroughly implemented and enforced. Independent organizations need to be engaged to conduct water policy assessments and water audits.

Institutional Reform

The institutions of the PRC water governance should be strengthened to increase integration, consistency, accountability, and capacity. At the national level, intersector coherence should be promoted to enhance effectiveness and efficiencies. As the central government will continue, in the near term, to play a focal role in water affairs governance, it is crucial to promote and prioritize the national integration of water management.

Integrating leadership at the national level. The integration of water affairs does not mean the unification of all departments or ministries with responsibilities on water-related functions. What is necessary is the integration of water planning and oversight functions through systematic information sharing and harmonization of water-related standards and policies to ensure coherent, integrated, and co-decided planning processes and policy documents, and coordinated oversight and control.

Given the emergence of water as a national security issue, water security leadership and water affairs integration will be strengthened at all levels starting at the central level.

(i) **National water security leadership.** A national water security leadership committee may be set up in the framework of the National Security Commission, as proposed by the central government, to establish a coordination mechanism between different departments at the national level. The major functions of the committee will be to formulate overall strategies and master plan for national water security; establish mechanisms to guarantee water security; plan, deploy, and coordinate policies and reforms related to water security; periodically study and assess national water security conditions; and annually prepare working programs and policies.

(ii) **Coordination mechanism.** In addition to establishing a national water security leadership committee, a coordination committee or mechanism may be helpful to strengthen the leadership and integration of water management affairs at the national level. An interdepartmental coordination committee or working mechanism led by a state leader or chaired by the line ministry of water affairs should be created. This committee or mechanism will comprise all relevant departments having water-related responsibilities to allow horizontal cross-sector discussion, negotiation, and agreement regarding all water functions. The role of this committee is to define for each important water function the competent authority and the scope of responsibilities regarding water planning, resource allocation and protection, infrastructure development, and financing.

(iii) **Information sharing mechanism.** Integration is not only translated into the streamlining of ministerial functions, but is also seen in the establishment of coordination and information-sharing mechanisms between departments, as well as improvement of transparency and accountability among responsible officials toward other departments and the public as a whole. The review and clarification of functions and responsibilities for water resources development and water resources protection should be accelerated, as there are many overlapping functions between the Ministry of Ecology and Environment and the Ministry of Water Resources. Initially, particular emphasis should be on the need for more integration, improved coordination, and public disclosure of water environment quality monitoring data and pollution load discharged into water bodies.

Enhancing integrated water resources management. River basin (watershed) integration, urban water affairs integration, and urban–rural integration are the three basic elements of the PRC's integrated water resources management.

(i) **River basin or watershed integration.** A river basin is not only an integrated hydrological unit, it includes important space for human habitat. The water resources of a river cannot be effectively protected or managed without adequate consideration of the entire basin and the need to sustain environmental flows and the ecological health of the water bodies across the whole basin. In the same way, water pollution within a river basin cannot be effectively controlled if it does not consider the pollution generated across the entire basin by all sectors including agriculture, urban, and industry development. Flood control, river sedimentation, and river ecological health require a holistic approach across the entire river basin and are all interlinked.

River basin integration aims at maximizing the benefits for the river basin in ecological, economic, and socio-environmental terms. At present, most river basins are treated in a fragmented way by various sectors associated with water, like energy, water, environment, land, agriculture, industry, and urban development. A carrying capacity-based integrated planning at the basin level can help resolve confusion and conflicts among the sectors, especially between natural resources protection and human development.

Other specific issues on integration that need to be addressed are (a) awareness raising on the benefits of integration, (b) institutional reform to support integration, (c) participatory decision-making, and (d) expansion of the basin commissions.

Basinwide integrated management is still a confusing concept for many decision makers with responsibilities in basin management. The actions needed to be taken to foster integration are also often not clear. It is therefore beneficial that steps be taken to expand the knowledge and promote awareness of integrated basin best management practices based on international experiences. A technical framework and guidance documentation of what exactly is involved in river basin integrated planning and management is useful.

On institutional reform to support integration, the present river basin commissions for the seven big rivers and other smaller rivers are mainly focusing on water supply and flood risk control. They largely ignore water environment protection, human development and control based on carrying capacity of water resources, and the links between land use and water. The decision-making bodies of these commissions are generally composed of government representatives and are short of representatives from the local water users and other related basin stakeholders. These shortcomings are constraining the capacity of these river basin commissions to manage river basins in an integrated manner. It is recommended that the PRC select some pilot basins in which institutional reforms toward more devolution to local water users can be tested. The reform directions should be two-pronged—first, expanding the coverage of the commission's management responsibility beyond water to integrate wider water-impacting aspects in the basin; and second, increasing the participation of decision-making bodies beyond government representatives toward a broader combination of basin stakeholders, local residents, local water users, and individuals.

With regard to participatory decision-making in the river basin governance reform process, participatory committees should be attached to the existing government commissions. These committees will be tasked to draw the involvement of concerned provinces, municipalities, counties, and even water users' representatives. Through such reform, the voices of basin stakeholders would have more chance to be heard and integrated into the decision-making process. A participatory framework for river basin decision-making can facilitate the identification of mutually beneficial solutions that can defuse risks of conflicts at the local level and promote efficiencies for river basin management.

Finally, on the expansion of the basin commissions, new basin commissions integrating the proposed reforms above should be established for other subriver basins especially in the northern region of the PRC, which suffers from water shortages.

(ii) **Urban water affairs integration.** Different public services need to be integrated to optimize water use and improve harmony among different urban water users.

To do this, urban affairs bureaus should be expanded to more cities in the PRC. Urban water affairs integration has already been developed and tested in some pilot cities as an effective way of addressing urban water challenges. The integrated water affairs offices should bundle all water-related activities—e.g., urban flood control, water source protection, water supply and drainage, water conservation, sewage treatment and reuse, groundwater recharge and management, and low-impact development planning—into a single management entity.

Consultative institutions for urban water governance should also become more participatory and attract the involvement of water users and related stakeholders. Efforts will be made to establish urban water affairs consultation mechanisms and instruments. These instruments should aim at involving relevant nongovernment organizations and water users' representatives into the decision-making process by factoring in their views and suggestions.

Integrated planning for urban development is likewise needed. Urban water security and risk management should be taken as top priority in urban planning and construction, as they generally have adverse impacts on rivers and lakes in urban areas. It is proposed that low-impact development planning practices be adopted in urban development to mitigate impacts on water cycling and to increase water security. The serious waterlogging and floods in 2016 in the southern cities of the PRC demonstrated the importance of integrated urban planning.

(iii) **Integrated urban and rural water management.** The interdependence of urban and rural water is becoming more apparent, particularly in dealing with water supply, water quality, and water-related disaster risk management. As part of the urbanization process, it is recommended to expand urban water supply to a wide circle of neighboring communities to fully integrate urban and rural drinking water systems. Effective pollution control of rivers should also consider linking and coordinating both urban and rural pollution discharges. Currently, pollution from rural villages is largely ignored, although, as a whole, it may be significant.

Urbanization is a continuing process in the PRC that is not limited to the migration of farmers into urban areas for jobs. When rural residents have water service standards closer to the standards of urban residents and when rural sanitation infrastructure matches the infrastructure available in urban areas, some displacement of population from rural areas to urban areas is expected to decelerate or even be reversed. Hence, to reach the goal of equity in water affairs, rural residents need to have equal water services with urban residents. Integration of urban and rural water services can help promote rural water welfare.

Supporting integration of other water affairs. Water utility operators need to be more widely integrated. In the wastewater field, a municipal bureau often manages the collection of wastewater, which has little funding to develop the sewers; while the wastewater treatment plant is managed by a CWWTP utility. This may be the main cause why current urban sewer capacity does not match the corresponding CWWTP capacity. The whole water collection and treatment systems need to be integrated into comprehensive wastewater municipal utilities that cover all wastewater services.

Considering that paying for water supply is better accepted than paying for wastewater collection and treatment, it may also be desirable to combine the collection of water tariff and wastewater tariff into a single bill payment. This may trigger the progressive integration of water and wastewater services into a single municipal water utility.

The responsibility of water reservoirs is not only to deliver water to downstream users or to protect against floods and droughts. They also have the responsibility to keep the instream environmental flows at levels compatible with good ecological health of the water bodies. This also means the need for further integration of river water services.

Promoting independent regulators and auditors. At present, there are no independent regulators and/or auditors taking care of water resources use, water pollution control, ecosystem preservation, etc. on behalf of governments. Existing regulators or auditors are parts of governments, and few efforts have been made in terms of their supervision and regulation. It is proposed to reform the regulation institutions to get rid of political interference, particularly in the area of water service supervision and regulation on behalf of users' interests.

Consolidating water service providers. Consolidating water services into one company that takes care of water supply, drainage and collection, and wastewater treatment and recycling is consistent with integrated water governance in urban and rural areas. It is seen to facilitate the provision of better water services to local residents. To be sustainable, these companies should be able to get full cost recovery of the water services they provide; they also need to promote efficiencies to reduce costs. Public finance support for water services (e.g., discounts, rebates, subsidies) can then be gradually decreased.

Water service providers can be selected from markets, and private investors can also be encouraged to join. The regulators or auditors mentioned above should supervise the water services provided by these companies through regular monitoring, assessment, and audit processes.

Strengthening capacity development. An important component of institutional reform is building the capacity and knowledge of water service providers, decision-makers, and users.

(i) **Professional service providers.** For water utilities to function along sound commercial principles, the professionalism of water service operators should be continually strengthened to enhance their capacity to operate independently and, thereby, reduce the demand for public finance contribution (except for initial infrastructure investment). A cadre of water utilities should be appointed based on professional competence and past track record and merits.

(ii) **Systematic planning and decision-making.** Strategies to improve water governance should be based on systematic planning to optimize design and implementation measures. Local and international professional consulting specialists may be engaged to guide planners and decision-makers. Independent auditors may also be contracted to objectively evaluate programs and projects upon completion to identify strengths and weaknesses, and ensure lessons are passed to future project developers. International cooperation can facilitate access to innovative and efficient governance and management techniques, which are not yet available in the PRC but are proven effective elsewhere in comparable situation.

(iii) **Improved public awareness.** Capacity development can start in the classrooms, communities, families, and enterprises through water education courses that would build awareness about water issues and strengthen understanding of water risks and how to mitigate them.

Regulation and Enforcement

To ensure adequate implementation of water management laws and policy, enforcement, supervision, and inspection should be strengthened, particularly in the areas of accountability, monitoring capacity, supervision and oversight, and inspection and auditing. Objectives and targets for water management functions should be set for all levels of water managers and users, with regular control measures to track progress against objectives and to demand corrective actions in relation to set targets. This should be accompanied by incentives in the form of accelerated advancement for strong achievers.

Enforcing water space protection. Water body areas, drinking water source protection areas, soil and water erosion control areas, and floodplains and flood retention areas are the four aquatic ecological spaces in the PRC. These spaces can be secured through clear delineation of boundaries, strict regulation and control, and improved urban planning.

(i) **Clear boundaries and markings.** Water body areas cover the water and land areas that can become flooded at defined recurrence periods. They are wider than riverbeds and banks. For water bodies (rivers, lakes, and riparian areas), protection zones should be clearly defined—including blue lines (potentially inundated zone), green lines (buffer zones), and gray lines (land-use controlled zones)—to prevent land use and urban development from taking hold of the water space with permanent structures.

Drinking water source protection areas cover different zones starting from the inlets of drinking water supply and extending to the river basin boundaries of small basins. Different zones require different levels of protection as well as different levels of signage and representation in land use maps. Labeling and signage for different types of zones should be clarified and systematically enforced in maps and in the fields to promote awareness of the protection objectives. These differences in protection level and labeling requirement are often absent or ignored in many rivers.

In the PRC, drinking water source protection areas are generally clearly defined and visible. However, the other three areas (water bodies, soil and water control areas, and floodplains and flood retention areas) are not clearly marked, leading to many residents and farmers developing illegal activities in these zones. These illegal occupations in many provinces impact on flood risks control, which is another responsibility of the government.

(ii) **Regulation and control.** The various types of water uses permitted in water function zones need to be clearly defined to ensure adequate public awareness. For example, a drinking water source zone should be strictly protected from fisheries, cattle grazing, swimming, pollution disposal, etc. Instream and offshore infrastructure along rivers should be strictly controlled to protect the integrity of river corridors and allow ecological life to develop unhampered. Discharge outlets, ports, sand mining, fishing, and many more need to be tightly managed and controlled.

(iii) **Water space-based urban planning.** Land use plans and urban development plans should clearly integrate the entire water space areas and ensure that no encroachment on any of these areas is allowed under any circumstances

Enforcing water abstraction and usage regulation. In the PRC, water is a public natural resource, which should be managed effectively and fairly by the government. The water regulatory framework establishes water allocation and water use rules, and defines ownership and rights of users for the used resources. However, oversight, supervision, and enforcement are weak. The following measures are recommended to strengthen regulatory oversight and control.

(i) **Integration of water supply and demand.** Based on river basin water resources availability and users' demand, a rational allocation mechanism should be established that takes into account the various sources of available water and their variability. Water sources include sustainable local surface water yield, sustainable groundwater yield, conservation water, reclaimed water, and transferred water. Quality of water from sources and for use should be fully integrated into the water allocation process. In areas where reclaimed water of reasonable quality is available, farmers or industries may not be allowed to claim permits for high-quality fresh surface water or groundwater. In areas that are overexploiting freshwater sources, water conservation should be promoted and enforced including, if needed, some curtailment of water availability for specific water usage.

(ii) **Development of water allocation plans.** For river basins experiencing water shortage, a strengthened riverwide water allocation plan should be developed to mitigate the conflicts between the regions and the users. This is critically required and now being applied in the northern PRC for the 1987 Yellow River Water Allocation Scheme. These water allocation plans, which are legal documents, should be prepared for most other river basins in the country. Such plans need to include some level of flexibility to take into account the future impacts of climate change and other aspects of hydrological variability. They should also be adjusted regularly to take into account emerging new circumstances.

To ensure that water allocation plans are accepted and respected by all water users, participatory discussion and decision-making involving all concerned stakeholders and users at all levels should be supported. Water allocation of surface water should be kept within the total regional water consumption caps defined under the three red lines. Water allocation process within regional caps should be devolved, if possible, to the lowest level of management and end users in accordance with the subsidiarity principle.

(iii) **Monitoring and control of end users' rights for use and discharge.** The responsibility, accountability, and liability of economic operators and owners of water-using facilities with regard to permitted water abstraction and use as well as permitted pollution discharge should be legally strengthened through the introduction of integrated water permits. Under no circumstances should permit be issued to release toxic or hazardous substances into rivers, lakes, or groundwater nor into urban sewers or drains.

Water abstraction permits will only be issued to clearly defined levels and ranges of abstraction volume and regime. This will require continuous self-monitoring and reporting by the operators, in line with conditions established by the authority issuing the permit. It will also allow access to the abstraction point for the control and monitoring of data by the inspector of the permitting authority any time without having to inform or secure the consent of the abstractor. Water abstraction and wastewater discharge, as controlled and approved by the permitting authority, should be self-monitored, reported, and controlled from time to time to ensure continued accuracy.

(iv) **Special focus on agriculture water use.** Agriculture water use corresponds to about 60% of the total national water use and is a major contributor to NPSP as well as groundwater overexploitation. In the future, activities of farmers should be integrated, whenever possible, into a larger entity to simplify water permitting and control. Irrigation water permits should encourage water-saving measures and the use of more efficient irrigation practices while limiting the discharge of pollutants into water bodies.

In the PRC's northern plain, farmers rely heavily on water overdraft to increase grain production. The Ministry of Finance provided CNY6 billion-CNY7 billion to encourage the application of water-saving systems to limit overdraft. The project failed to consider that groundwater overexploitation is an illegal activity and, therefore, should not have been permitted in the first place. It is imperative that government authorities always fully respect the prevailing legal requirements. In this case, the effort could have been oriented to the development of water-saving measures through water reclaiming from urban areas, which could have made the overdraft unnecessary. Overdraft of irrigation water should have been penalized.

(v) **Total water use control.** Based on national water resources availability and the overall socioeconomic demands for water, including ecosystem protection, the PRC has set its overall national total water use cap. Present water use reached 610 billion cubic meters (bcm) in 2014. The total water use should not exceed 670 bcm by 2020 and 700 bcm by 2030.

These overall national total water use caps have been translated into corresponding caps at lower levels across the country. Water managers need to continuously monitor and evaluate how water uses are managed to stay within the caps. When new circumstances develop, for example, in connection with climate change, changes or transfer of some of these caps between regions may be authorized to stay within the overall cap. Transparent and flexible mechanisms should be established to ensure that water uses do not exceed the overall cap.

(vi) **Use of penalties to enforce accountability.** This should be promoted as part of the evaluation mechanism of the effectiveness of administrators in managing water affairs, taking into account objectives and targets documented in water allocation or saving plans, water use permits, and the three red-line caps, and comparing them with monitored data. A natural resources inventory assessment is under preparation, the results of which will impact on the administrators' performance ratings and promotion prospects.

Water management and protection are not only the responsibility of governments; individuals and organizations also need to follow rules and regulations. An important part of efficient water resources management is the identification and penalization of violators and the development of judicial cases. Currently, this dimension of water management is very weak, and it is significantly cheaper for violators to pay fines than to invest and pay for the cost to satisfy the rules of law. Considerably increasing penalties for violators and strengthening enforcement procedures and resources are important factors for improving the water-saving efficiency and water quality of water bodies in the country.

Enforcing pollution discharge regulation. Similar to the water abstraction permit discussed earlier, wastewater discharge permit will only be issued for clearly defined levels and ranges of discharge volume, strength, and regime. The permit will also require regular self-monitoring and reporting by the operators of the list of pollutants, in line with the conditions and calculation methods established by the authority issuing the permit. In addition, the inspector of the permitting authority should be allowed access to the discharge point for control and oversight of the monitored data at any time without having to inform the wastewater discharge operator.

Enforcing environmental flow regulation. Limited availability of water within a river basin requires stronger legal water allocation mechanisms between regions of the basin to avoid potential conflict between water users. As part of this process, environmental flows should be clearly reserved before allocating resources to economic activities, including intrabasin or interbasin water transfers. The government should take full responsibility for preserving the ecosystems and should set environmental flows as priority in water allocation. A water allocation priority hierarchy list will be adopted to prioritize environmental and ecological water use. Scientifically defined environmental and ecological water use should be set just behind domestic water needs before other uses such as industry or agriculture water use.

Enforcing water risk management. The national water security dimensions should be assessed and regularly reviewed to systematically analyze the risk factors and potential hazards, and to develop response strategies adapted to evolving water security risks trends. Such water security risk analysis should not only be developed for big river basins but should also be progressively expanded to medium and smaller rivers. In water-scarce regions, the principle of developing urban water reserves or water-source fields dedicated to emergency response needs to be strengthened together with detailed emergency response plan and guidance.

Reforming asset management. The PRC has already developed numerous waterworks infrastructure in cities and urban areas, which are now facing operational constraints. Many more such infrastructure need to be built in cities and towns in the upcoming 5-year plan. To ensure these assets are being operated efficiently and sustainably, the following recommendations are made.

(i) **Government support for public waterworks.** The PRC government still needs to contribute funding for the development of public water infrastructure, in particular, for the construction or expansion of wastewater management infrastructure in cities and towns, and for the provision of rural towns and villages with safe water supply and sanitation facilities that would lower the differential of water services between urban and rural areas. Many of these infrastructure, like sewerage systems, are traditionally funded at the local level, which explains the sewer deficit observed in many areas.

(ii) **Private sector engagement.** Public finance will have to address many more socioeconomic challenges; hence, the competition for limited financial resources is expected to become more intense. Measures have to be developed to attract the private sector to engage in the water services sector as investor and/or operator of water infrastructure. This may call for adjustments in the water and wastewater tariffs to reflect the true cost of providing water and wastewater services so that private investors are able to recoup their capital investments with a reasonable surplus margin. It is expected that improved cost coverage of water services would also bring efficiency gains that would lower the unit cost.

(iii) **Tariff system reforms.** Most large and medium-sized urban waterworks are operated and maintained by water management institutions and water services providers, which act as water utilities. Operation of these waterworks has been rather poor, while service tariff collections are unable to recover the cost of service provision. The water price demanded from farmers for irrigation is usually just about one-third to one-half of the true cost of water services delivered. For urban areas, water prices are also below costs.

To ensure waterworks infrastructure are operated and maintained sustainably in the future, tariff reforms in water and sanitation services in urban areas and irrigation water in rural areas are required to ensure that collected tariffs adequately cover the marginal cost of providing these services. In developed countries, the cost of wastewater collection and treatment in built-up areas is usually twice to thrice the cost of providing drinking water. In the PRC, the situation is not expected to be radically different. This, therefore, translates to the need to multiply the PRC's water and wastewater tariffs in urban areas by a factor of four compared to current prices.

(iv) **Expansion of water user associations.** Big waterworks and noncost-recovering works like flood control are operated and maintained by government-linked organizations; hence, the costs are usually shared between the central and local budgets. But for small irrigation works, investors have the ownership and costs can be fully recovered from the services supplemented by local government budget. The water user associations (WUAs) will be encouraged to expand in the PRC, managing the farmland-level irrigation services including maintenance of the systems.

Strengthening monitoring and forecasting. Monitoring needs to cover the following components: water quantity, water quality, biodiversity, water use, and discharge.

Water allocation, water use permits, environmental flows, water discharge, and water rights trading all need accurate monitoring and metering for accountability. In the PRC, however, monitoring and metering still lag and do not meet water management requirements. The first phase of the national water resources and pollution monitoring network has been completed, and a second phase is under development. A national groundwater monitoring project covering 20,000 monitoring wells has also been completed. Nevertheless, the demand for further monitoring and metering systems, especially at the local level, remains large and needs to be promptly addressed.

Availability and disclosure of water information are other areas that need strengthening. Information sharing and public access to water-related data are important components for improving water pollution control in the country. As basis for management and supervision of water affairs, information is not limited to data monitoring. Encouraging greater involvement of media, facilitating analyses by nongovernment organizations and specialized independent think tanks, and public reporting are also important mechanisms to promote transparency and accountability in managing water affairs. Access to independent information and monitoring data is also crucial, especially regarding water pollution matters. The Ministry of Ecology and Environment is planning to establish a national-level control system of monitoring stations across the country. A similar constraint also exists for water resources, although hydrological monitoring is already managed vertically between lower and higher levels of government.

Climate change is already impacting water management in the country. To improve climate change mitigation and adaptation in the PRC, improved forecasting of water-related risks is necessary. More advanced forecast modeling systems and tools are needed to support future decision-making. Such systems should, for example, enable the accurate estimation of the demand for strategic water reserves to mitigate extreme drought events.

Public Involvement and Participation

Enhancing information and promoting transparency and accountability. The improvements that have so far been made in the PRC's water systems and network monitoring and metering will need to be accompanied by enhanced information management mechanisms covering data reporting standardization, data exchange, data exploitation, and information and data sharing between administrations as well as between relevant authorities and the public. Information and data will be made publicly available and will encompass a wide range of water-related information, such as water resources and pollution discharge data, water development plans and targets, water sources quality, water space boundaries, and project information with potential adverse water impacts. Various channels for promoting transparency and strengthening accountability in the management of water affairs will be considered including administrative supervision, performance evaluation, media reporting, metering and monitoring, and stakeholder engagement.

Encouraging public participation. Participatory mechanisms are required to strengthen the dialogue between administration, stakeholders, users, and the wider public. Public participation needs to become routine procedures for planning and important decision-making that impacts on water users or the public (such as prices and tariffs). The most important form of participation is the active involvement of stakeholders from the beginning of the decision-making process, including the right to vote during the process, instead of just connecting with them through broadcast or public announcements after a decision has been made. For important stakeholders, they should approve policies and project justifications before implementation.

For rural areas, irrigation and water conservancy project management should be reformed further to improve farmer participation and promote direct management. This is already practiced by WUAs, whereby farmers can build and manage micro or small water conservancy projects supported by multiple economic entities. Areas for further improvement include irrigation management specifications, technical standards formulation, and guidance on efficiency of systems and components. The new social reforms of the PRC initiated by the central government encourage self-governance of communities. For the water sector, it is proposed to expand WUAs in the PRC from small rural irrigation units to urban communities.

Promoting awareness-raising efforts. A national and local water awareness promotion plan is proposed, which can raise knowledge and understanding of the public on water issues and water management matters. Several education programs and awareness-raising efforts are already under way in the PRC, but the fragmented practices need to be integrated and expanded systematically.

Pricing and Marketing Tools

Applying economic instruments. Price signals can be an effective instrument to encourage conservation and savings. The prices of urban water use should be allowed to vary to reflect the scarcity of water and the full costs to deliver the water services to customers. Transparent and fair mechanisms need to be established to set and periodically revise the prices of water to promote conservation, where needed. For reclaimed water in which the cost of treatment may be high (even above the cost of drinking water supply), preferential prices and incentive policies need to be developed and promoted to encourage the use of reclaimed water in the cities and urban areas. For agriculture water prices, consider applying a block tariff system that offers preferential prices for low or rated volume water use and cumulatively progressive prices for water use exceeding the rated volume.

Water-related eco-compensation has been discussed and tested in the PRC in several cities and provinces like Anhui Province, Beijing, Hebei Province, Zhejiang Province, etc. However, no clearly defined rules have been formed or implemented nationwide. It is thereby recommended to strengthen and accelerate the development of policies to push forward the in-depth and expanded application of eco-compensation reflecting equity among various stakeholders or regions.

Mobilizing water markets. Markets have the ability to optimize the allocation of a good or service between potential users based on price, taking into account demand and supply.

(i) **Water trading market.** The establishment of tradable rights for water may be a good mechanism to optimize the allocation of water between competing interested parties and to encourage water use efficiency in areas where water shortage prevails.

In the PRC's northwest region, some water rights trading practices have been piloted such as the water use right transfer from agriculture to industry in the autonomous regions of Inner Mongolia and Ningxia Hui, where total water consumed have reached available caps. Present water trading practices in the PRC do not involve a comprehensive water market, but employ only a single negotiated approach between users intermediated by local governments. The local industries have, in most cases, been encouraged to invest in water-saving irrigation systems in order to obtain access to available water allocation created by the water conservation efforts in agriculture irrigation. A national water market center is currently under operation and is expected to focus on macro level water trading between provinces and big river basins.

(ii) **Discharge permit trading market.** In the PRC, water pollution discharge permits trail behind water use permits. It is expected that issuance of wastewater discharge permits will be expanded across the country to more effectively control water pollution. Once wastewater discharge permits become widespread, it is possible to consider an extension into tradable pollution discharge permits, particularly in sensitive river sections where excessive pollution is difficult to limit and is contributed by a multiplicity of dischargers.

Carbon dioxide emissions trading market has been practiced internationally and can be used as guide. Water discharge market can also be set up in the PRC, and it is proposed that the water use and pollution discharge markets be integrated since water use parallels pollution discharge most of the time.

(iii) **Water infrastructure development market.** The government mostly undertakes water infrastructure building, including investment, construction, and operation and maintenance. In the future, private investors are encouraged to participate in the process through project financing arrangements such as the build–operate–transfer facility, the public–private partnership (PPP) approach, and other modes.

(iv) **Water service market.** Water services comprise revenue-generating and nonrevenue-generating services. For the revenue-generating services, which include water supply and wastewater management services whose costs can be covered by water and wastewater tariffs, it is preferable to establish market mechanisms that allow private investors to develop and/or operate a water service concession during a reasonable time period. This requires the establishment of a water service regulator that can supervise the operators and ensure they are living up to the conditions of the concession and are respecting fairly agreed calculation rules when requiring increase in service tariffs.

Supporting private investment. Considering the aging population of the PRC, more financial resources, especially at the local levels, are likely to get directed to social services for the elderly, thereby constraining the capacity of local governments to support new infrastructure, such as water and wastewater facilities, in which it has so far played a leading role. Hence, efforts should be made to encourage and support private investment.

(i) **Public–private partnership models.** Mobilizing private capital for investment and private expertise for operation of water and wastewater works and river restoration measures is an attractive proposition, which can be developed with the help of PPP models. However, there are still some restrictions in the involvement of the private sector for the development of public utilities. For instance, current regulation does not warrant full cost coverage of delivered services from tariffs. Also, no revenues are considered in river basin restoration or reservoir building. In developing the PPP models, many steps are required, which are accompanied by risks and uncertainties caused by unclear position of the overseeing authority.

(ii) **Operation and maintenance.** Under current rules applied in the PRC, the operation and maintenance (O&M) costs of nonrevenue projects (such as monitoring systems) should be supported by public finance from central and local governments and should likewise be managed by public institutions. The O&M costs should be earmarked in annual public finance budgets. For PPP projects, on the other hand, only revenue-generating projects should be considered. They should be operated and maintained by public institutions or quasi-public enterprises, with costs supported by the fees collected from users and beneficiaries of the delivered services. The operator has the sole responsibility for the surplus or losses generated by the project, based on the public rules established by the overseeing authority.

Therefore, it is proposed to develop an investment reform for PPP models in the water sector and to test the efficiency and practical applicability of these models during the 13th Five-Year Plan period through various pilot projects conducted in more developed cities and irrigation regions.

Monitoring the Strategies and Their Implementation

Progress in achieving the goals and implementing the strategies and their respective measures can be effectively monitored using quantifiable indicators. These monitoring indicators, grouped according to their applicable water security dimension, are presented in Table 48. The targets for 2020 and 2030 consider different levels of and options for development, water conservation, water supply, and wastewater treatment.

Table 48: Quantifiable Indicators and Targets for Water Security Improvement, 2014, 2020, and 2030

Water Security Dimension	Performance Indicators for Monitoring	2014 (base year)	Target	
			2020	2030
Domestic	1. Urban tap water coverage ratio (%)	85.6	90.0	95.0
	2. Ratio of cities with multiple water sources (%)	30.7	45.0	60.0
	3. Ratio of urban–rural drinking water sources satisfying designated standards (%)	72.3	80.0	95.0
	4. Safe and standard rural tap water coverage ratio (%)	74.6	80.0	90.0
	5. Percentage of urban domestic water use metered (%)	...	>85.0	>95.0
Economic	6. Percentage of total water use over maximal control target (%)	90.1	100.0	100.0
	7. Water shortage rate (%)	8.0	5.0	3.0
	8. Water use per CNY10,000 of GDP (m^3)	109.4	84.0	49.0
	9. Farmland irrigation efficiency	0.53	0.55	0.60
	10. Percentage of industrial water use metered (%)	...	>85.0	>95.0
	11. Percentage of irrigation water use metered (%)	...	>70.0	>80.0
Environmental	12. River length ratio of Class III or higher (%)	72.8	70.0	75.0
	13. Ratio of PSP COD discharge over ceiling control limit (%)	191.2	126.0	99.0
	14. Ratio of PSP NH_3-N discharge over ceiling control limit (%)	243.7	121.0	92.0
	15. Industrial wastewater treatment rate (%)	71.4	88.0	100.0
	16. Urban wastewater treatment rate (%)	77.3	85.0	93.0
	17. Rural wastewater collection and treatment rate (%)	10.0	30.0	50.0
	18. Percentage of metered urban and industrial discharges into water bodies (%)	...	>60.0	>90.0
Ecological	19. Ratio of areas with heavy soil and water erosion (%)	10.4	7.0	5.0
	20. Ratio of environmental flows diverted for water supply (%)	3.1	0.6	0
	21. Ratio of overexploited groundwater supply (%)	18.0	7.0	0
	22. Ratio of protected freshwater wetland (%)	47.8	55.0	90.0
	23. Ratio of aquatic ecological space areas over total national territory (%)	10.5	12.0	14.0
	24. Percentage of river length considered ecologically healthy (%)	...	50.0	70.0
	25. Percentage of main river control nodes and provincial river sections monitored (%)	...	80.0	100.0
Disaster Resilience	26. Ratio of GDP loss due to flood (%)	0.4	<0.6	<0.3
	27. Ratio of GDP loss due to drought (%)	0.2	<0.8	<0.5
	28. Ratio of population affected by flood and drought disasters (%)	9.0	6.0	3.0

... = data not available, CNY = yuan, COD = chemical oxygen demand, GDP = gross domestic product, m^3 = cubic meter, NH_3-N = ammonia nitrogen, PSP = point source pollution.

Source: Asian Development Bank. 2016. *People's Republic of China: Country Water Assessment*. Consultant's report. Manila (TA 8715-PRC).

CHAPTER VII
Summary of Key Policy Recommendations on Water Security

Strengthen Water Security Leadership and Coordination

Given the integrated character of water security affairs, several policy measures at the highest level are required to ensure that water security issues are adequately addressed.

Establish national water security leadership and coordination. Water is undeniably vital for the continued advancement of the socioeconomic and ecological civilization development in the People's Republic of China (PRC). Hence, it is recommended to establish a high-level national water security leadership committee headed by a vice premier or a water security leadership structure. This new high-level governance system could be set up as an independent new committee or mechanism. Alternatively, it could be structured as an upgraded form of the existing current State Flood Control and Drought Relief Headquarters. The major functions of the national water security leadership committee will include (i) formulation of the overall strategies and master plan for the PRC's national water security; (ii) establishment of mechanisms guaranteeing water security; (iii) planning, issuance, deployment, and coordination of water security-related policies and reforms; and (iv) regular examination of national water security condition to help guide annual working programs and policies.

Mainstream water security into national socioeconomic security planning process. This requires the establishment of upgraded procedures for systematically incorporating water security assessment, water risk evaluation, mitigation actions, and monitoring requirements into the formulation of socioeconomic development plans such as regional development plan, urban development plan, land use development plan, industrial park development plan, etc. Consequently, this would entail the development of comprehensive water security and risk assessment and the integration of water security impacts and mitigation measures into the approval process of government development plans at all levels.

Formulate national water security plan. The national water security plan should be formulated, issued, and updated periodically under the organization of the State Council or the administrative authority of water management, with the purpose of clearly defining the overarching integrated strategy and action plan for the improvement of national capacity to deal with countrywide water security matters. The security situation should therefore be reviewed regularly and reassessed quantitatively based on the individual key dimension of water security at the national, river basin, and regional levels. It would also define the monitoring framework for the implementation of the national water security plan with clarified responsibilities of actors and clear-cut indicators and targets.

Promote an Integrated Approach to Water Resources Development and Management

Water security improvement in the PRC requires the integration of water policy and actions in multiple dimensions.

Strengthen river basin planning. This requires the development and regular updating of integrated risk-based river basin plans covering all five key dimensions of the water security framework—domestic water security, economic production water security, environmental water security, ecological water security, and resilience to water-related disasters. The plan should be an integrated plan crossing all relevant water administrative or sector boundaries. Given the urgent need to improve water security in all river basins, the plan should include both structural and nonstructural measures and actions. The plan should also include an operational budget that can monitor the implementation of the plan from a water security perspective.

Reinforce integrated river basin management. To support the decision-making process and the implementation of measures specified in the river basin plans, it is recommended to set up in each basin a river basin management commission composed of representatives of local administration (province, cities, and counties) as well as major enterprises, professionals, or individual stakeholders concerned with the basin's water use. The commission should be endowed with a legal status to validate its mandate and responsibilities and to establish its operational mechanisms. It should also be empowered to form technical committees to provide advice on special water security issues faced in each river basin. The core mission of the commission should be to strengthen supervision, transparency, and accountability. It should help improve the mechanisms and procedures for the development, integration, coordination, and approval of the river basin plan. Enhanced procedures should enable public bodies and river basin stakeholders who have an interest in the content of the river basin plan to participate in its development and its approval.

Strengthen monitoring and metering. Water monitoring capacity needs to be improved to strengthen (i) construction of monitoring networks for hydrology, water resources, water environment, aquatic ecology, and water-related disasters; (ii) metering and monitoring of the whole process of water abstraction, use, and drainage; (iii) monitoring of wastewater discharge loads and concentration as well as the water quality of receiving water bodies; and (iv) monitoring of aquatic ecological spaces and the health of the aquatic ecology and ecological services. All water users and pollutant discharge units should have the responsibility to install metering equipment, and to report to the competent authorities any issues or relevant readings. They should also be liable for their deficiencies.

Upgrade the Legal and Regulatory Framework

Applying an integrated approach to water security requires the updating and upgrading of the water-related legal and regulatory framework to ensure that integrative features needed for water security improvement are adequately covered.

Upgrade existing water-related laws and regulations. This concerns essentially the Water Law and the Water Pollution Control Law, both of which need to take into account "water security" and "integrated governance" concepts as well as the integrative nature of water security risk management, which covers water use control management, aquatic ecological space protection and regulation, control of pollutants discharged into water bodies, allocation of water use rights and pollution discharge rights, etc. Along with its rapid economic growth, the PRC is taking a proactive approach to addressing emerging water issues with several new policy frameworks. However, these new initiatives may have some overlaps, duplication, and contradictions with existing regulations and policies, which need to be reviewed and rectified while promoting synergies between them.

Formulate new laws and regulations. The PRC has very comprehensive water laws and regulations, but there is still room for improvement such as to enhance quality and practicality and to address emerging water security issues. Some policy gaps have also been noted; thus, new forms of laws and regulations need to be developed and issued to ensure water security issues and risks are thoroughly and adequately addressed and mitigated. These should include, but are not limited to (i) integrated river basin management law or regulation, (ii) regulation for water resources security assessment in regional development planning, (iii) groundwater management and protection law or regulation, (iv) regulation to promote water saving and conservation, (v) pollution discharge regulation, (vi) water rights and trading regulation, (vii) flood risk management and insurance regulation, and (viii) regulation on eco-compensation for aquatic ecology restoration.

Strengthen enforcement of laws and regulations. Some existing regulations can further be enhanced by filling the gaps, for example, through (i) regulations on aquatic ecological space, which should establish and improve its protection zones; (ii) regulations on permit process and postpermit management for water abstraction, which should rationally determine annual water allocation scheme and annual water abstraction plan and should strengthen metering and monitoring of units for water abstraction, use, consumption, and drainage; (iii) regulations on permit process and postpermit management for wastewater pollution discharge, which should strengthen linkages between pollution discharge permit, pollution discharge standard, and regional eco-environmental functions and water quality; (iv) regulations on environmental flows, which should incorporate environmental flows into objectives; and (v) regulations on human-made risks, which should control the development of urban and industrial areas into high-risk or vulnerable zones, for instance, by imposing strict limitation on development activities in the floodplains or by decreeing no encroachment of river–lake space.

Set Up Red Lines, Criteria, and Checklists for Aquatic Ecological Protection

Clearly delineating aquatic ecological red lines and developing criteria and checklists for the different water protection zones are helpful in monitoring performance and progress of aquatic ecological protection efforts.

Examine eco-hydrological characteristics. Based on the *First National Census for Water*, regular investigation and survey of rivers, lakes, and wetlands should be conducted. Eco-hydrological characteristics of these water bodies should be analyzed alongside historical and surveyed data, including hydrological regime, water resources quantity, water quality, habitats and aquatic organisms, ecological service functions, and their changing processes and influencing factors.

Develop protection objectives and requirements for different zones. Based on a scientific analysis of river basins and regional eco-hydrological characteristics, regional planning should be carried out for river–lake protection. It should also resolutely take into account the rational development and utilization of water resources with the objective of balancing requirements of socioeconomic development and eco-environmental protection.

Define aquatic ecological red lines. Boundaries of aquatic ecological space should be clearly defined and should primarily include river and lake boundaries, protection zones for drinking water sources, key prevention areas of soil and water erosion, and floodplains and flood retention areas. These boundaries should be documented on maps to be made available in all administrative levels of government as guides for future land and economic development.

Establish criteria and checklists for different river basins and zones. For different river basins and zones with diverse eco-hydrological characteristics, protection objectives, and requirements, criteria should be established and documented, particularly in the form of river basin report cards. The report cards can use specific sets of indicators and indexes on different water and ecological dimensions, and can serve as a decision-making or communication tool.

Implement Better Eco-Environmental Protection and Restoration Measures

To secure the functioning of water-related ecological services, a robust program of aquatic ecological restoration in water bodies is required.

Set up aquatic ecosystem database. In view of the worsening aquatic ecosystems, representative samples of varied aquatic ecosystems need to be protected and secured. These samples will be used for establishing base references and genetic materials in restoring degraded habitats. Currently available aquatic ecosystems data are fragmented and not readily accessible to administrative authorities who have the mandate to oversee aquatic ecological protection. Establishing an aquatic ecosystems database and information system is fundamental to enhancing ecosystem services for the public good, and to reverse excessive use of or damage to them.

Implement eco-environmental protection and restoration. Based on surveys on ecological dynamics of inland water systems, both basinwide and on a regional basis, there is a need to develop an environmental and ecological restoration action plan at the national level, in each river basin, and at the local level of every river and lake. The action plan should include river health assessment (river health report card), costs of measures for restoration and rehabilitation, ecological monitoring, and sources of funding for implementation.

Strengthen water pollution control. To balance socioeconomic development with water environmental carrying capacity, main pollutants discharged into water bodies should be strictly controlled within the specified pollution discharge thresholds. These thresholds need to be strengthened to ensure that they are compatible with the water quality standards of water function zones. To maintain the ecological function of water bodies, current point source pollutant discharge in water bodies should be reduced by half, while nonpoint source pollutant discharge should be reduced by about 40%. These pollution reduction goals should be realized through the promotion of clean water actions such as the enforcement of pretreatment of industrial wastewater and the issuance of water abstraction and pollution discharge permits.

Improve Water Infrastructure Upgrade, Construction, and Management

To improve public water services, expanded and modernized water infrastructure networks and their regulatory management system are necessary—especially for water resources deployment and distribution, water resources protection and monitoring, flood and waterlogging control, stormwater drainage, urban and rural water supply, and wastewater collection and treatment.

Strengthen research on security standards for water infrastructure. Upgrading of the design standards of water infrastructure should be based on scientific assessments. Research should focus on new aspects of water-related security such as water resources variability, socioeconomic development (including the ongoing restructuring toward green economy), climate change adaptation, and risk resilience for improved water security.

Upgrade and modernize existing water infrastructure. Water networks, like the water supply distribution and sewerage systems in urban areas or the water supply and sanitation facilities in rural areas, are insufficient to reach the more needy and vulnerable groups of people. Existing water infrastructure needs to be upgraded according to the following modernization requirements: complete functions, perfect system, coordinated standards, high-quality facilities, easy control, effective operation, and long-term benefits. Eco-efficient infrastructure should be actively promoted to minimize the potential adverse impacts on water eco-environment.

Strengthen the operation and maintenance of water infrastructure. To improve the management of water infrastructure networks, it is recommended to develop systems that can enhance operational management, planning, or emergency response. There is an equal need for digital water conservancy through the application of information and communication technology in infrastructure such as in monitoring stations, data centers, telecommunication, decision support systems, etc. Through institutional reforms and mechanism setup, the development of adequate tools and systems for the efficient and sustainable operation, maintenance, and management of all water infrastructure should be established, with secured funding at all levels.

Improve Water Demand Management and Water Conservation

General Approaches to Water Demand Management

The objective of water demand management is to control current demand and the continuous growth of demand through hardware application and regulation of water-use behavior.

Utilize hardware application for water conservation. The hardware application approach involves the following:

(i) **Water conservation.** Enhance water conservation during the whole course of water development mainly through water abstraction, conveyance and distribution, and water use with more efficient hardware. Residential water-saving measures include the installation of code-compliant devices such as low-flow showerheads, low-volume toilets, and water-saving dishwashers. Commercial and public water-saving initiatives promote the use of water-efficient toilets, urinals, faucet aerators, and commercial washing machines. Industry water-saving measures encourage the employment of recycling and efficient cooling systems, and include the enforcement of a labeling system of water-efficient devices.

(ii) **Agriculture (irrigation) water saving.** This includes canal seepage control, pipeline water delivery, efficient irrigation methods, and adoption of an artificial intelligence-supported irrigation management.

(iii) **Leakage control.** This should be strengthened in both urban water systems and irrigation networks.

(iv) **Water metering.** Metering urban water services for homes, businesses, industries, and agriculture should be proactively promoted to get accurate estimation of water supplied and sold.

(v) **Information and communication technology application.** Mobile phones and the internet are being widely used in the PRC. These and other applications of information and communication technology can be utilized to manage water demand at local levels.

Regulate water-use behavior. The behavioral regulation approach includes the following:

(i) **Water pricing.** It is necessary to formulate water tariffs to cover the full cost of water services while providing appropriate price signals to all users to encourage wise use of water. Tariffs should not only be for urban water but also for rural and irrigation water. Special tariffs should also be charged for groundwater exploitation and use.

(ii) **Incentives.** Different types of financial incentives can be employed to encourage the efficient use of water. These include discounts, rebates, subsidies for using water-efficient devices, free disposal of old fixtures, and others. Special tax incentives for installing water-efficient equipment are recommended for the industry sector.

Water Conservation

Water conservation efforts should be promoted in the following areas:

Agriculture water conservation. Water conservation in agriculture can be improved by upgrading the large and medium-sized irrigation systems in the main grain production areas into modern irrigation systems. These systems should be equipped with water-saving devices like sprinklers, drip or micro sprinklers, together with high-quality canal lining. Cultivation of drought-resistant and high-yield crop varieties, improvement of rainfed irrigation, and adoption of conservation tillage method are equally encouraged.

Industry water conservation. Water savings can be achieved in industries through a combination of behavioral changes; modification and/or updating of outdated machinery with water-saving equipment such as for cooling and thermal processes; and application of the three R's (reduce, reuse, and recycle) of resource conservation. Major benefits may be achieved from truly rethinking the entire urban water, carbon, and energy systems. This approach can be a crucial part in the establishment of a circular economy, wherein water and material loops are closed.

Urban water conservation. Measures for urban water conservation should prioritize (i) the application of efficiency codes for water-using devices—i.e., all water-using devices manufactured, imported, and sold in the PRC should meet strict water and energy efficiency standards; (ii) the promotion of residential water conservation through subsidies for the installation of code-compliant devices and through other types of financial incentives such as discounts, rebates, and subsidies paid for the cost of replacement; (iii) the promotion of commercial and public water conservation; (iv) the implementation of leakage control program; and (v) the regulation of water pricing. As mentioned earlier, designing water tariffs that fully cover the cost of water services and deliver appropriate price signals to promote high water-use efficiency is equally important.

Regional water conservation. There are significant disparities in per capita water availability and use among the regions. Although conservation measures to reduce water demand are generally well established, they often require societal or economic incentives to implement. To avoid overlaps and duplication and improve synergies among subsectors, water demand can be optimized, integrated, and coordinated among different users and uses in each region.

The strategy considers the availability, demand, and development stages that are unique to each region in the PRC. The recommended strategic actions by region are given in Table 49.

(i) **Northeast.** The PRC's northeast region is utilizing 70% of its available freshwater resources. In addition, it is overexploiting its groundwater resources and diverting water away from needed environmental and ecological flows. The region still faces eminent water shortages.

(ii) **North.** Water security within the northern PRC has national economic significance. This is because the region is critical to the country's grain production and national food security. The region has a developed economy and a dense population. Its per capita gross domestic product (GDP) is higher than the national average, while per capita water resources in the region is far less than the national average. Like in the northeast region, the northern PRC has been severely overexploiting its water resources, especially groundwater, and also diverting water critical for instream environmental flows. Home to the Beijing–Tianjin–Hebei region, the northern PRC's economy and population are expected to grow briskly.

(iii) **Southeast Coast.** The region is strategically positioned for shipping, trade, and export manufacturing. It is heavily populated and is experiencing water shortages because of scarce resources, water pollution, and deficient infrastructure. The current rate of urbanization in the southeast coast is higher than the national average, and its per capita GDP is greater than the national average (by over 30%).

(iv) **Central.** The central region of the PRC hosts the country's main grain production. Its per capita GDP is nearly a quarter lower than the national average. Only 20% of the region's abundant available water resources are exploited.

(v) **Southwest.** Located in the upper reaches of the Yangtze and Pearl river systems, the southwest region of the PRC enjoys abundant water resources, making it a natural reservoir for the country; however, it lacks large reservoirs. The economy is underdeveloped and urbanization rate is low, but the region is expected to begin developing quickly. Water utilization is relatively low, with per capita water supply of just a little over 300 m^3 per year.

(vi) **Northwest.** The PRC's northwest region faces a challenging and fragile future. The region is economically underdeveloped and is also short on available water resources. Water exploitation is unbalanced and excessive, characterized by severe groundwater overextraction and diversion of water needed for eco-environmental flows. The national government's "develop-the-west" strategy is expected to expedite development of the region's key economic zones and energy bases.

Table 49: Strategic Actions for Water Conservation by Region

Region	Strategic Action
Northeast	• Develop high-efficiency, water-saving irrigation to ensure national grain security and correct supply–demand imbalances that are evident in the rate water resources are being abstracted and used. • Fully utilize water transfer and interregional water connectivity projects to secure water for cities and industries. • Enhance the protection of wetlands and return diverted ecological water. • Control soil and water losses in the region's fertile plains. • Restore wetlands through reconnected rivers and lakes. • Improve resilience to flood hazards in Heilong River, Liao River, and Nen River.
North	• Develop high-efficiency water-saving measures in all sectors. • Increase the availability of surface water supply by developing water transfer systems and reservoirs. • Enhance the use of nonconventional water sources such as reclaimed, brackish, or desalinated water. • Restore instream ecological flows by returning diverted flows and reducing groundwater overexploitation. • Increase resilience to flood hazards in the Hai River Basin with new river infrastructure and improved flood retention.
Southeast Coast	• Reinforce the management of wastewater discharge to improve the quality of the water environment, especially in the Yangtze River Delta and the Pearl River Delta. • Develop water transfer and storage projects, improve the interconnectivity of water bodies, and develop nonconventional water sources. • Restore and protect aquatic ecological areas. • Strengthen infrastructure in the estuaries and develop seawalls to mitigate flood and storm surge hazards.
Central	• Construct large and medium-sized reservoirs to retain water resources for future water demands. • Reinforce medium, small, and micro-sized water projects to enhance the security of water supply in impoverished mountainous areas. • Develop urban contingency water sources. • Strengthen flood control embankments in weak sections of the Yangtze River and in major tributaries, while continuing to build infrastructure for Dongting Lake and Poyang Lake.
Southwest	• Develop water transfer infrastructure as well as large and medium-sized reservoirs. • Enhance the protection of the sources of key rivers and some high plateau lakes, and minimize soil and water losses and rock desertification areas. • Mitigate the impacts of hydropower development on the aquatic ecology. • Strengthen flood risk infrastructure of medium and small-sized rivers and rivers in mountainous areas.
Northwest	• Adjust its water utilization rate to the carrying capacity of its water resources by reducing some overexploited irrigation areas and transitioning to high-efficiency, water-saving agriculture. • Develop regional infrastructure for water reallocation to reduce groundwater overexploitation, and provide water for key economic zones and energy bases. • Protect key water resource conservation areas, and restore the Heihe, Shiyang, and Tarim river basins. • Strengthen monitoring, provide early warning systems for flash floods in mountain areas, and improve flood control.

Source: Asian Development Bank.

Mobilize Market and Economic Instruments

There are several market and economic instruments that suit water users and operators for the allocation of water resources and for maximizing benefits. The following instruments are appropriate in the PRC.

Conduct tax reform on water resources fee and establish water rights trading market. To encourage the sustainable use of water resources in the face of water scarcity, it is recommended to (i) improve the system of pay-per-use of water resources and promote progressive tax or tariff rate for excess use, (ii) incorporate water resources fee into the tax system, and (iii) establish reliable water price formation mechanisms to promote water conservation. Water resources tax reform is particularly important and recommended in the water-scarce region of the northern PRC, where serious groundwater overexploitation exists. It is also recommended to explore the possibility of water rights and trading market in watersheds and areas experiencing water shortage to optimize water allocation and defuse risks of water conflicts.

Conduct reform on pollution discharge permit and establish pollution discharge rights trading market. The pollution discharge permit system should be reformed, making it an effective solution for supervision and regulation on pollution discharge from fixed sources: (i) establish correlation between water abstraction permit and pollution discharge permit, (ii) formulate and enforce the *Management Regulation on Pollution Discharge Permit* and the *Administrative Measures on Pollution Discharge Permit License,* (iii) strengthen design and realize effective linkage among point source management systems through the pollution discharge permit system, (iv) widen pollution permit coverage and scope, (v) embed information and communication system, (vi) establish relationship between pollution discharge and regional water environmental quality, and (vii) strengthen effective regulation of postpermit management. It is recommended to promote the establishment of pollution discharge rights trading system.

Establish watershed eco-compensation mechanism. Taking watershed as a unit, interregional horizontal aquatic eco-compensation mechanisms should be promoted with priority on economic and eco-environmental coordination between upstream and downstream areas. The mechanism will include eco-compensation for key ecological function areas, river source areas, drinking water sources, sensitive river sections, aquatic ecological rehabilitation areas, soil and water conservation areas, and transboundary cross sections.

Improve water-related infrastructure and operation market. It is recommended to promote (i) the public–private partnership models to attract social investment for the development and operation of water infrastructure that are generating revenues through water tariff; (ii) the development of operation and management market and the establishment of water service enterprises for water conservation, wastewater management, water supply, project maintenance, and river–lake management; and (iii) the implementation of contract management on water conservation and wastewater treatment to attract social investment.

Enhance Transparency and Public Participation

Transparency and public involvement and participation are crucial elements for improving water security in the PRC.

Enhance transparency. Transparency can help improve policy enforcement by allowing people to understand and act on recommended positive changes. The following aspects need to be strengthened through appropriate legal or regulatory frameworks: (i) public platform to aquatic eco-environmental information covering water resources quantity and quality, pollution discharge, and aquatic ecological changes; and (ii) public access to water affairs information covering water usage, costs and tariff, water allocation, water services, and water-related decisions.

Encourage public participation. Proper water governance requires active participation of stakeholders. Besides public access to water information, effective water governance also needs (i) public involvement and public participation in planning and decision-making (e.g., public hearing and public scrutiny systems for urban water pricing, water allocation, and environmental impact assessment; and active participation of farmer representatives and water user associations in irrigation and water conservancy projects); (ii) access to public defenders in judicial proceeding linked to water issues; and (iii) public participation in public interest litigation on water resources protection.

Implement accountability. The accountability of administration at every level (regarding implementation of plans and their achievement or shortcoming) needs to be strengthened. Performance should be checked periodically against regulation targets for the control of water abstraction, use, and consumption; control of pollution effluents and discharges in water bodies; regulation and restoration of aquatic ecological space; environmental flows guarantee; natural asset management of water resources; water-carrying capacity; water security risks; etc. Corrective actions should be defined and enforced when performance falls behind targets.

Promote awareness building and education. Knowledge about water conservation, water issues, and their interrelation, as well as water eco-environmental protection should be promoted among the wider public through primary and secondary education, civil servants training, vocational education, and informal education. Awareness building should make use of all available media, including modern multimedia channels and other gadget applications.

Promote Research and Development of Innovative Solutions

Strengthen research on fundamental theory and technology. The scientific research on water security needs to be strengthened, including fundamental theories and advanced technology on water resources, water environment, aquatic ecology, rivers and lakes conservation principles, water resources deployment and distribution, ecological regulation, water security assessment, and accounting methods.

Promote application of new technology. Application and dissemination of new technologies, new materials, and new processes should be promoted. Water conservation and the development of water-saving technologies for urban, industry, or agriculture water use should be encouraged through policy and action plans. The new ideas and innovations need to be recognized and piloted for possible practical implications.

CHAPTER VIII
Opportunities for Cooperation between the Asian Development Bank and the People's Republic of China

The challenges and recommended strategies described in the previous chapters provide many opportunities for cooperation between the Asian Development Bank (ADB) and the People's Republic of China (PRC). The long-standing collaboration between ADB and the PRC has made remarkable progress in the past in improving water security; however, there is still a long way to go to resolve such a large-scale water security problem in the PRC. The report illustrates some emerging water challenges in the PRC that may benefit from the ADB–PRC cooperation. Implementing the new policies and strategies of the PRC requires a translation into concrete projects, and ADB can provide support for the development and implementation of these projects. ADB can also play a role in realizing the aspiration of the PRC to support other countries in developing their water resources, for example, in the framework of achieving their water-related targets under the Sustainable Development Goals (SDGs).

Country Partnership Strategy

ADB's current country partnership strategy (CPS) for 2016–2020 recognizes that ADB's relationship with the PRC has evolved into a full partnership.[34] The PRC has long been an important client, collaborator, and contributor to ADB not only in terms of lending but also in the area of knowledge enhancement and sharing such as in policy research, capacity development, innovation and value addition, and development experiences. Moreover, the PRC is collaborating with ADB in jointly supporting the South–South knowledge cooperation.

The agriculture and natural resources sector, including water, has always been in the forefront of the ADB–PRC collaboration during the last 3 decades, as highlighted by the recent report published by ADB.[35] The report discusses the water-related investment in the PRC by ADB, which grew from 5% of total investment during 1986–1991 to about 45% during 2013–2017. The report also illustrates the fact that the global and regional environments are changing fast along with ambitious targets by the PRC for modernization by the middle of the 21st century. Such development, including in the water sector, may require ADB and the PRC to work together to ensure that their partnership remains responsive to the evolving needs.

Projects and programs addressing regional public goods, climate change, urbanization, regional cooperation and integration, inclusive growth, and environmental management have been the

[34] ADB. 2016. *Country Partnership Strategy: People's Republic of China, 2016–2020—Transforming Partnership*. Manila.

[35] R. F. Wihtol. 2018. *A Partnership Transformed: Three Decades of Cooperation between the Asian Development Bank and the People's Republic of China in Support of Reform and Opening Up*. Manila: ADB.

priorities of ADB in its engagement with the PRC. Along with the disclosure of ADB's 2030 strategy,[36] ADB and the PRC government will continue seeking potential areas of meaningful cooperation and effective investment modalities. Among the potential areas of cooperation between ADB and the PRC government could be, but are not limited to, managing climate change and the environment, promoting regional cooperation and integration, fostering knowledge cooperation, and supporting institutional and governance reform. In particular, ADB could focus on operations that will produce regional benefits, such as achieving greenhouse gas emission commitments ahead of the 2030 target; piloting projects to reduce air, water, and soil pollution; and promoting emerging renewable technologies such as solar power and carbon capture and storage. These strategic priorities are aligned with the PRC's 13th Five-Year Plan (2016–2020), ADB's Strategy 2030, and ADB's approach to supporting upper middle-income countries.

Through many projects jointly carried out in the PRC, ADB has gained significant insights and learned valuable lessons. Such tacit knowledge may be of interest and significant value for other ADB developing member countries. ADB has been exploring knowledge partnerships with the PRC's centers of excellence to expand joint studies and mutual learning experiences between the PRC and other countries. ADB can continue leveraging know-how and lessons learned from the PRC to the other countries and regions.

To help the government achieve improved water security, ADB can provide support for integrated water resources management and sustainable land management, including strengthening water security, water governance, and water pollution control; improving forestry management and water-related disaster risk management; and promoting innovative eco-compensation mechanisms, water environmental regulation and compliance, and other market-based instruments to support environmental protection and pollution control.

The private sector could play a larger role in the sustainable development of the PRC, with focus on private sector-led solutions to water and environmental problems and climate change. Knowledge solutions are at the center of ADB's operation in the PRC, and ADB can introduce innovative ideas into actual projects and programs for implementation, support transformative and demonstration projects and programs for replication and scaling-up in the PRC and other developing member countries, and promote good governance and institutional reforms along with the five key dimensions of water security discussed in the previous chapters: domestic water security, economic production water security, environmental water security, ecological water security, and resilience to water-related disasters.

Support for the Development Priorities of the People's Republic of China

Particular attention can be given to support the PRC in implementing their new and innovative policies described in Chapter III and elsewhere in the document. These include, among others, the development of the Yangtze River Economic Belt (YREB), the rural vitalization strategy, and the development of the Beijing–Tianjin–Hebei region.

[36] ADB. 2018. *Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific.* Manila. https://www.adb.org/sites/default/files/institutional-document/435391/strategy-2030-main-document.pdf.

Yangtze River Economic Belt

The government formulated the YREB Development Plan for 2016–2030,[37] which stipulates the prioritization of ecological protection and promotion of green development as the guiding principle for the YREB development.[38] In this connection, ADB and the PRC government have agreed to adopt a framework approach, providing about $2.0 billion worth of funding to the YREB during 2018–2020 to strategically program ADB's lending support for development initiatives in the YREB with priority given to the following areas: (i) ecosystem restoration, environmental protection, and water resources management; (ii) green and inclusive industrial transformation; (iii) construction of an integrated multimodal transport corridor; and (iv) institutional strengthening and policy reform.[39]

The red lines policies (on water resources and on ecology) are currently being prioritized in the YREB, which will guide project development in the coming years. Also, the river chief system will be promoted to improve governance in water management. ADB is supporting the application of the river chief system for ecological protection in the YREB.[40] The aim is to improve river health monitoring and supervision in Chishui River, a major tributary of the upper Yangtze River. ADB has been providing several other nonlending support to improve the water resources management, including flood forecasting and early warning system in the region. ADB, through its lending support instrument, has also assisted the PRC in piloting and demonstrating the sponge city program in the YREB. ADB is equally engaging in policy dialogues with the PRC government to bring the water challenge upfront and provide necessary assistance through both lending and nonlending operations.

Rural Vitalization Program

The PRC, in general, is now facing a contradiction between unbalanced and inadequate development. The government has prioritized rural vitalization by modernizing its agriculture and rural areas. E-commerce has the potential of transforming and upgrading rural life, but its application has encountered some major obstacles.[41] Small watersheds in the PRC, where majority of the rural populations reside, have lower standards of flood protection and poor water quality due to the lack of waste management, poor soil and water conservation, and inability of standards to keep pace with the rate of development. The use of high-level technologies, including information and communication technology, to support the agriculture value chain, resources management, and related service systems is immense in rural vitalization plans. But many rural residents need further business and technical education to be able to fully harness the opportunities brought by rural vitalization and advanced technologies.

To promote agriculture and rural development in view of the emerging need for implementing a rural vitalization strategy in the PRC, the National Development and Reform Commission and the Ministry of Finance have signed a memorandum of understanding (MOU) with ADB on 29 August 2018 (footnote 39). The MOU prioritizes several areas of potential cooperation, which include

[37] Government of the People's Republic of China. 2016. *Outline of the Yangtze River Economic Belt Development Plan, 2016–2030*. Beijing.

[38] Green development aims to (i) change the traditional development model to a sustainable development model, (ii) address the challenges of rapid urbanization, and (iii) serve as a guide to socioeconomic development.

[39] ADB. 2018. ADB President Visits the People's Republic of China, Reaffirms Partnership. News release. 29 August. https://www.adb.org/news/adb-president-visits-peoples-republic-china-reaffirms-partnership..

[40] ADB. 2017. *Technical Assistance to the People's Republic of China for Supporting the Application of River Chief System for Ecological Protection in Yangtze River Economic Belt*. Manila.

[41] ADB. 2018. *Internet Plus Agriculture: A New Engine for Rural Economic Growth in the People's Republic of China*. Manila.

(i) integrated urban-rural development, (ii) improvement of public service provision in the rural areas, (iii) management of solid waste and wastewater in rural areas as a priority in building ecologically-friendly and livable rural villages, and (iv) capacity development of local governments in relation to water sector development in the PRC. The MOU anticipates an assistance package amounting to $6 billion from ADB and other development partners, which will support the implementation of the rural vitalization strategy from 2018 to 2022.

ADB has supported a variety of water-related projects in the PRC. These projects have improved access to clean water, reduced water pollution, strengthened wastewater management, promoted pilot water-saving irrigation technology, and improved structural and nonstructural aspects of flood management in different regions of the PRC. ADB has also supported the protection and restoration of key river basins and wetlands such as the Baiyangdian Lake, Chao Lake, Dongjiang Lake, Hai River Basin, Sanjiang Plain, and Songhua River Basin. Along with emerging issues and challenges associated with different drivers of change, innovative solutions need to be embedded in the investments. The $6 billion rural vitalization assistance package, for example, will include innovations to improving agriculture productivity through more efficient water use and proposals to improving water quality by waste water treatment, solid waste management, and better agriculture practices.

Beijing–Tianjin–Hebei Region

The city-cluster government approach has been pivotal in the ADB–PRC cooperation, particularly in Beijing–Tianjin–Hebei Region.[42] This approach is essential to overcome challenges in governance, mainly in relation to planning, investments, and management of connectivity infrastructure. The PRC government has already completed strategy and investment plans for 11 of its city clusters and is finalizing the remaining plans in 2019. The ADB–PRC cooperation in city clusters focuses on creating synergies and encouraging cooperation across administrative boundaries aimed at supporting economic, urban, and infrastructure development, as well as social inclusion, open space, and environmental protection and management.

Other Potential Areas of Cooperation

Coping with Climate Change

The PRC has recognized the impacts of climate change as a big threat and considers itself as among the countries most vulnerable to the adverse impacts of climate change. The PRC government has adopted short- and medium-term goals for limiting emissions as well as for adopting and formulating wide-ranging policies, strategies, and plans that contribute to meeting the goal of combating climate change and its impacts. The PRC will continue collaborating with and getting support from global communities to achieve this goal and, at the same time, exchanging know-how and lessons learned with other regions. ADB can support the government in implementing the "Intended Nationally Determined Contributions" through its Climate Change Strategic Framework, which was agreed at the United Nations Framework Convention on Climate Change Conference of the Parties 21 in Paris in December 2015. Water and energy as well as climate change adaptation are key priorities in the agreement.

[42] ADB. 2018. No reason for city clusters not to succeed - Stephen Groff and Stefan Rau. Op-Ed and Opinion. 2 May. https://www.adb.org/news/op-ed/no-reason-city-clusters-not-succeed-stephen-groff-and-stefan-rau.

Meeting the Sustainable Development Goals

The PRC government has made a commitment of implementing the 2030 sustainable development agenda; it seeks solidarity and cooperation to constantly push the cause of global development. The SDGs not only include improvements in sanitation and drinking water quality, but also address how water is managed and governed, covering access to basic water and sanitation services, water resources management, and pollution and wastewater management. While water as a public and regional good matters at the local, regional, basin, and global levels, the PRC's national mechanisms and present institutional setup will not suffice to deliver this commitment. Unlike other sectors, its water sector is still fragmented and falls under the responsibility of different ministries and departments. Protecting or preserving water as part of the ecosystem and environmental management is a shared responsibility among different ministries. Yet, there is lack of coordination among these line ministries due to the absence of an overall national coordination body. In 2018, the PRC went through a massive institutional reform, but this reform will take some time to be effective as some new ministries still lack full capacity to carry out their mandates. The PRC will benefit from international experiences on integrated water resources management at river basin scale and on enhancing water governance, where the role of ADB as a development partner will be critical.

Strengthening Integrated River Basin Management

Provinces and municipalities in large river basins, such as the Yangtze River Basin, have paid attention to environmental protection with emphasis on accountability system. However, water and environmental conservation should first be integrated into institutional, policy, and sector levels through integrated planning. Such integration will also address the spatial differences between basins and regions, upstream and downstream, rural and urban, and the left and right banks of the rivers. In other words, there is a need for spatial, functional, and organizational integration. The PRC government is promoting its "one river one policy," but fragmented and uncoordinated development planning in different sections of the river basins by individual local governments has resulted in poor application of such policy. The function and role of the river basin authority in integrated river basin management, including transprovincial water and environmental management with proper monitoring and evaluation mechanisms, need to be reinforced rather than undermined to avoid any potential fragmentation with individual subbasins. ADB can extend its support to the PRC on water governance, covering the different dimensions such as legislation, policy, institutions, regulation and enforcement of policies, stakeholder participation, and water pricing and marketing.

Managing Water-Related Disaster Risk

An important lesson learned from the recent 2016 and 2017 flood events is that the majority of the flood damages did not come from the main stem rivers but from small- to medium-sized river subbasins. Rapid urbanization of small cities and towns in these subbasins has triggered flash flood and landslide disasters, which, in the past, were not regarded as among the government's priorities. Learning from these flood events, the Ministry of Water Resources issued the National Flash Flood Disaster Prevention Plan (2017–2020) in December 2017, which prioritizes the nationwide disaster risk mitigation from flash floods. This plan is still to be improved and implemented nationwide incorporating the most advanced knowledge, experiences, and best practices. Recently, ADB introduced a framework approach that embraces the nexus between flood, environment, and ecological risks and realizes the gains to be captured from cross-sector synergies. In addition, ADB has introduced a new practice, whereby any project with a potential imprint on flood risk and the environment should undertake an assessment to determine those impacts for which it is accountable.[43] This know-how will be helpful in the implementation of the national plans.

Supporting Eco-Compensation Mechanism

Eco-compensation is a policy that the PRC government has been developing as it explores options for ensuring the country's environmentally and socially sustainable development. The central government decided in 2010 to regulate eco-compensation at the national level but focusing on ecological function areas, including the YREB, in limited development zones. In this context, eco-compensation will function as a means to more equitably distribute the benefits of overall national economic growth to the country's rural, poorer areas. To realize this, there is a need for (i) appropriately determining the eco-compensation rate; (ii) reforming the existing tax regime to support and provide incentives for ecosystem conservation as well as pollution control; (iii) establishing an eco-compensation arbitration system; (iv) understanding the upstream–downstream relationships and actual needs of the beneficiaries; (v) strengthening the supervision, monitoring, and evaluation mechanisms that might otherwise lead to inefficient use of funds; (vi) undertaking independent third-party monitoring of eco-compensation programs; (vii) clarifying property rights; and (viii) incorporating measures designed to ensure that eco-compensation supports poverty alleviation. ADB has long been engaged to support the PRC government in implementing eco-compensation through both lending and nonlending operations.

Promoting Regional Development and Integration

At present, ADB's support in water sector development and management in the PRC focuses more on the YREB. The water resources issues and conditions as well as the demands for water vary widely from region to region in the PRC. Therefore, ADB and the PRC government can discuss widening the scope of ADB support to other regions depending on the need for value additions from ADB. In the northeast region, the PRC needs to prioritize improvement of water supply security, ecological security, and resilience to flood hazards, particularly in the Heilong, Liao, Nen, and Songhua rivers. In the northern region, the PRC will focus on employing high efficiency water-saving measures, developing nonconventional water sources, reducing groundwater exploitation, and prioritizing flood risk management in the Hai River Basin. In the central region, the government will invest more on constructing water storage to meet the rapidly increasing water demand, strengthening flood risk management in the Yangtze River Basin, and building infrastructure in Dongting and Poyang lakes. In the southeast coast regions, priority will be given to developing nonconventional water resources, strengthening flood risk management, and improving waste management, particularly in the Yangtze River Delta and Pearl River Delta. In the southwest region, the government will build more water storage infrastructure, promote soil and water conservation including rocky desertification, support hydropower generation, and strengthen flood risk management in medium- and small-sized rivers. In the northwest region, priority will be on high-efficiency irrigation and water-saving agriculture, control of groundwater exploitation, water resources conservation, and flood risk management, mainly in Heihe, Shiyang, and Tarim river basins. The water security problems are equally challenging in all regions and river basins in the PRC, such as the Yellow River Basin and the Hai River Basin, which means ADB and the PRC government can expand the areas of cooperation in other river basins and regions, learning lessons from the YREB.

[43] R. Osti. 2018. Integrating Flood and Environmental Risk Management: Principles and Practices. *ADB East Asia Working Paper Series*. No. 15. Manila: ADB.

Improving Environmental and Ecological Water Security

The most critical water security issues in the PRC relate to environmental water security and ecological water security. In terms of these two water security dimensions, provinces like Gansu, Hebei, Henan, Shaanxi, and Shanxi, together with the autonomous regions of Inner Mongolia and Xinjiang Uygur, are considered poor performers. An important initiative for improving the PRC's water security is more investment to control point source pollution (PSP) from cities, county towns, and the industry sector. This requires strengthening of the regulatory framework for integrated water use and wastewater discharge permit system and other similar tools, as well as the enforcement of regulatory frameworks. While the priority should be given to addressing PSP, similar effort is also required for reducing nonpoint source pollution, especially those pollutants coming from animal husbandry and from farms' overapplication of fertilizers and pesticides. Ecological security can be improved through programs and plans for ecological restoration, including soil and water conservation; strengthening of water-based biodiversity, which includes ecosystem rehabilitation by protecting ecological space and reducing groundwater overexploitation; maintaining environmental flows; and enhancing effective monitoring and evaluation systems with measurable ecological health indicators.

The 14th Five-Year Plan (2021–2025) and Beyond

The PRC government is now formulating its 14th Five-Year Plan. As with the previous plan, ADB can continue supporting the PRC in the formulation of its new plan. The outputs of the country water assessment study, as examined in this report, will inform the PRC in the preparation of its development plan, which seeks to overcome the middle-income trap and achieve more inclusive and sustainable development. The analysis and recommendations provided in this report include a background analysis of the PRC's current and future water development and challenges, and its linkages to its socioeconomic structure, growth potential, and internal and external forces that are likely to drive changes in the next 5 years. ADB's knowledge contribution toward the PRC's preparation of the new plan will be made not only through this report but also through many other recent, ongoing, and planned knowledge work by ADB. Therefore, ADB and the PRC will identify potential areas for collaboration, particularly aiming at different projects and programs such as addressing regional public goods, climate change, urbanization, regional cooperation and integration, and environmental management.

Managing Water Resources for Sustainable Socioeconomic Development

A Country Water Assessment for the People's Republic of China

This study provides an overview of the water security situation in the People's Republic of China. It assesses the policy and institutional requirements for addressing issues and recommends strategic areas for strengthening and reform. The five dimensions of water security covered in the research are domestic water security, economic production water security, environmental water security, ecological water security, and resilience to water-related disasters. A summary of key policy recommendations identifies the essential measures needed to effectively move forward the alleviation of water security issues in different time frames.

About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 67 members—48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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