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KEY POINTS

- A water security assessment identified water scarcity, water-related disaster risks and ecological degradation as the main challenges in the Yellow River basin.
- Strengthening institutional capacity and coordination mechanisms to manage water security challenges in the basin can be accomplished through the implementation of the Yellow River Protection Law and by strengthening the management role of the Yellow River Conservancy Commission.
- The natural capital and climate-resilient approach that underpins the Asian Development Bank's Yellow River Ecological Corridor Program facilitates interagency coordination, upstream–downstream cooperation, and high-quality green development in the basin.

Achieving Water Security in the Yellow River Basin

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SUMMARY

The Yellow River basin in the People's Republic of China (PRC) extends across the country's east, central, and west regions, traversing seven provinces and two autonomous regions. The basin provides an important ecological corridor across semiarid and arid landscapes, which connect headwaters on the Qinghai–Tibet Autonomous Region Plateau to the downstream floodplain and river delta. The basin hosts globally significant biodiversity hot spots, serving as a habitat not only for migratory birds but also for over 150 threatened species. Agriculture, energy production, industry, tourism, and natural resources all depend on water. Water is also the primary medium through which the impacts of climate change are felt. Water-related disasters triggered by floods and droughts put communities, businesses, and service providers at risk. The Ministry of Water Resources approved the Plan for Guaranteeing Water Security for Ecological Protection and High-Quality Development of the Yellow River Basin in May 2022. The plan will be implemented by the Yellow River Conservancy Commission (YRCC). In addition to the plan, the Yellow River Protection Law, adopted in October 2022, promotes a comprehensive approach to protecting the environment and water resources, preventing water-related disasters, and promoting green development. The Asian Development Bank (ADB) provided technical assistance to the YRCC in conducting a water security assessment. The study adopted and adapted the methodology developed through the Asian Water Development Outlook (2020), assessing the five key dimensions (KDs) of water security for the first time in the Yellow River basin.[1] The main issues are water shortage, flooding, excessive soil erosion, high loads of sedimentation, water pollution,

Notes:
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In this publication, "$" refers to United States dollar and "CNY" refers to yuan.
ADB recognizes "China" as the People's Republic of China.

[1] ADB. 2020. *Asian Water Development Outlook 2020: Advancing Water Security across Asia and the Pacific*. Manila.

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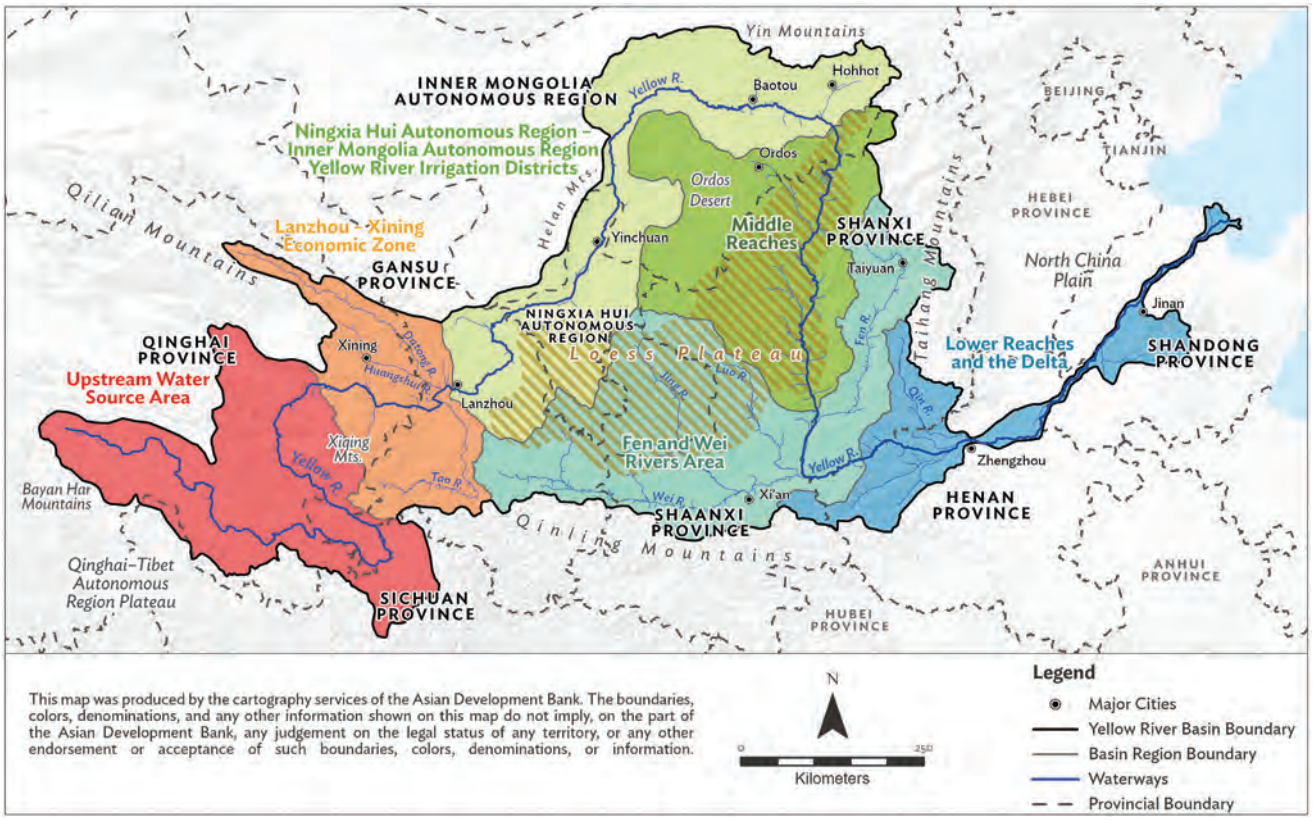
Figure: Regional Divisions of the Yellow River Basin



Source: Asian Development Bank.

environmental degradation, and climate change. Proposed interventions for a more water-secure Yellow River basin include the following measures: (i) building a more efficient water system and improving capacity to address the shortage of water resources and the imbalance in its regional distribution; (ii) optimizing water utilization methods; (iii) strengthening ecological protection and restoration; (iv) improving the water quality of rivers and lakes; and (v) preventing water-related disasters, including floods and droughts. Enabling conditions to promote an integrated source-to-sea management approach in the basin include policies and legislation, strengthened institutions and coordination, improved management instruments, and a strengthened coordination role of the YRCC.

OVERVIEW OF THE YELLOW RIVER BASIN

Geography

The Yellow River is 5,464 kilometers long and is the second-largest river in the PRC from its headwaters on the Tibetan Plateau to its estuaries on the Yellow Sea. It flows through seven provinces and two autonomous regions: Qinghai Province, Sichuan Province, Gansu Province, Shanxi Province, Shaanxi Province, Henan Province, Shandong Province, Ningxia Hui Autonomous Region, and Inner Mongolia Autonomous Region. About 120 million people live in the basin, and more than 420 million people living in the provinces and regions depend on the Yellow River's water to sustain their livelihoods. The gross regional product of the basin amounted to CNY23.9 trillion, or $3.3 billion, which equals 26.5% of the 2018 national gross domestic product (GDP).[2] With about 2% of the country's water resources, the Yellow River supplies drinking water for 12% of the country's population, 15% of the arable land, and 26.5% of the water supply for other economic activities.

Based on its geographic and socioeconomic characteristics, the methodology underpinning the brief divides the Yellow River basin into six regions (Figure):

- The **Upstream Water Source Area** is a sparsely populated and economically less-developed region, comprising degraded ecosystems in need of ecological protection, where the ecological space is seriously encroached, and natural wetlands have shrunk by nearly 50%. Qinghai, Sichuan, and Gansu are partially located in this area.

[2] Z. Zhang et al. 2021. Eco-Economic Coordination Analysis of the Yellow River Basin in China: Insights from Major Function-Oriented Zoning. *Sustainability*. 13, 5: 2,715.

- The **Lanzhou–Xining Economic Zone** is a key urban and economic development area but is constrained by water availability. Qinghai and Sichuan provinces are partially located in this area.
- The **Ningxia Hui Autonomous Region–Inner Mongolia Autonomous Region** Irrigation Area is characterized by desertification. This hinders important agricultural development, especially grain production.
- The **Middle Reaches** is a region subject to high rates of riverbank and hillside soil erosion. It is less developed, but important for energy production. Shaanxi and Shanxi are partially located in this region.
- The **Fen and Wei Rivers Area** is the most developed and densely populated area of the basin, where coal and grain production are predominant. Production in this area contributes 46% of the basin's GDP and 38% of its area is irrigated.[3] Shanxi and Henan are partially located in this area.
- The **Lower Reaches and the Delta** are characterized by high population density, grain and cotton production, and oil industry. It suffers from high sediment loads, very low river flows, and shrinking wetlands due to water diversion projects. Henan and Shandong are partially located in this region.

In addition to the six regions, the Loess Plateau characterizes large parts of the basin's central regions (Figure).[4] It covers an area of roughly 400,000 square kilometers and is the largest deposit of loess in the world, originating thousands of kilometers away on the steppes of Central Asia. The Loess Plateau has been cultivated and logged extensively for centuries, causing increasing desertification and soil erosion. The Loess Plateau contributes 90% of the sediment load of 1.6 billion metric tons per year of the Yellow River, the highest river sediment load in the world.[5]

A WATER SECURITY ASSESSMENT OF THE YELLOW RIVER BASIN

ADB has analyzed the most pressing water security challenges across the five KDs defined by ADB's *Asian Water Development Outlook 2020*.[6] The Asian Water Development Outlook defines water security as the availability of an adequate quantity and quality of water to ensure safe, affordable, equitable, and inclusive water supply and sanitation, along with sustainable livelihoods, healthy ecosystems, and manageable water-related risks. The five KDs used in the Yellow River assessment have been adjusted to address context-specific challenges:

Key Dimension 1: Water Supply Security

Availability of water resources per capita and the capacity of the water system to regulate the water resources and provide public water supply service.

The basin has an annual average precipitation of 446 millimeters, which is approximately 40% less than that in the Yangtze River basin and approximately 70% less compared to the national average. Water resources which are unevenly distributed to the river are characterized by great interannual and seasonal variation. Water availability per capita is 473 cubic meters per year (m^3/year). This is only 15% of the national average, well below the water scarcity threshold of 1,000 m^3/year, and below the 500 m^3/year, which is considered as absolute water scarcity.[7] Despite the introduction of an integrated water regulation in 1999, the ecological flow in the Yellow River is still low, and several tributaries in the middle reaches of the Yellow River have experienced zero flow, causing damage to the ecological functioning of the basin.[8] This is mainly the result of overuse of surface water and shallow groundwater in the basin. Water resources development and utilization in the basin have long exceeded its sustainable levels. The current water supply is insufficient to cover the increasing demands, and the water allocation across provinces needs to be improved.

Key Dimension 2: Economic Water Security

Capacity and efficiency of the water system to support economic activities in the basin, such as agricultural and industrial production.

The Yellow River has supported the basin's rapid development for centuries despite being extremely water scarce. Water consumption for $10,000 worth of GDP in the Yellow River basin is 449 m^3, which is 214 m^3 higher than the average in high-income countries. Agricultural use accounts for 70% of total water use, partly due to inefficient irrigation practices and low water productivity. Both energy and industrial water consumption keep growing. Promoting more economically efficient water use is essential to sustain food, energy, and ecological security. The unequal spatial balance in water availability and the different levels of socioeconomic development of the provinces also results in significant differences in the economic water security of the provinces. The energy sector in the basin's middle reaches relies on natural resources including land, coal, natural gas, solar power, and wind. Energy-related industries use large amounts of water, resulting in low economic water security upstream. Downstream provinces use water more efficiently.

[3] ADB consultant's report. Unpublished. Data provided by the Yellow River Conservancy Commission.
[4] Taking its name from loess, the term for deposits of fine-grained, yellowish soil.
[5] C. Shi, Z. Dian, and L. You. 2002. Changes in Sediment Yield of the Yellow River Basin of China during the Holocene. *Geomorphology*. 46 (3–4). pp.267–283.
[6] Footnote 1.
[7] Food and Agriculture Organization of the United Nations. Water Scarcity. https://www.fao.org/land-water/water/water-scarcity/en/.
[8] Based on the Unified Water Flow Regulation Agreement of 1987, which regulates a cross-provincial, quota-based water allocation scheme, and enforced in 1999.

Key Dimension 3: Ecological Water Security

Ecological health of the water system and its ability to provide ecosystem services, including water and soil conservation.

Ecological health in the basin is at risk. The upstream water source area and the Qilian mountains in the upper reaches of the Yellow River are fragile alpine and arid ecosystems, highly prone to degradation. This region is affected by climate change with shrinking glaciers, melting permafrost, and disappearing grasslands. The areas in the upper and middle reaches, especially in the Loess Plateau region, suffer from severe soil erosion. The annual average sediment inflow has gradually decreased since the early 2000s due to water and soil conservation measures, including the "Grain-for-Green" program in the Loess Plateau, one of the first and largest eco-compensation programs in the PRC. However, large-scale coal mining in the center of the Loess Plateau has caused additional major ecological and environmental issues. The low reaches and the estuary face low ecological flows with shrinking natural wetlands in the delta and biodiversity loss. The ecological protection of rivers and lakes is under increasing pressure. The use of Yellow River water resources for human and economic uses has decreased ecological security in the river channel and threatened the health of the river.

Key Dimension 4: Environmental Water Security

Chemical quality of surface water and groundwater and the capacity of the system to treat domestic and industrial wastewater as well as agricultural nonpoint source pollution.

Increased prevention and treatment of sewage, industrial effluents, and agricultural runoff has reduced water pollution over the last decades. However, in the cities and key development zones along the mainstream and tributaries, pollution often exceeds the carrying capacity of the river. Water quality in Huangshui River, Wei River, Fen River, and Jing River, for instance, do not meet the Environmental Quality Standards for Surface Water formulated by the Ministry of Ecology and Environment. In 2019, only 62.1% of sewage from urban areas and towns was collected and treated. Less than 20% of wastewater was reused for other purposes (i.e., irrigation). Around 50% of surface water in the basin does not meet drinking water quality standards. Although, since 2018, surface water quality has improved by 5.2% (with the proportion of level V water—the worst water quality category—decreasing), water pollution is still severe, especially in the middle reaches.[9] Paper and coal industries around the Huangshui, Wei, and Fen rivers are still a major source of pollution. Agricultural pollution is accelerating environmental degradation in the Fen Wei plain and Inner Mongolia Autonomous Region irrigation areas.

Key Dimension 5: Water-Related Disaster Security

Capacity of the system to deal with floods and droughts.

Historically, one of the most severe threats to water security in the basin has been river flooding. Flood risks are exacerbated by severe soil erosion in the Loess Plateau and the resulting high sediment accumulation in the middle and lower reaches. As the sediment deposits accumulate, the riverbed has risen above the surrounding areas, resulting in the 800-kilometer-long phenomenon of the so-called "suspended river."[10] To reduce the threats from flooding to residents, particularly in the middle and lower reaches, flood control infrastructure was constructed, including banks, reservoirs, and water diversion systems. Since the mid-19th century, the lower reaches of the river and the delta have been extensively engineered to control flooding and to protect coastal development. Despite these efforts and the development of the sponge cities to reduce fast urban runoff, flooding remains a major challenge.[11] Besides river flooding, torrential rainfall-induced flooding is a growing risk in urban areas. The 2021 flash floods in Henan's city of Zhengzhou are a more recent example, where insufficient drainage and extreme precipitation (a year's worth of rain falling in 3 days) led to major inundation and damage. Droughts occasionally occur, exacerbating water scarcity in the basin. The low flow period from the 1970s to 1990s caused major droughts in the basin with zero flow in the downstream reaches. Around 30%–40% of the reduction in runoff in the Yellow River basin can be attributed to climate change.[12] Resolving the imbalance between water supply and demand under a changing climate has become a major challenge.

Assessing the Overall Water Security in the Yellow River Basin

Water security in the Yellow River basin was calculated by averaging the scores of five KDs for each of the nine provinces and autonomous regions. The scores are presented in Table.[13] A color-coding system highlights the relative scores from red (worse) to dark green (best) among the provinces for each KD, and for overall water security in the entire basin. The provinces and autonomous regions are listed from upstream (Qinghai) to downstream (Shandong).

Table shows that the basin performs comparatively weakly in water supply security (KD1), ecological water security (KD3), and water-related disaster security (KD5). The poor performance

[9] Z. Dong. 2020. Greening the Yellow River for a Beautiful China. *China Water Risk*. 19 March.

[10] This includes highly sedimented river sections, such as the riverbed of the Yellow River in Xinxiang City, and in Kaifeng City, which stand 20 and 13 meters above the surrounding terrain, respectively.

[11] The concept of a "sponge city" originates from the PRC's efforts to address its urban water management issues, especially frequent and severe flooding. A sponge city aims to mimic the natural water absorption capabilities of a sponge, effectively managing and utilizing rainfall and stormwater within the urban environment to reduce flooding risks, recharge groundwater, improve water quality, and enhance overall urban resilience.

[12] United Nations Framework Convention on Climate Change. 2018. The People's Republic China Third National Communication on Climate Change.

[13] Eighteen indicators were scored at a scale of 1 to 100, with the upper scale indicating a perfect situation. The scores of each KD were determined by calculating the average of the indicator scores.

Table: Scores of the Yellow River Basin in Five Key Dimensions by Province/Autonomous Region

PROVINCE OR AUTONOMOUS REGION	KD1	KD2	KD3	KD4	KD5	YR WS
Qinghai	86.5	67.1	81.5	81.8	75.1	78.4
Sichuan	82.3	58.8	87.1	78.5	77.1	76.8
Gansu	64.8	64.1	72.3	82.1	63.6	69.4
Ningxia Hui	64.7	75.6	71.9	77.8	69.4	71.9
Inner Mongolia	67.0	80.0	68.3	78.9	69.2	72.7
Shaanxi	63.5	90.2	64.8	66.8	75.9	72.2
Shanxi	62.8	82.8	65.0	65.1	75.1	70.1
Henan	69.0	95.3	70.9	74.7	72.3	76.4
Shandong	66.8	98.0	69.9	73.1	75.6	76.7
Entire basin	69.7	79.1	72.4	75.4	72.2	73.8

>80 75–80 70–75 <70

KD = key dimension, YR WS = Yellow River basin water security.

Note: The provinces and autonomous regions are ordered from upstream to downstream.

Source: Asian Development Bank estimates.

of KD1 is mainly caused by water scarcity, especially in Shaanxi Province and Shanxi Province. The weak performance of KD3 is caused by the poor water and soil conservation in the same provinces. KD5 is performing comparatively weakly because of drought in the middle-reach provinces and floods downstream. The table shows also that the upstream provinces score comparatively well in all KDs except KD2. The low score in KD2 in these provinces is due to the low efficiency of water use for industrial activities. The middle-reach provinces Shaanxi and Shanxi also score low in KD4 because of poor water quality. Overall, the provinces Gansu and Shanxi have the lowest water security. The KD assessment supports the formulation of interventions at KD level, but these interventions need coordination with interventions in other dimensions of water security simultaneously. The next section will give an overview of recommended interventions by KD with a regional focus.

PLANNING FOR A MORE WATER-SECURE YELLOW RIVER BASIN

In response to the increasing water security challenges, the PRC's 14th Five-Year Plan (2021–2025) sets out a national water security plan.[14] Jointly released by the National Development and Reform Commission and the Ministry of Water Resources in January 2022, the plan aims to significantly enhance national water security through four main goals: (i) improving the ability to prevent floods and droughts, (ii) enhancing the ability to conserve water resources, (iii) improving water resources and optimizing allocation capacity, and (iv) strengthening the ecological protection and governance of large rivers and lakes. In line with the national plan, the Ministry of Water Resources issued the "Plan for Guaranteeing Water Security for Ecological Protection and High-Quality Development of the Yellow River Basin." The plan aims to improve the basin's management, including water conservation, and disaster risk management, through an integrated approach and effective coordination among local governments by 2030. The plan also prioritizes environmental protection over economic growth and suggests that the industrial development plan by local governments should be based on the available water resources in the basin rather than the other way around. Water resources management strategies and interventions should be tailored to each region's challenges and characteristics.

Ningxia Hui–Inner Mongolia Autonomous Irrigation Region

The focus of water management in this area should be on improving agricultural activities and promoting efficient utilization of the water resources. This includes the rehabilitation and modernization or transformation of the large and medium-sized irrigation areas and promotion of crop varieties applicable to the water supply conditions. The water pricing mechanism should be reformed, and advanced irrigation quota allocation should be likewise introduced. The water and sediment regulation system should be improved, among others, by construction works in the Heishanxia River, to prevent the development of new suspended rivers in this area. Diversified strategies for modernization works and promotion of water markets should be explored in the Qingfongixa irrigation areas.

[14] Government of the PRC. 2021. Outline of the 14th Five-Year Plan (2021–2025).

KD1: Water Supply Security

The suggested approach aims to increase water supply security. The focus should be on upgrading the water supply system capacity, incentivizing the development of water storage, groundwater aquifer recharge, and regional water resources allocation projects. A demand-based solution could be to recycle water resources and incentivize wastewater reuse. Reducing water leakages by upgrading or replacing old pipe networks is another key measure to improve the efficiency of urban and rural water supply and services.

Lanzhou–Xining Economic Zone

In this region, the focus should be on planning of urban and economic development activities in accordinance with water availability. The economic development for the Lanzhou–Xining and Lanzhou–Baiyin urban clusters should be accompanied by a poverty alleviation program. Water-saving programs should be strengthened, including the restriction of industrial development with high water consumption, and regulating agricultural water consumption. Proposed projects could include diverting water from Datong River to the Huangshui River and the Qinwangchuan basin. Environmental management should be strengthened.

KD2: Economic Water Security

The suggested approach aims to increase economic water security and promote a more efficient and economical utilization of the water resources in the basin. The focus should be on improving irrigation efficiency through modernizing large-scale irrigation, construction of improved farming systems, and building modern irrigation facilities with high water-saving efficiency. Promoting cropping patterns that are applicable to water supply conditions should be accompanied by measures to reform the water-right system. The current water allocation system introduced in 1987 should be revised to include international best practices for water resources allocation, as well as water markets.

KD3: Ecological Water Security

The approach would increase ecological water security and ecological restoration. In the upper reaches, the focus would be on strengthening water source conservation by developing natural restoration and ecological restoration projects; protecting the forest ecosystem in the northern foot of Qinling Mountains; and promoting afforestation and restoration of natural vegetation, with the goal of developing water conservation forests. In the middle reaches, implementing anti-erosion measures, restoring degraded lands in mining areas, and constructing sediment-retaining projects would strengthen prevention and control of water and soil loss in the Loess Plateau. In the lower reaches, the focus should be on using landscape planning through ecosystem development and connectivity, enhancing hydraulic conditions to enable ecological flows, converting croplands to wetlands, and limiting the use of herbicides and pesticides to reduce nutrient loads in the floodplains.

Upstream Water Source Area

The focus of water management in this area should be on ecological protection and water conservation. Specific areas are the river source regions, mainly the Qilian mountains; the Gannan river watershed; and lakes including Gyaring Lake, Ngoring Lake, Maqu River, as well as the rivers and lakes in Maduo county; and the snow mountains and glaciers. Economic activities, including irrigated agriculture, should be scaled down, supported by the introduction of an eco-compensation mechanism.

KD4: Environmental Water Security

The approach suggested aims to increase the environmental water security of rivers and lakes. First, monitoring and early-warning systems should be applied to control the environmental carrying capacity in the basin and take adequate measures to protect drinking water sources. Point source pollution (including domestic and industrial pollution) should be controlled by increasing the sewage treatment capacity and water reuse facilities. Agricultural nonpoint source pollution should be controlled by reducing the use of chemical pesticides, fertilizers, and herbicides, promoting sustainable agricultural practices. Alternative livelihood opportunities would be created through the implementation of eco-compensation and water quality trading.

Fen and Wei Rivers Area

In this region, it is important that planning of economic activities follow a water–food–energy nexus approach. Management and protection of the ecological environment should be strengthened through improving the carrying capacity of water resources in densely populated and economically important areas. Industries with high water consumption should be restricted or incentivized with advanced water-saving technologies. Transformation of irrigation practices and use of efficient energy-saving irrigation technologies should also be promoted. Water allocation can be optimized by diverting water from the Hanjiang River to the Wei River, and from the Yellow River to Wanjiazhai reservoir. Minimum ecological flows for rivers and lakes would need to be enforced and a management plan should be developed to prevent the overabstraction of groundwater.

KD5: Water-Related Disaster Security

The approach proposed aims to increase water-related disaster security and improve integrated flood control management and drought prevention. For this dimension, flood risks can be mitigated by building flood retention areas in the delta, constructing ecological embankments, and floodplain management works in the lower reaches. Flood risk management should be strengthened through upgrading flood monitoring and early-warning systems, as well as drought monitoring and prevention. Managing water and sediment flows would also optimize water-sediment regulation.

Lower Reaches with Irrigation Areas and the Delta

The focus of water management in this area should be on flood control and restoring ecological conditions. Flood mitigation works require coordinated water and sedimentation management in the river channels and the floodplains, such as stabilization of the current flow path of the Diaokou River. To better manage river channels and protect downstream areas from flood risks, land use changes including urban settlements in the floodplains should be reduced. Ecological conditions should be improved by strengthening the protection and rehabilitation of the river and wetlands in the estuary, including providing ecological water flows in the river and into the sea.

INSTITUTIONS AND GOVERNANCE MECHANISMS FOR RIVER BASIN MANAGEMENT

Institutional Framework: The Yellow River Conservancy Commission and the "Three Yellow Rivers"

The diverse institutional and governance setting of sector ministries and provincial governments can make effective water governance challenging. At present, dozens of institutions across the basin manage water resources. The central government is responsible for setting policies, national plans, and regulations for improving water quality and efficiency. Provinces and regions along the Yellow River oversee the development and implementation of their own environmental protection, water conservation, flood prevention, and disaster reduction plans. Cities, counties, and townships are tasked with the implementation of national and provincial policies. One of the most notable institutions in the basin is the YRCC. Established in 1946, the commission is mandated to enforce the water laws and related water acts on behalf of the Ministry of Water Resources. Over time, the role of the YRCC has expanded to include managing water allocation in the entire basin and environmental water management. The YRCC prepares and implements the water basin development plan, resolves interprovincial disputes, develops and implements river basin master plans, and carries out flood control by managing and constructing hydraulic projects (including dams and embankment) along the Yellow River. It monitors and controls soil erosion in the Loess Plateau to protect the water quality of the main river stream and formulates guidelines for the conservation of the river–lake system and coastline. Over the years, the YRCC made great progress in balancing water management with socioeconomic development and ecological protection through the so-called "Three Yellow Rivers" approach, which brings together science, technology, and infrastructure approaches explained as follows:

- **The Digital Yellow River: The Yellow River Central Regulation Center.** Functioning as an information and centralized decision-making center, the digital system provides hydrological monitoring and forecasting using geographic information system-related applications, such as satellite imagery and remote sensing. Collecting rainfall, soil moisture, water level, flow volume, reservoir storage, and water quality data, the system can inform water demand management. This includes the water allocation scheme and the water use plan on an annual and monthly basis. The center is also used as a remote-control system for managing and monitoring water flows, including dams and reservoirs, drainage and sluice gates, and diversion canals. Based on the collection and analysis of data, the system develops scenarios to prevent low flow and river depletion, balance water uses between upstream and downstream and the two riverbanks of the river, improve water security for agriculture and industrial purposes, ecological restoration of wetlands and floodplains, and groundwater recharge.
- **Scaled Model: The Yellow River Hydraulic Laboratory.** The scaled model reproduces the river channel, dams, and reservoirs, Loess Plateau, and delta estuaries, and it is used for hydraulic research. Experiments include soil and water conservation, reservoir design and operations, flood control and disaster mitigation, river training works, and sediment management. An 800-meter-long model of the river channel was built to represent the 480 kilometers of the lower Yellow River downstream. Soil erosion simulations are also provided to improve soil erosion monitoring at the Loess Plateau. In addition, the laboratory uses a drought monitoring and flow forecasting meteorological satellite system to predict water runoff patterns. Through the laboratory, the YRCC conducts extensive research on hydrology and sediment transport and simulates water and sediment regulation in the river to manage floods more effectively.
- **Physical Yellow River: The Yellow River Infrastructure.** The YRCC is also responsible for monitoring and operating infrastructure along the Yellow River, including the standardized embankments, river works, the Xiaolangdi dam, the flood detention basin, water supply projects, irrigation districts, water diversion projects, floodplain wetlands, and the ecological corridor.

Enablers for Integrated Water Resources Management in the Yellow River Basin

While the PRC is one of the most dynamic countries in terms of policy formulation and incentives for natural resources management, three key difficulties remain: (i) the implementation of policies and enforcement of regulations, (ii) the duplication of mechanisms and planning among provinces, and (iii) the fragmented mandates among central and local agencies. Such challenges require an integrated approach, upstream–downstream coordination, and a balance between economic development and ecological protection. Integrated water resources management can directly address the linkages between land, water, delta, estuary, coast, nearshore, and ocean ecosystems leading to holistic natural resources management and green development in the basin. It can promote governance and finance mechanisms to strengthen collaboration and coherence in the basin, improving water security. The implementation of the Yellow River Protection Law and the strengthened role of the YRCC can enable upstream and downstream environmental, social, and economic linkages, and stimulate coordination across sectors and agencies.

The Yellow River Protection Law. Strengthening ecological protection and promoting high-quality development are the

building blocks of the Yellow River Protection Law.[15] The law, effective from April 2023, is expected to strongly support the development of a coordinated river basin management system. Geographically, the law covers all county administrative regions within the seven provinces and two autonomous regions within the basin area, including the main streams, tributaries, and lakes. It emphasizes the need to improve all aspects of water security in the basin. The law also focuses on developing adequate water allocation plans to regulate different uses with a reform of the water rights and the establishment of a water quota system. In terms of law enforcement, a promising policy approach is the river and lake chief system.[16] Such a system promotes stronger engagement by local governments for protection and management of rivers and lakes by appointing local officers as river chiefs. Among the responsibilities of the river chiefs are water resources protection, river shoreline management, water pollution prevention, water environment governance, water ecology restoration, and law enforcement supervision. While promoting local ownership and responsibilities, the river chief system also faces challenges of fragmented management across river chiefs on various levels, inconsistent standards, and possible conflicts of interests. A study on how to refine their organizational setup should be carried out to identify policy gaps for comprehensive governance, management, and cooperation of transboundary rivers and lakes and their surrounding land areas. Such analysis should lead to multisector cooperation, responsibility sharing, information sharing, problem consultation, and collaboration on water resources management.

A Strengthened Role of the Yellow River Conservancy Commission. Despite its central role in managing and protecting the entire river basin, the position of the YRCC as the central institution under the Ministry of Water Resources was weakened by overlapping roles of other ministries, such as the Ministry of Ecology and Environment, especially for the ecological protection of the river basin.[17] Supported by the Yellow River Protection Law, the YRCC can take on a stronger role in harmonizing water resources management in the basin, from policy to planning, and provide a backstopping point for local governments that require technical and management guidance for actual implementation in their own jurisdictions. The State Council will establish a "Coordination Mechanism" (Article 4 of the Yellow River Protection Law) to provide overall guidance, cross-regional, and cross-sector coordination among different levels of governments and agencies. On the one hand, all provinces and autonomous regions in the basin are encouraged to set up their own provincial coordination mechanisms. The YRCC is also expected to coordinate the activities of the provinces and autonomous regions to ensure that an integrated water resources and river basin approach is adopted.

A Natural Capital and Climate-Resilient Approach for the Yellow River Basin

ADB is supporting the Government of the PRC to strengthen the sustainable management of natural capital through the Yellow River Ecological Corridor (YREC) program. Established in 2020, the YREC adopts a comprehensive ecosystem-based management approach for water resources and land management by considering the river basin as an ecological corridor.[18] The program is currently under implementation in collaboration with the YRCC, Ministry of Ecology and Environment, Ministry of Agriculture and Rural Affairs, Ministry of Water Resources, National Development and Reform Commission, National Forest and Grassland Administration, the nine provinces and autonomous regions in the Yellow River basin, local governments including Qixia and Changhzi city governments, and local academic institutes including the Chinese Academy of Science. The YREC builds on three key principles: (i) protect the basin's fragile ecological environment, (ii) address the severe condition of the water resources and natural capital (balancing use and preservation), and (iii) promote high-quality green development and sustainable livelihoods. The YREC includes a program of lending, non-lending, and policy interventions across four main thematic areas: (i) natural resources management and biodiversity conservation, (ii) climate-resilient and sustainable smart agriculture, (iii) climate change mitigation and adaptation, and (iv) integrated urban–rural green development. Adaptation and resilience play a key role in reducing exposure and vulnerability to climate change. The PRC's Ministry of Ecology and Environment drafted the National Strategy for Climate Adaptation 2035. The strategy will strengthen policy coordination, improve governance mechanisms for decision-making processes, advance knowledge and tools for climate impact analysis risk assessment, and promote adoption of nature-based solutions. Implementing national adaptation targets in the Yellow River basin is listed as a government priority under the PRC's national strategy. ADB is currently supporting the Ministry of Ecology and Environment in developing an adaptation plan for the Yellow River basin to operationalize the national strategy.

CONCLUSION

The PRC has formulated various policies and initiatives to promote water security and resilience in the Yellow River basin. The Yellow River Protection Law reflects national ambitions to achieve a balanced and sustainable economy while preserving its natural resources under a changing climate. To ensure effective implementation, a more prominent leadership role of the YRCC is needed to enable interagency cooperation among

[15] It was adopted at the 37th Meeting of the Standing Committee of the Thirteen National People's Congress in October 2022.
[16] The river and lake chief system is a river and lake management and protection system in the PRC that aims to manage local government leadership on water resources. D. Shen. 2020. The River and Lake Chief System. *Global Issues in Water Policy* Volume 26. 22 November.
[17] S. Jia and D. Li. 2021. Evolution of Water Governance in China. *Journal of Water Resources Planning Management*. 147 (8).
[18] S. Cardascia and S. Robertson. 2021. Scaling Natural Capital Investments in the Yellow River Ecological Corridor. *ADB Briefs* No. 199. Manila: ADB.

all key line agencies, and the provincial and local governments. The coordination and governance mechanism for managing the basin needs to be improved, including clarifications of roles and responsibilities outlined in the Implementation Law. The "Plan for Guaranteeing Water Security for Ecological Protection and High-Quality Development of the Yellow River Basin," approved by the Ministry of Water Resources in May 2022, alongside the effective implementation of the Yellow River Protection Law will be instrumental to address the most pressing challenges and advance water security.

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