China Council for International Cooperation on Environment and Development

Building a Climate-Adaptive Society

Scoping Study 2026



August 2022 | Chongqing· Compound heat-drought disaster



September 2023 | Shenzhen· Extreme rainstorm and flood disasters

China Council for International Cooperation on Environment and Development (CCICED)

Building a Climate-Adaptive Society

CCICED Scoping Study Report

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Executive Summary

In the face of increasingly severe climate change and growing climate risks, the Chinese government has been actively advancing climate adaptation. In September 2025, President Xi Jinping announced China's 2035 Nationally Determined Contributions (NDCs) at the United Nations Climate Summit, including the goal of establishing a climate-adaptive society by 2035. How to build a climate-adaptive society has therefore become an important research topic for both the present and the 15th Five-Year Plan period. This study systematically reviews policy progress in building climate-adaptive societies in China and internationally and draws on international comparisons to propose a vision and key development areas for building a climate-adaptive society. It also examines representative regions and river basins in China and Europe, applying the climate-adaptation capacity assessment framework developed in the 2023–2024 CCICED Special Policy Study report *Green Development and Climate Adaptation for Urban and Rural Areas* to analyze differentiated climate risks and key adaptation strategies in typical regions and priority sectors, with inland waterway transport as a case study. On this basis, the study puts forward policy recommendations for building a climate-adaptive society and, in line with the priorities of the 8th phase of CCICED, proposes future research directions on climate adaptation, providing a reference for CCICED's next-stage research in this field.

Key Findings

1. In the face of increasingly severe climate risks, China and countries around the world continue to face gaps in climate resilience capacity, underscoring the urgent need for a transformation in climate-adaptation capacity. In recent years, experience from Europe, the United States, China and other developing countries—illustrated by the Chinese and international case studies undertaken in this project—shows that the scale of losses and the range of impacts caused by short-term threats such as extreme rainfall, heat waves and typhoons, together with the long-term trend of global warming, continue to expand.

2. Climate adaptation policies in China and around the world are shifting toward more proactive, systematic, and coordinated governance, with growing emphasis on the mainstreaming and institutionalization of adaptation, collaborative governance, and climate justice. The focus of climate adaptation governance is also continuing to broaden, from an early emphasis on disaster prevention to climate resilience in areas that include agriculture and food security, water resources, public health, urban infrastructure, energy, transport, ecosystems, and finance and insurance.

3. Climate adaptation is not only essential for enhancing societal safety and resilience, but also an important pillar for promoting and safeguarding green and low-carbon development. Building a climate-adaptive society is inherently cross-cutting, spanning physical, economic, social, and ecological systems. It requires coordinated innovation in policies and institutional mechanisms, including legislation, institutional arrangements, organizational mechanisms, technical standards, fiscal and financial support, and science and technology. For example, climate resilience in inland waterway transport is not merely an engineering challenge. It requires integrated governance across vessels, logistics, investment, digital innovation, and sustained adaptation actions, while balancing objectives for navigation, ecology, water supply, flood safety, and other priorities across river basins.

4. As climate risks and existing adaptation conditions vary significantly across regions, climate adaptation has a strong local dimension. Adaptation strategies and measures should therefore be tailored to local climatic, physical, economic, and social conditions and informed by local climate adaptation assessments, rather than applying a one-size-fits-all approach.

Main Recommendations:

1. Elevate the development of a climate-adaptive society to a strategic goal for modernizing China's national security policy framework, while promoting the "mainstreaming" of climate adaptation by improving the work and policy system for climate adaptation.
2. Promote locally tailored climate-resilient upgrading and retrofitting of infrastructure and lifeline infrastructure.
3. Link climate adaptation capacity assessments with differentiated and targeted local climate adaptation strategies.
4. Establish and improve coordination mechanisms for climate adaptation.
5. Promote climate justice and strengthen the climate resilience capacity of vulnerable groups and less-developed regions.
6. Improve the fiscal and financial support system for climate adaptation and attract diverse stakeholders to participate in climate resilience investment.
7. Enhance public awareness and participation in climate adaptation and foster collective adaptation efforts across society.
8. Deepen South–South and East–West cooperation on climate resilient development and promote the exchange of adaptation expertise and experiences.

In addition, the study recommends that climate adaptation remain a dedicated research theme throughout the 5-year work plan of the 8th phase of CCICED, with research projects established on an annual basis. The report further recommends that all future CCICED Special Policy Studies (SPSs) include dedicated analyses of climate-resilience capacity in their respective fields. This would help to build a climate adaptation policy framework covering major priority areas, providing systematic and forward-looking scientific support and decision-making references to strengthen the capacity to address climate change and advance climate adaptation policy development and implementation for a climate-adaptive society.

Key words:

Climate-adaptive society, legal and policy framework, urban and rural resilience, climate adaptation capacity assessment, transformative capacity, case studies, inland waterway transport, climate justice.

Nomenclature

Term	Definition
Climate-adaptive Society	A climate-adaptive society is a development goal in the field of climate adaptation set forth by the Chinese government. In September 2025, President Xi Jinping announced China's new round of Nationally Determined Contributions at the United Nations Climate Change Summit, setting the goal of basically establishing a climate-adaptive society by 2035.
Conference of the Parties (COP)	The COP is the supreme decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC). All States that are Parties to the Convention are represented at the COP, where they review the implementation of the Convention and any other legal instruments that the COP adopts and take decisions necessary to promote the effective implementation of the Convention, including institutional and administrative arrangements. The COP usually meets annually. As of September 2026, 30 COP sessions have been held.
National Adaptation Plan (NAP)	Strategic policy documents on climate adaptation formulated at the national level by various countries. In 2010, COP16 called on countries to formulate and implement NAPs.
Nationally Determined Contribution (NDC)	NDCs are climate action goals formulated by the Parties to the UNFCCC based on their national circumstances. NDCs were formally established in the 2015 Paris Agreement. The Parties are required to communicate and update their emission reduction targets every five years. These updates shall include information on mitigation measures, adaptation actions, and financial needs.
Global Goal on Adaptation (GGA)	A set of goals established by the international community to address the adverse impacts of climate change. It seeks to strengthen the capacity of countries and regions worldwide to adapt to challenges such as sea-level rise, extreme weather events, and ecosystem degradation.
Nature-based solutions (NbS)	Actions to protect, sustainably manage, and restore natural or modified ecosystems, which effectively and adaptively address societal challenges while providing benefits to human well-being and biodiversity (IUCN, 2016).

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1. Introduction

In recent years, the impacts of global climate change have become increasingly evident, and climate risks have further intensified. By 2025, the global average near-surface temperature had risen by 1.43°C compared to pre-industrial levels[1]. Since 2026, driven by the combined effects of global warming and an extreme El Niño event, extreme weather events have occurred frequently worldwide, posing a significant threat to the stable socio-economic development of nations and to the lives, health, and safety of their populations. Some examples: South Asia, Europe, and North America have successively experienced record-breaking heat waves. In Europe, extreme heat caused more than 35,000 excess deaths across 23 countries[2]. Many parts of Africa and China have also faced extreme rainfall and severe flooding. In July 2026, flooding in Hengzhou, Guangxi, China, resulted in 107 deaths and seven people missing. In Brazil, drought has led to a record number of fires in the Amazon Rainforest.

Against this background, the urgency of climate adaptation has become even more pronounced, and accelerating the implementation of climate adaptation actions has become a global consensus. In 2025, the 30th Conference of the Parties (COP30) to the United Nations Framework Convention on Climate Change (UNFCCC), held in Belém, Brazil, listed "climate adaptation" as one of its core agenda items and adopted the Belém Adaptation Indicators, along with targets for climate adaptation funding. By March 2026, 75 developing countries and 12 developed countries had submitted national adaptation plans (NAPs)[3]. For example, the Chinese government released the National Strategy on Adaptation to Climate Change 2035 in 2022.

In September 2025, President Xi Jinping announced at the United Nations Climate Summit that establishing a climate-adaptive society by 2035 would be an important objective of China's new Nationally Determined Contribution (NDC). As climate change poses wide-ranging risks to society, economic development, and ecosystems, building a climate-adaptive society requires a systematic and integrated approach, with coordinated action across society and multiple sectors. It also requires accelerating the mainstreaming of climate adaptation in social governance and sustaining adaptation efforts over the long term.

This Scoping Study focuses on the development of a climate-adaptive society. Given the significant differences in how climate risks affect different regions and systems, the study conducts case studies from two perspectives—typical regions and key sectors—to support the development of systematic policy recommendations. The specific research objectives include (1) review and summarize the vision, objectives, and key priorities for building a climate-adaptive society; (2) use empirical case studies to examine the diverse challenges and practical experiences faced by different types of regions and sectors (using inland and delta waterway transport as an example) in climate adaptation, as well as pathways and measures for strengthening climate resilience; (3) develop policy recommendations for building a climate-adaptive society and propose research recommendations on climate adaptation for the 8th phase of CCICED.

A summary of each chapter of the report is as follows:

Chapter 2 reviews the evolution of climate adaptation policies both domestically and internationally and summarizes a proposed vision and key development areas for building a climate-adaptive society.

Chapter 3 conducts case studies in four typical regions of China, analyzing the diverse climate challenges, gaps in climate resilience capacity, and adaptation strategies involved in building a climate-adaptive society.

Chapter 4 uses the Rhine River and Yangtze River as case studies to examine the climate risks facing inland and delta waterway transport, as well as corresponding climate adaptation measures and pathways.

Chapter 5 presents recommendations for the CCICED's future ongoing research on climate adaptation,

suggesting a focus on topics such as collaborative governance of climate adaptation, adaptation capacity assessment, comprehensive benefit accounting, adaptive retrofitting of infrastructure, health impacts, climate justice, and related issues.

Chapter 6 presents eight policy recommendations for building a climate-adaptive society, including elevating the development of a climate-adaptive society as a strategic goal for implementing the Holistic Approach to National Security and advancing China's modernization, while mainstreaming climate adaptation worldwide by improving the working and policy systems for climate adaptation; carrying out locally tailored upgrading and retrofitting of infrastructure and lifeline infrastructure; and linking climate adaptation capacity assessments with differentiated and targeted local adaptation strategies.

2. Research on Building Climate-Adaptive Societies, Internationally and in China

2.1 Characteristics of Policy Evolution and Cutting-Edge Trends in the International Climate Adaptation Field

International climate adaptation policies are undergoing a transformation from a marginal issue to one that is mainstreamed, institutionalized, and subject to systematic governance. The 2010 Cancún Adaptation Framework marked a significant turning point in the institutionalization of adaptation issues. It explicitly stated that "adaptation must be addressed with the same priority as mitigation," recognized adaptation as a common challenge facing all Parties, and emphasized a country-driven, gender-sensitive, participatory, and transparent approach to governance, focusing on vulnerable groups, communities, and ecosystems. It promoted the gradual integration of adaptation from a response to individual disasters into broader development policy frameworks, such as economic policy, urban planning, agricultural policy, water resource management, and social governance[4]. The 2015 Paris Agreement further established the global goal on adaptation (GGA), calling for enhanced climate resilience capacity, increased resilience, and reduced vulnerability. Through NAPs, adaptation communications, transparency frameworks, and global stocktaking, it laid the groundwork for a cyclical governance mechanism comprising "goals—planning—communications—assessments"[5]. The Intergovernmental Panel on Climate Change's (IPCC's) *Sixth Assessment Report* introduced the concept of "climate-resilient development," emphasizing the synergistic advancement of adaptation, mitigation, and sustainable development. It also noted that adaptation has certain limits, highlighting the urgency of accelerating adaptation actions against the background of escalating risks from global warming[6].

From the perspective of the global governance process, climate adaptation is gradually evolving from principled initiatives into a quantifiable, monitorable, and assessable governance framework. Regarding the GGA, parties have long held divergent views on issues such as adaptation responsibilities, financial support, technology transfer, capacity-building, national ownership, and global accountability. In 2023, COP28 adopted the United Arab Emirates (UAE) Framework for Global Climate Resilience, identifying key thematic areas including water, food and agriculture, health, ecosystems, livelihoods, infrastructure, and cultural heritage, as

well as key dimensions such as risk assessment, planning, implementation, monitoring, evaluation, and learning. This marked an important step in advancing the GGA from broad directional goals toward a more concrete framework. At COP30 in 2025, the GGA indicator framework was formally launched, comprising 59 Belém Adaptation Indicators to systematically assess countries' progress in addressing extreme climate events and strengthening societal resilience. Meanwhile, multilateral development institutions and international city networks, including the World Bank and C40 Cities Climate Leadership Group (C40), have also promoted the integration of climate adaptation into national development strategies, urban planning, and infrastructure investment decisions through climate finance, national climate and development reports, urban resilience projects, nature-based solutions (NbS), and urban adaptation toolkits[7][8][9][10][11].

In the context of the Global Goal on Adaptation, countries have generally articulated comprehensive visions and objectives for climate adaptation. However, based on practices in representative countries and regions, climate adaptation pathways vary according to countries' development contexts, governance systems, and adaptation priorities. Countries and regions such as the European Union, the United States, and Japan place greater emphasis on institutionalized governance, scientific assessment, legally mandated planning, infrastructure resilience, and cross-sectoral coordination. The European Union focuses on integrating adaptation into the green transition and a rule-of-law framework, proposing to build a "climate-resilient society" by 2050; Under the previous administration (prior to 2025), the United States has set forth the goal of becoming a "climate-resilient nation" [12], integrating climate risks into planning and management, infrastructure, public health, community safety, and the operations of federal agencies. By contrast, countries such as Brazil, Tanzania, Bangladesh, and Dominica place greater emphasis on the interconnections between climate risks, development needs, and social vulnerability. Their adaptation policies not only seek to strengthen climate resilience and reduce disaster risk, but also directly address food security, water supply, public health, livelihood stability, ecosystem protection, and the protection of vulnerable groups, with stronger emphasis on international climate finance, technology transfer, capacity-building, and local community participation. For example, Brazil's new Climate Adaptation Plan: National Adaptation Strategy, released in 2025, is grounded in strengthening resilience to climate risks and places particular emphasis on integrating climate justice, the management of social vulnerability, and ecosystem protection into climate adaptation policy.

Overall, international climate adaptation policies are showing six emerging trends. **First, the trends toward mainstreaming and legalizing climate adaptation are becoming more pronounced**. Climate adaptation is being integrated into policy frameworks covering national development, spatial planning, infrastructure, agriculture, water resources, public health, and disaster risk management, and is gaining more stable support through climate-related laws and institutional arrangements. The Climate Change Laws of the World database maintained by the LSE Grantham Research Institute shows that, as of October 2025, more than 1,500 climate laws have been recorded globally, including 75 climate framework laws covering 69 countries [13]. **Second, climate adaptation policy systems are becoming more comprehensive, with greater emphasis on policy coordination to avoid maladaptation.** Building on NAPs and adaptation strategy frameworks, countries are gradually developing more comprehensive climate adaptation policy systems encompassing laws and regulations, sectoral action plans, technical guidelines, and other instruments. They are also establishing policy processes covering risk identification, planning, implementation, monitoring and evaluation, and feedback and adjustment, while strengthening cross-sectoral coordination to prevent short-term measures from creating new risks. **Third, climate justice is becoming an increasingly important consideration in adaptation policy.** Adaptation policies are placing greater focus on highly vulnerable groups—such as low-

income populations, the elderly, women, children, Indigenous Peoples, traditional communities, and underdeveloped regions—and are attaching greater importance to the equitable allocation of adaptation resources and the fair distribution of adaptation benefits in areas such as risk identification, resource allocation, public services, infrastructure development, and post-disaster recovery. **Fourth, the scope of key adaptation areas continues to expand.** Sectors such as agriculture and food security, water resources, public health, urban infrastructure, energy and transportation, coastal zones, ecosystems, disaster risk management, and finance and insurance have become policy priorities, reflecting a shift from responding to individual disasters to ensuring basic livelihoods, the security of critical systems, and the stable operation of the economy and society. **Fifth, the transformative capacity that is needed to reduce long-term climate risks is gradually gaining attention.** Adaptation policies are no longer limited to engineering protections and post-disaster recovery but, by creating favourable policy, institutional, and resource conditions, are driving the transformation of spatial planning, industrial structures, infrastructure systems, and governance approaches toward safer, more resilient, and sustainable states. **Sixth, public awareness and social participation continue to rise**, with risk information disclosure, early-warning system development, public education on potential solutions, and community engagement becoming crucial foundations for the implementation of climate adaptation policies. **Overall, international climate adaptation policies are evolving from an initial focus on discrete adaptation projects and immediate adaptation needs toward comprehensive planning processes that identify medium- and long-term priorities, strengthen institutional arrangements, are inclusive and gender-responsive and integrate climate risks into development planning across sectors and levels of governance.**

2.2 Background and Trends in China's Efforts to Build a Climate-Adaptive Society

In 2007, China issued China's National Climate Change Program, becoming one of the first countries to formulate and implement such a program on a national level. From this starting point, China's climate change adaptation policies have followed a clear trajectory and can be broadly divided into three developmental stages. **The first stage (2007–2012) was the initial stage.** During this period, policy efforts focused on ecological protection and basic infrastructure for greenhouse gas emission reduction and disaster prevention, covering only a limited number of fundamental areas, such as agriculture, forests, and water resources. The main objective was to strengthen disaster prevention capacity, with an emphasis on reducing disaster losses and safeguarding basic security. **The second stage (2013–2021) was a period of deepening adaptation.** Climate adaptation was increasingly integrated into the overall process of economic and social development, covering both natural and socio-economic systems. Climate-sensitive sectors such as infrastructure, public health, culture, and tourism were incorporated, while technical and standards systems for climate adaptation were gradually established, with particular attention to reducing climate risks faced by vulnerable regions and populations. **The third stage (2022–present) is a phase of systematic and coordinated adaptation,** characterized by ongoing efforts to develop a systematic and coordinated approach to climate adaptation. Pilot programs for deepening the development of climate-adaptive cities have been launched in 39 cities and districts. In September 2025, President Xi Jinping announced the goal of building a climate-adaptive society. In August 2026, the Ecological and Environmental Code of the People's Republic of China came into force. Its dedicated section on climate change adaptation sets out basic policies and institutional arrangements for climate adaptation, as well as the responsibilities of different government departments.

Table 2.1: List of 39 pilot cities for deepening climate-adaptive urban development

Type	City size classification	List of pilot cities
Coastal cities	Megacity	Shenzhen, Shanghai (Chongming District), Tianjin (Binhai New Area)
	Supercity	Dalian
	Large city	Qinhuangdao, Fuzhou, Weihai, Haikou
Inland cities	Megacity	Beijing (Mentougou, Tongzhou, Yanqing Districts), Chongqing (Qijiang, Tongnan Districts, Liangjiang New Area), Chengdu
	Supercity	Jinan (Jinan New and Old Kinetic Energy Conversion Pioneer Zone)
	Large city	Changchun, Xiong'an New Area, Baoding, Changzhi, Hohhot, Yanbian Prefecture, Yangzhou, Jinhua, Longyan, Jiujiang, Shiyan, Baise, Guangyuan, Liupanshui, Tongren, Qujing, Tongchuan, Shangluo, Xi'an New Area, Baiyin, Xining, Yinchuan
	Medium-sized city	Lishui

2.3 Vision and Key Development Areas for a Climate-Adaptive Society

2.3.1. Vision, Development Principles, and Assessment Framework

(1) Objectives and Vision

Building a climate-adaptive society is a key measure and an important objective for China in implementing its national strategy of actively addressing climate change and fulfilling its international responsibilities in global climate governance. The vision is that, by 2035, China will basically establish a climate-adaptive society by elevating climate adaptation as a strategic priority, improving the systems and procedures for climate adaptation, and strengthening climate science and innovation. It will feature effective risk control, system resilience assessment, coordinated governance, green and low-carbon development, and climate justice with shared benefits, while contributing "Chinese solutions" to global climate adaptation.

(2) Construction Principles

Prevention First and Proactive Adaptation: Develop an integrated climate monitoring network across land, air, and space, supported by intelligent and refined early-warning systems, to identify risks accurately and strengthen proactive prevention and forward-looking preparedness by sharing data and knowledge of solutions and pathways.

Systematic Governance and Targeted Risk Control: Focus on climate-sensitive and vulnerable sectors and key regions, integrate disaster prevention and mitigation resources, and prioritize climate adaptation actions to strengthen climate resilience capacity in key sectors and major strategic regions.

Rule of Law Guidance and Regulatory Safeguards: Improve laws and regulations, technical systems, and industry standards for climate adaptation, and establish a comprehensive, well-regulated, and efficient modern climate governance system.

Multi-Stakeholder Collaboration and Whole-of-Society Governance: Establish an inclusive climate governance framework featuring government coordination, social collaboration, and public participation; promote climate security and adaptation awareness; and encourage gender-balanced and inclusive participation in climate governance.

Climate Justice, Inclusion, and Shared Benefits: Uphold climate justice, strengthen the climate resilience capacity of vulnerable groups and less-developed regions, and ensure that the benefits of climate adaptation are shared equitably across society and regions.

(3) Assessment Framework

To promote the in-depth construction of a climate-adaptive society and enhance climate resilience, it is essential to strengthen the assessment of climate resilience capacity. An assessment framework was established around five core capacities for climate resilience and their enabling conditions[14]. The five climate resilience capacities include: preventive capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity. Chapters 3 and 4 of this report apply this framework to conduct case studies on climate adaptation across different regions and key sectors.

Specifically, **preventive capacity** refers to the capacity to anticipate and avoid disaster losses by establishing protective thresholds, avoiding exposure and reducing vulnerability to extreme weather events and slow-onset changes such as sea-level rise. **Coping capacity** refers to the ability to reduce disaster losses following a disaster caused by extreme weather. **Recovery capacity** refers to the capacity to recover from a disaster to a state consistent with or better than the state before the disaster ("Build Back Better"). **Adaptive capacity** refers to the ability to cope with uncertainty about future climate change, as well as uncertainty about demographic, economic, technological and other developments, and adapt our systems to such unforeseen conditions. **Transformative capacity** refers to the ability of the current social, economic, and governance system to transform and proactively change itself in the face of expected disaster risks, such as climate change impacts, by changing into a new system with different system characteristics.

Enabling conditions needed to keep these capacities strong in the long run include awareness and sense of urgency on the side of the public, businesses, and decision-makers; a multi-level and multi-scale systems approach beyond jurisdictions and human-made borders; capacity to develop the adaptation knowledge and skills of individuals, communities, and organizations; the availability of trusted and reliable knowledge, data, and information; adequate financing; fair and just distribution of the financial and social burdens, risks, and rewards; citizens' engagement in the co-creation, implementation, and assessment of interventions; solid policy, legal, regulatory frameworks for the assessment, planning, and implementation of interventions; innovation, creativity, research by design and best practices testing; public-private collaboration; and mechanisms to fairly allocate risks and benefits, protect the vulnerable, and include silent, poor and marginalized groups.

In applying this framework, the case studies assess both the five capacities and the governance, knowledge, financing, participation and institutional conditions that enable them now and in the long run.

2.3.2. Key Areas of Development

(1) Climate Change Monitoring, Early Warning and Risk Management: The full-cycle risk management chain—comprising climate change observation, risk assessment, data disclosure, early warning and response, and integrated disaster prevention, recovery, and relief—is the cornerstone of climate resilience.

(2) Resilience of Infrastructure and Lifeline Systems: Strengthening the extreme weather resilience of critical infrastructure and lifeline systems—including transport, energy, water infrastructure, communications, and municipal services—is essential to the safe and stable operation of cities and regions amid extreme weather events and the long-term impacts of climate change.

(3) Industrial Supply Chains and Social Stability: Climate change significantly affects key industries, the security of critical raw materials, supply chains, and logistics networks and, hence, social stability. It is

therefore necessary to ensure the stability and continuity of industrial and supply chains when they are exposed to extreme weather events.

(4) Natural Resources, Agriculture and Food Security: This area includes strengthening climate resilience in the management of natural resources, including water resources, and in agricultural production and food security.

(5) Community Resilience and Climate Justice: Ensuring that residents of local communities, particularly vulnerable groups, have the capacity to respond to climate risks is an important aspect of equity in building a climate-adaptive society.

(6) Natural Ecosystem Protection: Strengthening adaptive ecosystem conservation, restoration, and sustainable management can enhance the capacity of ecosystems—including forests, grasslands, wetlands, deserts, rivers and lakes, and coastal zones—to adapt to climate change and prevent and mitigate disasters.

(7) Climate Investment and Financing Support: Providing stable, diversified, and sustainable financial support for climate adaptation projects is an essential safeguard for building a climate-adaptive society.

(8) Scientific Research and Knowledge Sharing: Continued climate change scenario projections, impact and risk assessments, research and development of adaptation technologies, and knowledge dissemination provide an essential foundation for science-based and systematic adaptation and public participation.

3. Case Studies on Climate Adaptation in China

3.1 Shanghai Case Study: Climate Adaptation Under the Risk of Sea-Level Rise

3.1.1. Sea-Level Rise Combined With Land Subsidence Is Intensifying Compound Extreme-Disaster Risks

Under global climate change, the level of the East China Sea rose by an average of 3.4 mm per year between 1980 and 2022. In 2022, the sea level in the Yangtze River Estuary reached a record high and is projected to rise by a further 8–19 cm over the next 30 years. Although Shanghai has slowed large-scale land subsidence through strict controls on groundwater extraction, average annual subsidence in some areas still reached 5.6 mm in 2022. Together, sea-level rise and land subsidence have raised the local relative sea level by 8–8.5 mm per year, far above the global average. By 2050, it is projected to be 32–34 cm higher than in 2010, substantially increasing the risks of seawall overtopping, seawater intrusion, and saline groundwater seepage in low-lying coastal areas.

Shanghai has an average elevation of only 3–4 m and soft soils prone to differential settlement, causing the concurrent subsidence of embankments, sluices, pumping stations, and other hydraulic infrastructure. This lowers crest elevations, reduces effective flood-protection standards, and continues to erode the safety margins of hydraulic infrastructure. Embankments originally designed to a once-in-100-year standard may now provide only once per 50-year protection. The city is also exposed to compound events involving river floods, storm surges, astronomical tides, and short-duration intense rainfall. The increasing frequency of extreme weather events in recent years has further intensified these risks. Typhoon In-fa in 2021 produced a record tidal level of 4.79 m at Mishidu, while 23 similar hazardous high-water-level events have been recorded over the past 30

years, placing sustained pressure on coastal flood defence.

3.1.2. Overlapping Marine and Terrestrial Climate Risks Are Increasing Safety Challenges in Coastal Areas

In terms of **flood and tidal protection and urban drainage**, sea-level rise and land subsidence have reduced the effective standards of Shanghai's river and coastal defences. Only 82% of the city's main seawalls meet required standards; some central-city floodwalls designed for a once per 1,000-year event now provide only 100-year protection, and nearly 90 km of riverside embankments have insufficient safety margins. Most areas meet only a once per 20-year drainage standard, while just 19.43% of central-city drainage pipelines meet conventional drainage standards. Ageing networks and limited sponge-city coverage further increase the urban flood risk of waterlogging during extreme rainfall.

In terms of **water-supply security,** Yangtze River sources provide 74% of Shanghai's water supply, but sea-level rise has increased the frequency, intensity, and duration of saltwater intrusion. In 2022, anomalously low flood-season flows combined with an astronomically high tide caused severe saltwater intrusion, preventing normal abstraction from core water sources for 27 consecutive days and affecting more than 2 million residents in northern Shanghai. Inadequate interconnection and emergency dispatch among water sources, together with the lack of strategic backup sources, further weaken water-supply security.

In terms of **coastal ecological protection,** sediment supply from the upper Yangtze River has fallen to only 20% of its 1960s level, while sea-level rise has accelerated tidal-flat loss in the Yangtze River Estuary. Between 1974 and 2014, 41.8% of the regional tidal-flat area disappeared; accretion at Chongming Dongtan slowed markedly, and the Nanhui tidal flat shifted from accretion to erosion. Degradation of these natural barriers for wave attenuation, flood storage, and sediment accretion has weakened coastal ecological protection and increased inundation risks.

In terms of **biodiversity conservation**, at Chongming Dongtan, multiple pressures have reduced native salt-marsh vegetation, with *Scirpus mariqueter* declining by more than 70% over 20 years and benthic biomass by 40%–60%[15]. Resulting food shortages have reduced migratory-bird breeding success and disrupted migration, while the spread of invasive *Spartina alterniflora* has further simplified wetland communities and weakened ecosystem self-adaptation and self-recovery.

3.1.3. All Five Core Capacities Require Urgent Improvement of the Coastal Disaster Prevention System

(1) Preventive capacity: Existing embankments, drainage networks, and other infrastructure are based on static standards that do not reflect long-term sea-level rise and land subsidence. Large-scale tidal-protection and storage infrastructure has lagged, while proactive assessment and source-level prevention of compound disasters remain inadequate. Risk management still relies heavily on post-event emergency response.

(2) Coping capacity: Ageing, subsiding, and deteriorating hydraulic and drainage infrastructure is designed mainly for conventional flood conditions and lacks sufficient capacity under combinations of typhoons, rainstorms, and high tidal levels.

(3) Recovery capacity: Emergency interconnection and cross-regional dispatch among water sources remain inadequate, while strategic reserve water sources are insufficient. The system therefore has limited capacity to maintain essential water supply functions during saltwater intrusion and low-flow events and to recover afterwards.

(4) Adaptive capacity: Coastal development continues to encroach upon natural buffer spaces such as tidal flats and floodplains, without adequate ecological space reserved for sea-level rise. Tiered management of high-risk coastal areas and implementation of flood-resilient construction standards also remain insufficient.

(5) Transformative capacity: Existing wetland-restoration approaches remain relatively rigid and do not yet support the system-level transformation of coastal protection and ecosystem management required under changing hydrological and sediment conditions.

3.1.4. Focusing on the Five Capacities to Iteratively Upgrade the Coastal Climate-Adaptation System

(1) Dynamically update engineering protection standards: Establish protection standards responsive to sea-level rise and land subsidence, and advance super levees in key areas, estuarine tidal barriers, and underground storage facilities to strengthen tidal, river. and pluvial flood protection.

(2) Enhance infrastructure resilience: Upgrade ageing embankments, sluices, pumping stations, and drainage networks; optimize protection thresholds for compound hazards; and strengthen integrated dispatch of hydraulic infrastructure across the city.

(3) Strengthen coordinated water-source dispatch and distribution: Improve interconnection and emergency mutual support among water sources, develop emergency intakes and strategic reserve reservoirs, strengthen saltwater-intrusion warning, and improve cross-basin dispatch.

(4) Reform ecological restoration: Restore tidal-flat terrain, tidal-creek systems, and habitats; strengthen native salt-marsh cultivation and invasive-species control; and improve coordination between ecological restoration and hydraulic engineering to enhance overall climate adaptation.

(5) Optimize integrated land–sea spatial management: Restrict disorderly development in low-lying coastal areas, protect tidal flats and floodplains, implement coastal risk zoning, and enforce flood-resilient construction standards.

3.2 Shenzhen Case Study: Climate Adaptation in High-Density Cities Under Extreme Rainfall

3.2.1. Extreme Rainfall Is Intensifying, With Flood Risks Continuing to Rise in High-Density Built-Up Areas

Under global climate change, extreme rainfall in the Pearl River Delta has intensified, with greater short-duration intensity, localized sudden onset, and stronger spatial and temporal concentration. Hong Kong Observatory records show that rainfall extremes have repeatedly exceeded historical levels. On September 7, 2023, Typhoon Haikui produced the highest hourly rainfall totals ever recorded in both Hong Kong and Shenzhen, indicating that extreme rainstorms once considered low-probability events are increasingly becoming the norm.

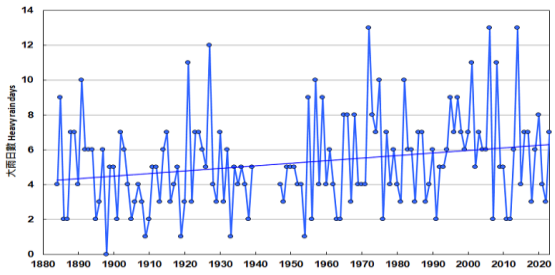


Figure 3.1 Annual number of heavy rainfall days recorded at the Hong Kong Observatory headquarters, 1884–2023

Data source: Hong Kong Observatory website.

3.2.2 Extreme Rainfall Triggers Cascading Safety Risks, Placing Critical Urban Systems Under Severe Pressure

Urban flooding can generate cascading failures across lifeline systems. Shenzhen's flood-risk assessment shows high risks in underground spaces: more than 50 metro stations are located in medium- and high-risk areas, multiple lifeline facilities are in high-risk zones; and more than 10 general hospitals are in medium- and high-risk areas.

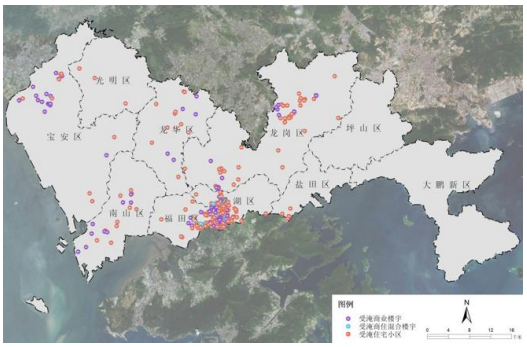


Figure 3.2 Distribution of flooded buildings (basements) during Shenzhen's "9.7" extreme rainstorm in 2023

3.2.3. Climate-Adaptation Measures Taken and Remaining Capacity Gaps

(1) Preventive capacity: Shenzhen has issued China's first municipal medium- and long-term climate adaptation plan, incorporated flood-risk control lines into the territorial spatial planning "one map", and refined weather warnings to the subdistrict level. However, extreme rainfall processes such as warm-sector rainstorms remain difficult to forecast, while stronger risk constraints are still needed at the project siting and planning-permission stages.

(2) Coping capacity: Shenzhen has largely established a flood-control and drainage system comprising reservoirs, rivers, seawalls, flood-storage areas, and pumping stations. Overall flood and tidal protection has reached a once per 200-year standard and urban flooding-control capacity has a 50-year standard. However, some early-developed areas retain low drainage standards, while metro systems, hospitals, and underground substations still lack sufficient protection under extreme rainfall.

(3) Recovery capacity: Shenzhen relies on approximately 19,000 community workers for risk inspection, evacuation, and emergency response, supported by multi-level shelters, catastrophe insurance, and comprehensive disaster-reduction communities. However, backup and continuity of operations for healthcare,

water, electricity, and communications remain insufficient, as do post-disaster support mechanisms for small and medium-sized enterprises and vulnerable groups.

(4) Adaptive capacity: Shenzhen dynamically updates street-level waterlogging thresholds, flood-risk maps, and waterlogging-site inventories, and has launched climate-resilient community pilots using risk profiling, sponge greenways, permeable paving, resident training, and emergency drills. However, community adaptation remains largely pilot- and project-based, rather than a structural and long-term adaptive capacity, with uneven routine risk education, facility maintenance, and limited self-help and mutual-aid capacity in urban villages, ageing residential communities, and among underground-space users.

(5) Transformative capacity: Shenzhen has incorporated climate adaptation into territorial spatial planning, emergency management, and public health policies, and has been selected as a national pilot city for deepening the development of climate-adaptive cities. Its flood-risk early-warning platform is an indicator of an emerging institutional transformation from conventional engineering defence to climate risk governance, but cross-departmental data standards and upstream-downstream and cross-regional coordination still require improvement.

3.2.4. Key Climate Adaptation Strategies and Implications

(1) Strengthen resilience-oriented territorial spatial management: Integrate flood-resilience requirements into territorial spatial plans, use a citywide "one map of urban flood risk" for zoned management, and make risk levels a prior constraint on urban development, underground-space construction, and regeneration.

(2) Enhance urban lifeline infrastructure resilience: Increase municipal-system redundancy through urban regeneration, retrofit lifeline facilities in medium- and high-risk areas, ensure emergency power supply, and establish differentiated flood-protection standards and dedicated plans for critical underground spaces.

(3) Establish a smart early-warning and decision-support platform: Develop a citywide hydraulic digital model and use the Internet of Things, big data, and AI for real-time waterlogging prediction and engineering simulation, supporting forecasting, early warning, scenario simulation, and contingency planning. Use the "one map of urban flood risk" to enable cross-departmental data sharing and routine assessment.

(4) Advance innovative collaborative governance mechanisms: Remove data barriers among meteorology, water, emergency management, housing and urban-rural development, transport, and natural-resource authorities; establish a shared flood-, drought, and extreme heat-risk platform; and strengthen basin-based coordination across administrative boundaries, including unified upstream-downstream river-management standards and transboundary river governance.

(5) Promote multistakeholder co-governance: Establish a collaborative disaster-prevention system involving government, enterprises, communities, research institutions, and the public. Conduct routine public education on rainstorm risks and emergency training and drills, strengthen grid-based community flood-control responsibilities, and mobilize residents to participate in hazard inspection and waterlogging response, fostering whole-of-society participation in climate adaptation governance.

3.3 Chengdu–Chongqing Case Study: Climate Adaptation of Energy and Water Systems Under Extreme Heat

3.3.1. Trends and Spatial–Temporal Characteristics of Heat and Drought Risks in the Chengdu–Chongqing Region

Over the past 60 years, the average temperature in the Chengdu–Chongqing region has risen by about 0.18°C per decade, while annual precipitation has declined by around 25 mm per decade, indicating the simultaneous expansion of heat and drought[16]. Extreme heat and drought repeatedly exceeded historical records in 2022 and 2024, suggesting a shift from linear progression to nonlinear escalation, with extreme events likely to become more frequent[17]. Disaster risk increases from west to east, with major high-risk areas in eastern Sichuan, western Chongqing, and north-eastern Chongqing[18], overlapping with the region's main population and economic centres.

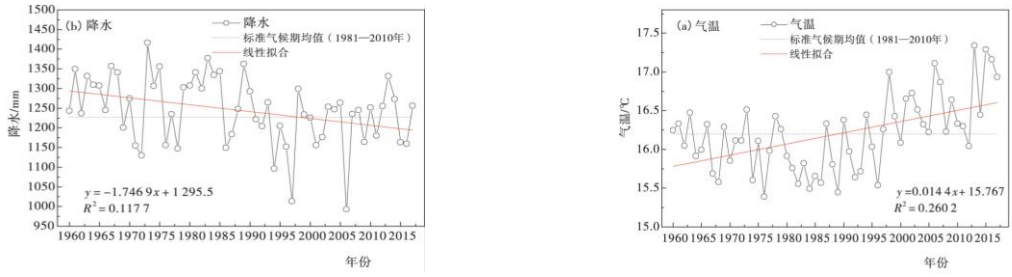


Figure 3.3 Trends in precipitation and temperature in the Chengdu–Chongqing region over the past 50 years[19]

3.3.2. Cascading "Water–Energy" Disasters Triggered by Heat and Drought and Their Underlying Mechanisms

Heat and drought create a cascading "water–energy" disaster chain through three interrelated shocks. **First, supply declines sharply.** Drought reduces river flows and reservoir storage, disrupting an energy system in which hydropower accounts for nearly 80% of Sichuan's supply. In summer 2022, hydropower output fell by more than 50%[20], widening the electricity deficit and disrupting pressurized pumping stations and secondary water-supply facilities. **Second, demand surges.** Extreme heat turns air-conditioning into a continuous necessity; in 2022, cooling loads accounted for up to 26% of Sichuan's total grid load. Combined with rising irrigation and domestic water demand, this pushed the water–energy system toward a critical threshold, forcing power rationing and water-supply interruptions. **Third, competition for resources intensifies.** As inflows decline, domestic water use, power generation, agriculture, and ecological needs compete directly. Fragmented departmental management makes such conflicts difficult to resolve, with agricultural irrigation and ecological replenishment often affected first. In 2022, 7.96 million people were affected across the region: 960,000 faced drought-related drinking-water difficulties, crops failed, and algal blooms re-emerged in the Three Gorges Reservoir bays[21].

The chain of "reduced inflows → reduced generation → tight electricity supply → reduced water supply → insufficient irrigation → ecological damage"[22] amplifies meteorological drought into a compound energy–food–ecological crisis, showing that fragmented sectoral governance is no longer adequate for compound risks and should shift toward whole-chain resilience governance.

3.3.3. Climate-Adaptation Measures Taken and Remaining Capacity Gaps

(1) Preventive capacity: Chongqing dynamically regulated water levels at the Caojie and Pengshui hydropower stations in 2024 based on rainfall forecasts, moving beyond fixed flood-limit levels to store water in advance. However, uncertainty in short-term runoff forecasting still constrains dynamic regulation, while forecast accuracy and climate disaster risk mapping need improvement.

(2) Coping capacity: Coordinated upstream reservoir operation reduced the approximately once per-100-year flood at Cuntan Station in 2020 to an event equivalent to a 20-year return period. Ultra-high-voltage transmission, source–grid–load–storage (SGLS) coordination, and time-based load restrictions have also strengthened electricity security. However, Sichuan still relies on hydropower for about 75% of its supply, pumping stations remain electricity-dependent, and rural areas rely on numerous small and dispersed water sources, leaving the system vulnerable under extreme drought.

(3) Recovery capacity: Agricultural insurance, compensatory late-autumn planting, and community fundraising for drought-relief equipment have supported recovery. However, dedicated recovery funds and policy-based insurance for key industries and micro, small, and medium-sized enterprises remain insufficient, institutionalized risk-sharing mechanisms are weak, and community resilience still depends heavily on temporary social mobilization.

(4) Adaptive capacity: Chengdu's electricity-supply measures and virtual power plants[1], progressive surcharges for excess consumption and off-peak water-use incentives, Chongqing's civil-defence cooling spaces, and the promotion of drip irrigation and drought-resistant crops in rural Sichuan together provide a relatively diverse set of demand-side management tools. However, rural water and electricity services still lack adequate fiscal support, while ageing irrigation systems continue to deteriorate and lose adaptive functions.

(5) Transformative capacity: Climate adaptation action plans have been incorporated into urban development frameworks. However, flood control, water supply, and power generation still lack binding coordination mechanisms; basin dispatch remains centred on flood control; multi-objective conflicts under heat and drought lack formal adjudication procedures; and performance assessment, accountability, and institutional protection for vulnerable groups remain inadequate. These gaps fundamentally constrain the transformation towards integrated water-energy governance.

3.3.4. Key Climate Adaptation Strategies and Implications

(1) Improve forecasting and information sharing: Enhance spatial and temporal forecasting of extreme heat and drought; develop multi-hazard climate-risk maps covering heat, drought, and flooding; and integrate hydrological and meteorological data to support precise dispatch and advance deployment.

(2) Strengthen infrastructure standards and redundancy: Revise protection standards for electricity and water-supply lifeline systems under compound hazards, promote distributed layouts and mutual support among multiple sources, and prioritize upgrades to numerous small and dispersed rural water-supply systems.

[1] A collection of many energy storage cabinets that store electricity during off-peak hours and release it during peak demand, somewhat similar to pumped-storage hydroelectric power generation

(3) Strengthen insurance and institutionalized risk sharing: Expand catastrophe-insurance coverage, explore the inclusion of drought risks in policy-based agricultural insurance, and establish differentiated drought- and flood-related subsidies, prioritizing agricultural irrigation losses and rural water-supply restoration. Clarify post-disaster cost-sharing among government, enterprises, and society, shifting from temporary mobilization to institutionalized risk sharing.

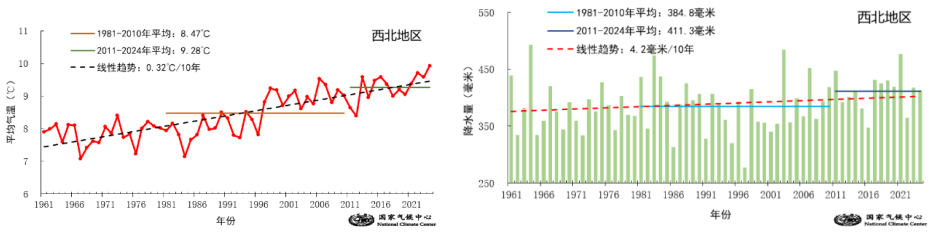
(4) Break down departmental barriers and reshape governance rules: Institutionalize Chongqing's dynamic flood-limit water-level practice, establish formal rules for multi-objective water–energy dispatch under heat and drought, create basin-level joint-dispatch teams, incorporate climate adaptation performance into district and county assessments, and integrate climate-risk zoning into detailed territorial spatial planning and project approval.

(5) Strengthen long-term adaptation through demand-side management and local ecological knowledge: Develop virtual power plants and incentives for self-generation, reduced electricity consumption, and vehicle-to-grid interaction. Promote drip irrigation and drought-resistant crops, while drawing on local ecological knowledge in mountainous and hilly farming-settlement systems. Restore small reservoirs, water-storage fields, and local irrigation systems through incentive-based subsidies and community co-management to develop low-cost, locally adapted climate-resilient infrastructure.

3.4 Case Study of Arid Northern China: Climate Adaptation Under Climatic "Warming and Wetting"

3.4.1. Pronounced Warming and Wetting Are Increasing Compound Risks to Urban Infrastructure

Northwestern China has warmed rapidly, with annual mean temperatures rising by about 0.32°C per decade, around 1.8 times the global average. Annual precipitation has increased by 4.2 mm per decade, accompanied by more frequent extreme heavy rainfall. However, the arid climatic pattern has not fundamentally changed: potential evapotranspiration remains more than five times precipitation, so increased rainfall is insufficient to offset the moisture deficit. Meanwhile, groundwater levels in North China have recovered markedly due to the South-to-North Water Diversion Project, reduced groundwater extraction, and climatic warming and wetting. For example, in Beijing's plain area, average groundwater depth recovered from 25.87 m in 2015 to 11 m in 2025, representing a cumulative rise of about 14.87 m. Although this has helped curb land subsidence in some areas, rising groundwater levels are creating new risks for underground infrastructure and existing building foundations.



a) Temperature **b) Precipitation**

Figure 3.4 Temperature and precipitation changes in Northwestern China, 1961–2024

3.4.2. Extreme Rainfall and Rapid Drought–Flood Shifts Expose Infrastructure Deficiencies and Increase Urban Safety Risks

More frequent extreme rainstorms are increasing urban flooding and secondary geological hazards. Between 2013 and 2023, cumulative drainage-infrastructure investment per unit of built-up area in Northwestern China was RMB 8.67 million/km², well below the national average of RMB 14.12 million/km². Extreme rainfall can also trigger flash floods, landslides, collapses, and debris flows, with particularly high risks from loess landslides and debris flows in eastern Qinghai and central Gansu, and from flash floods and glacial-lake outburst floods in southern Xinjiang.

Rapid shifts between drought and flooding, together with more frequent heat waves, are increasing pressure on water-supply security. Warming and wetting have not fundamentally altered the region's aridity, while drought-to-flood transitions place simultaneous pressure on flood control, drainage, and water supply. Heat waves further intensify water-supply–demand imbalances, pushing some water-treatment plants to full capacity and reducing reservoir storage. The strong spatial and temporal overlap of heat and drought poses a particularly severe compound challenge for water-scarce areas in Northwestern China.

Combined-sewer overflows also pose a persistent threat to aquatic ecosystems. Combined-sewer systems are more prevalent than the national average and generally have low interception ratios, allowing even light rainfall to trigger overflows. Dry-season sediment accumulation further intensifies the "first-flush" effect during rainfall events. With limited ecological baseflows and weak self-purification capacity, pollutants can accumulate and degrade aquatic ecosystems in arid and semi-arid areas.

Rising groundwater levels are creating additional risks for existing urban infrastructure. While groundwater recovery improves aquatic ecological conditions, it can disrupt the long-established dry equilibrium of underground spaces and contribute to foundation settlement, uplift of underground structures, and increased leakage from ageing pipelines.

3.4.3. Climate-Adaptation Measures Taken and Remaining Capacity Gaps

(1) Preventive capacity: Ningxia, Gansu, Qinghai, Shaanxi, and other provinces and autonomous regions have implemented climate adaptation action plans and expanded drainage and flood-control infrastructure according to local conditions. However, climate risk zoning and assessment remain at an early stage, climate risk has not yet become a binding constraint in territorial spatial planning, and adaptation-related engineering standards remain incomplete.

(2) Coping capacity: Cities experiencing significant rainfall increases have upgraded drainage networks, pumping stations, pipelines, and channels. However, sparse meteorological monitoring networks reduce the accuracy of warnings for localized intense rainfall. Ageing drainage systems and dry-season sediment accumulation also increase blockage risks and contribute to routine overloading of wastewater treatment plants during the rainy season.

(3) Recovery capacity: Regional emergency drainage bases and emergency water-supply facilities are being developed. However, an integrated system coordinating drainage, emergency response, flood control, and drought relief has not yet been established. Rapid post-disaster recovery, cross-regional assistance, emergency reserves, and dispatch capacity all remain insufficient.

(4) Adaptive capacity: Sponge-city and related projects are being promoted to strengthen local stormwater

retention. However, low interception ratios continue to cause frequent overflow pollution, while limited ecological baseflows and weak self-purification capacity allow pollutants to accumulate and degrade aquatic ecosystems.

(5) Transformative capacity: Adaptation measures remain fragmented and lack medium- and long-term action plans and dynamic assessment. Closed-loop management covering assessment, feedback, and optimization has not yet been established; combined-sewer upgrades are insufficiently coordinated with urban regeneration; and cross-departmental joint dispatch and community-level risk-sharing mechanisms remain weak.

3.4.4. Key Climate Adaptation Strategies and Implications

(1) Establish dynamic assessment and standards-revision mechanisms: Assess drainage and flood-control standards and infrastructure adaptability every 5–10 years and dynamically update storm-intensity formulas and technical parameters as extreme rainfall changes, avoiding infrastructure that becomes outdated soon after completion.

(2) Develop a cross-departmental joint-dispatch and smart management platform: Shift housing and urban-rural development, ecological-environment, and water authorities from information sharing to joint assessment and dispatch, and establish a real-time platform linking rainfall, drainage networks, and rivers to improve control of combined-sewer overflows.

(3) Strengthen community-level climate resilience capacity and protection for vulnerable groups: Establish community risk inventories and self-inspection mechanisms through grid-based governance, promote a shift from passive response to proactive prevention, and prioritize older people, children, and low-income households in emergency supplies and shelter planning.

3.5 Summary

3.5.1. Regional Heterogeneity in Climate Risks Calls for Targeted Enhancement of Climate Adaptation Capacity

Climate change manifests diversely across regions, necessitating localized rather than uniform adaptation approaches. Coastal areas face compound threats from heavy rainfall, storm surges, and sea-level rise; arid northern regions confront flooding and infrastructure damage from warming-humidification trends and rising groundwater; southwestern inland areas experience basin-scale flooding, pluvial flooding, drought-induced resource shortages, and extreme convective rainfall events. Moreover, socio-economic conditions and local preferences differ significantly by region and even locally. Adaptation strategies must therefore be tailored to regional disaster profiles and local development contexts, avoiding one-size-fits-all solutions.

3.5.2. Widespread Deficiencies in Climate Adaptation Capacity Call for a Shift Toward Proactive and Systematic Adaptation

As extreme weather events become more frequent and intense, the case study regions generally exhibit gaps in climate adaptation capacity. These include insufficient preventive capacity in infrastructure and engineering standards based on historical data; weaknesses in monitoring and early-warning systems; limited

disaster risk awareness among grassroots communities and residents; and insufficient consideration of cross-sectoral compound impacts and complex cascading effects, with inadequate coordination mechanisms constraining transformative capacity. This holds even more for regions threatened by slow-onset climate impacts like sea-level rise and related saltwater intrusion in rivers and aquifers.

Addressing these multiple capacity gaps requires climate adaptation to shift toward more proactive adaptation, cross-sectoral collaboration, and multi-stakeholder coordination, avoiding fragmented responses. Common adaptation measures identified across the case study regions include upgrading infrastructure and lifeline infrastructure, reserving and restoring ecological spaces, using AI and information technologies to strengthen early warning, emergency response and recovery capacity, and establishing cross-departmental and multi-level governance coordination mechanisms to this end.

4. Climate Adaptation for Waterborne Transport on Inland and Delta Waterways: Case Studies on the Rhine and Yangtze Rivers

Climate change is increasingly affecting inland waterway transport worldwide through more frequent droughts, floods, extreme weather, and sea-level rise. These impacts threaten the reliability and continuity of freight transport on rivers and deltas, which are essential for economic development, industrial supply chains, food security and energy systems. Inland navigation is a particularly attractive transport mode because of its relatively low emissions, high safety and lower societal costs compared with road transport. However, without adaptation, climate-related disruptions are expected to increase substantially during the coming decades.

This chapter focuses on the climate resilience of inland waterway transport on two globally important river systems: the Rhine in Europe and the Yangtze in China. Both rivers function as economic arteries, connecting ports, industries and hinterland regions, but they differ strongly in dimensions, governance structures, hydraulic infrastructure and adaptation traditions. The objective is to identify climate-related challenges, assess adaptation measures and pathways, and formulate policy and research recommendations for climate-resilient inland waterway transport. An elaborate and detailed description of the comparative analysis, conclusions, and lessons for the future can be found in the background document.

4.1 The Rhine River: Climate Risks and Adaptation

The Rhine is Europe’s most important inland waterway, connecting the seaports of Rotterdam, Antwerp, and Amsterdam with major industrial centres in Germany, Switzerland, and France. More than 60 million people live within the river basin, which spans nine countries and requires international governance and coordination.

Climate projections indicate increasing temperatures, more extreme weather, more precipitation in winters, and drier summers. As glacier contributions decline, the Rhine is progressively shifting from a snow-fed to a rain-fed river system. Winter discharges are expected to increase, raising flood risks, while summer discharges are projected to decline significantly, leading to more frequent and severe low-water conditions. Sea-level rise will further affect the Rhine delta through increased flooding risks, salt intrusion, and the more frequent closure of storm surge barriers.

Low water is identified as the dominant climate threat for navigation. Reduced river depth directly limits vessel loading capacity, particularly at known bottlenecks such as Kaub and Nijmegen. Droughts in 2018 and 2022 already caused major reductions in freight transport volumes and generated billions of euros in economic losses. Future climate scenarios indicate that navigation restrictions may occur much more frequently. Longer low-water periods can disrupt supply chains, increase transport costs, trigger shifts toward road transport, and affect the competitiveness of waterborne freight transport.

The Rhine also illustrates the complexity of multifunctional river management. Navigation competes with flood protection, freshwater supply, ecology, agriculture, and energy production. Measures that benefit one function may negatively affect another. For example, ecological restoration measures such as side channels or removal of bank protection may improve biodiversity but can reduce navigational depth. Conversely, new weirs could improve navigation but create serious ecological and groundwater impacts. Climate change and socio-economic developments therefore intensify competition for water and river space.

Adaptation strategies in the Rhine basin increasingly adopt a system-level approach that combines infrastructure, operations, governance, fleet adaptation, and digital technologies (information services). Measures include dredging, sediment management, river engineering, improved forecasting, real-time depth information, logistics optimization, and fleet adaptation. The background report elaborates on these measures, structured around five resilience capacities: preventive, coping, recovery, adaptive, and transformative capacity.

Given the uncertainties of future climate impacts, adaptive and flexible measures should be central design principles. Adaptive measures can be adjusted, expanded, or modified as new knowledge becomes available, thereby reducing long-term risks and increasing resilience. The Dynamic Adaptive Policy Pathways is a methodology that can be applied to develop flexible sequences of measures that can be adjusted as climate impacts evolve and adaptation tipping points are reached.

4.2 The Yangtze River: Climate Risks and Adaptation

The Yangtze River is the world's largest inland waterway system, supporting more than 4.2 billion tonnes of annual cargo throughput and serving as a backbone of Chinese economic development. The river extends over 6,300 km and includes extensive hydraulic infrastructure, most notably the Three Gorges system, which strongly influences hydrology, navigation, and flood management.

Climate change is projected to significantly increase temperatures, precipitation, and hydrological variability. Floods are expected to become larger and more frequent, while drought risks remain significant due to higher evaporation and uneven water distribution. Sea-level rise represents an additional challenge, particularly for the Yangtze estuary and delta, where higher coastal water levels, stronger storm surges, and saltwater intrusion create risks for navigation, ports, and freshwater supply.

The Yangtze differs fundamentally from the Rhine because of its extensive reservoir system and centralized governance. Climate change affects navigation through both low-water and high-water events. Droughts reduce navigable depths and force vessels to reduce loading, increasing transport costs. Floods create safety risks due to high velocities and changing channel conditions. Moreover, abrupt drought-flood (or vice-versa) transitions have become a distinct climate risk for Yangtze navigation. Unlike gradual seasonal shifts, these events involve rapid water-level swings within weeks. They demonstrate that abrupt transitions are an emerging pattern challenging conventional seasonal planning assumptions, calling for adaptive management strategies. Sea-level rise affects estuarine navigation by increasing extreme water levels and sedimentation.

Extreme weather, including dense fog, strong winds, and heat waves, also contributes to disruptions.

Like the Rhine, the Yangtze is multifunctional. Navigation must be balanced with flood control, hydropower generation, water supply, irrigation, and ecological restoration. Reservoir operations often involve trade-offs between power generation and maintaining sufficient navigation depths. Ecological protection policies increasingly constrain traditional engineering solutions and require more environmentally compatible approaches.

The Yangtze adaptation strategy is characterized by large-scale infrastructure interventions, reservoir regulation, and rapid implementation. Measures include channel deepening, systematic river regulation, the expansion of the Three Gorges navigation capacity, coordinated reservoir operation, intelligent monitoring systems, emergency response networks, and multimodal transport alternatives. Digitalization plays a particularly important role through extensive use of artificial intelligence, digital twins, and real-time navigation support systems. Simultaneously, the Yangtze is rapidly transitioning toward greener shipping fleets and intelligent transport systems.

4.3 Comparison Between the Rhine and the Yangtze

The Rhine and Yangtze share many challenges. Both are crucial economic corridors exposed to climate hazards, including droughts, floods, sea-level rise, and extreme weather. Both must balance navigation with multiple competing river functions and pursue sustainability goals through fleet greening and digitalization.

However, important differences emerge. The Yangtze is substantially larger in waterway length, fleet size, and freight volumes. Its centralized governance and extensive hydraulic infrastructure enable rapid implementation of large-scale adaptation measures. The Rhine, in contrast, depends on international cooperation and transboundary governance, resulting in a stronger emphasis on coordination, adaptive planning, and consensus-building.

The comparison reveals complementary strengths. Europe can learn from China's speed of implementation, reservoir management, fleet greening, and digitalization. China can benefit from European experience with long-term climate scenarios, adaptive pathways, ecological restoration, and transboundary governance. Both systems increasingly recognize that climate resilience requires a combination of infrastructure, fleet adaptation, logistics optimization, digital systems, and integrated water management.

4.4 Lessons Learned

Climate-resilient inland waterway transport requires a system-wide approach that combines infrastructure, fleet adaptation, logistics, governance, digital technologies, and integrated water management. Long-term resilience can be enhanced by aligning climate adaptation with the renewal of ageing infrastructure and by embedding navigation within broader water–energy–food–ecosystem systems.

4.4.1. Suggestions for the Rhine

Develop a shared long-term vision and adopt an integrated cross-sectoral adaptation strategy: Navigation, ecology, flood protection, freshwater supply, and energy production should be evaluated together within a shared vision for the future development of the Rhine corridor. Decisions should be based on an explicit

assessment of societal and economic impacts, including the costs of transport disruptions and modal shifts, and translated into coordinated investment and implementation plans across countries.

Strengthen governance during crises: While maintaining international cooperation, stronger temporary coordination mechanisms should be developed for severe droughts, floods, and infrastructure failures to improve response efficiency across countries.

Define adaptation indicators and tipping points: Clear performance indicators are needed to determine when adaptation becomes necessary and which interventions should be implemented. These indicators should include navigability, reliability, economic performance, and societal impacts.

Develop integrated assessment tools: Research and modelling should evaluate combinations of infrastructure, fleet, and logistics measures, including costs, benefits, implementation time, and stakeholder impacts.

Address physical bottlenecks with adaptive solutions: Remove critical bottlenecks such as shallow reaches and invest in flexible measures that can be adjusted over time. Reservoir operation and water buffering should be explored as additional navigation support measures. Maximize the positive ecological effects of these interventions.

Accelerate fleet transition and climate resilience simultaneously: Combine climate adaptation with fleet decarbonization by stimulating low-emission, shallow-draught, and modular vessel concepts. New vessels, propulsion systems and supporting infrastructure should be designed to remain operational under future low-water, high-water, and extreme weather conditions.

Exploit digital technologies: Invest in digital twins, artificial intelligence, forecasting systems, and integrated corridor-wide decision-support platforms.

4.4.2. Suggestions for the Yangtze

Improve data interoperability: Create integrated data-sharing platforms across navigation, water management, ecology, and meteorology agencies.

Support long-term modelling frameworks: Move beyond project-based funding and establish sustainable support for hydrodynamic, sediment, and climate models.

Strengthen fundamental research: Invest more in theoretical research on hydraulics, sediment transport, and river morphodynamics to support future engineering solutions.

Expand eco-compatible engineering: Increase the use of innovative river-regulation measures based on nature-based solutions (NbS) to support navigation while maintaining the health of aquatic ecosystems.

Extend planning horizons: Complement 5-year planning cycles with adaptation strategies extending to 2100.

Balance centralized control with stakeholder participation: Retain implementation efficiency while integrating regional authorities and local stakeholders more effectively into decision-making processes.

4.4.3. Shared Conclusion

The Rhine and Yangtze rivers demonstrate that climate resilience in inland waterway transport is not merely an engineering challenge. It requires integrated governance, strategic investment, digital innovation, and continuous adaptation. Future success depends on combining infrastructure solutions with flexible management approaches while balancing navigation objectives with ecology, water security, flood safety, and societal priorities.

5. Suggestions for a CCICED Climate Adaptation Research Work Plan

Considering the urgency and importance of climate adaptation, it is recommended that climate adaptation research continues throughout the 5-year work plan of the Eighth Phase of CCICED, with Special Policy Studies and/or Scoping Studies established on an annual basis. A dedicated task force could also be established within CCICED to coordinate related research, thereby contributing to CCICED's efforts to advance climate adaptation policy development and related actions in China and globally. At the same time, future CCICED Special Policy Studies (SPSs) in other thematic areas should include dedicated analyses of climate adaptation capacity in their respective fields, thereby building a coherent climate adaptation policy framework that covers major priority areas and spans the full policy cycle.

International cooperation and knowledge exchange are essential for countries to enhance their climate adaptation capacity. It is recommended that CCICED strengthen financial support for international cooperation in the field of climate adaptation knowledge exchange. In addition to online meetings, the scale and frequency of in-person exchanges should be increased to facilitate deeper and more effective knowledge sharing and mutual learning. Research institutions should be incentivized to invest more intellectual resources in climate adaptation research. Governments are advised to provide practical travel support for both Chinese experts travelling abroad and international experts visiting China, including, for example, the allowed duration of overseas visits for Chinese experts and the facilities made available to them. Furthermore, personal contacts, overseas field visits, traineeships, and other joint activities should be encouraged, while ensuring that research results remain open and accessible for sharing.

5.1 Proposed Research Topics

5.1.1. SPS on Key Climate Resilience Capacities and Their Enabling Conditions

At present, many countries and regions still have shortcomings in their preventive capacity, coping and recovery capacity, adaptive capacity, and transformative capacity in response—their resilience—to climate change. The required enabling conditions and support mechanisms also need to be further improved. Therefore, it is recommended that SPS be conducted around these capacities and their enabling conditions and how these are organized in different countries in a comparative case study analysis. The Five Capacities for Resilience assessment framework should be used as an analytical tool to carry out assessments of climate adaptation capacity and shortcomings in China and representative international regions; identify weaknesses, priority areas, and capacity gaps in existing resilience capacity-building in a differentiated manner; and put forward targeted interventions and climate adaptation strategies accordingly.

5.1.2. Enhancing Urban and Rural Climate Resilience Capacity Through Climate-Resilient Infrastructure Renewal and Retrofitting

In the face of intensifying extreme weather events and continued warming trends, the gaps in climate resilience capacity across global urban and rural spaces and infrastructure are becoming increasingly evident. At the same time, countries around the world are generally advancing large-scale infrastructure and spatial renewal and retrofitting, such as the "urban renewal" actions currently being promoted in China. Therefore, research should be conducted on pathways to a climate-adaptive society, by minimizing the damage of extreme weather while maximizing the day-to-day benefits of implemented solutions and embedding climate and extreme weather adaptation goals and key climate adaptation technologies, such as NbS into the renewal and upgrading of urban and rural spaces and infrastructure. Corresponding lists of key technologies, good governance approaches, and policy toolkits should be proposed according to the differences among countries and regions.

5.1.3. Methodology for Assessing the Comprehensive Benefits of Climate Adaptation Actions

Climate adaptation actions have significant comprehensive benefits for society, the economy, ecology, and disaster prevention. For example, NbS can provide significant ecosystem services and other benefits. However, compared with climate mitigation actions, the benefits brought by climate adaptation are usually difficult to quantify in financial/economic terms and have a time lag, often becoming visible only after disasters occur, which constrains financial support for climate adaptation actions. In addition, climate adaptation measures are not implemented in isolation, but are often deeply integrated with processes such as infrastructure renewal and retrofitting, urban renewal, and industrial transformation. There is an urgent need to establish targeted benefit-assessment methods to promote multi-objective coordinated implementation. Therefore, it is recommended that a Special Policy Study be carried out to explore a general accounting framework and evaluation methodology for climate adaptation benefits in combination with the GGA framework and the Belém Adaptation Indicators.

5.1.4. A Comprehensive, Coordinated Governance Mechanism for Climate Adaptation

Climate adaptation-related fields are not isolated from one another; they are interconnected and mutually influential. Therefore, climate adaptation requires the establishment of a systemic and integrated governance framework, with coordination across multiple aspects, including policy mechanisms, planning systems, infrastructure, logistics and transport, education and public communication, financial support, scientific and technological research and development, and talent cultivation, so as to promote the "mainstreaming" of climate adaptation. It is recommended that a Special Policy Study be carried out on climate adaptation governance mechanisms, proposing key aspects for building a climate adaptation policy framework for developing a climate-adaptive society coordination mechanism with cross-sectoral, multilevel, multiscale, and inclusive characteristics, and distilling a replicable implementation framework and policy toolkit for mainstreaming climate adaptation.

5.1.5. Pathways for a Just Transition in Climate Adaptation and for Strengthening Public Participation

Equity and social justice are complex issues in climate adaptation policies and practices. It is recommended that, through international case comparisons, the key demands and difficulties faced by vulnerable groups and

vulnerable regions in climate adaptation be identified, and that the practical experiences and policy implications of different countries and regions in climate adaptation equity and social justice be systematically summarized and taken as an important research direction for CCICED policy studies. In addition, mechanisms should be explored for raising public awareness of climate adaptation and increasing public participation as part of building a climate-adaptive society, enhancing society-wide awareness of climate adaptation and community adaptation capacity, and promoting the formation of a "bottom-up" climate adaptation capacity-building mechanism.

5.1.6. Climate Adaptation Needs in Key Sectors

Climate adaptation spans ecological, economic, and social development. It is recommended that in-depth research be conducted on climate risks and gaps in climate resilience capacity in key sectors, including personal and public health, urban areas and urban life, agriculture and food supply, transport and logistics, main waterway and railroad infrastructure, lifeline facilities, and biodiversity and nature conservation, to formulate targeted strategies to strengthen the climate resilience capacity of these domains.

5.2 Proposed Research Timeline

Based on the research themes above, a proposed research schedule for climate adaptation under the 5-year work plan of the 8th Phase of CCICED is presented below. Priority is recommended for studies related to the overall climate adaptation framework and those introducing new perspectives. But all are urgent and could be given a higher priority and start earlier.

Table 5.1 Proposed research timeline for climate adaptation under the 8th Phase of CCICED

Research year	Annual research theme
2027	SPS on Key Climate Resilience Capacities and Their Enabling Conditions
2028	Improvement of Urban and Rural Climate Resilience Capacity and Infrastructure Renewal and Retrofitting in Response to Extreme Weather; Climate Adaptation Needs in Key Sectors
2029	Methodology for Assessing the Comprehensive Benefits of Climate Adaptation Actions
2030	A Comprehensive, Coordinated Governance Mechanism for Climate Adaptation
2031	Pathways for a Just Transition in Climate Adaptation and for Strengthening Public Participation

Some of the proposed SPSs cover complex and extensive themes. Therefore, each of these studies could be given 18 or even 24 months instead of 12 months. And, if time and budget allow, some specific components of the proposed SPSs could be prepared by executing a dedicated Scoping Study. Topics like health impacts, public-private cooperation in adaptation, education, and awareness-raising are examples of such themes.

6. Policy Recommendations

6.1 Elevate the Development of a Climate-Adaptive Society to a Strategic Goal for Modernizing China's National Security Policy Framework, While Promoting the "Mainstreaming" of Climate Adaptation by Improving the Work and Policy System for Climate Adaptation

Climate change has transformed from a purely environmental issue into a prominent risk that affects the country's sustainable development. Climate adaptation is no longer merely a concept or initiative for disaster prevention and mitigation; it has become a fundamental pillar for supporting development and security, and for safeguarding people's lives, property, well-being, and economic operations. Therefore, policies should move beyond the "sectoral" and "fragmented" approaches, elevate the building of a climate-adaptive society to a key national governance and development goal, and comprehensively promote the "mainstreaming" of climate adaptation.

1. Systematically elevate the construction of a climate-adaptive society as a strategic ambition for national policy modernization and deploy it as a strategic task that integrates high-quality development with high-level security resilience to extreme weather conditions and the consequences of climate change. Guided by the 2035 goals, formulate a national action plan for building a climate-adaptive society, and set visionary targets for 2050 and 2100 under different climate scenarios.
2. Improve the working and policy systems for climate adaptation. In response to the needs of building a climate-adaptive society, systematically promote policy innovation in laws and regulations, institutional arrangements, working mechanisms, fiscal and financial support, scientific and technological innovation, and technical standards. Establish a full-chain workflow of "monitoring–early warning–assessment–action–feedback–improvement", together with a multistakeholder coordination mechanism in a multi-scale approach.
3. Establish a regular mechanism for assessing climate risks and climate resilience capacity. Integrate climate risk assessment into the full process of national economic and social development planning, territorial spatial planning, urban renewal actions, ecological and environmental governance, agricultural development, approval of major infrastructure projects, and siting of energy bases and public service facilities. Incorporate core risk and resilience assessment indicators into the central government's "urban development evaluation system."

6.2 Promote Locally Tailored Climate-Resilient Upgrading and Retrofitting of Infrastructure and Lifeline Infrastructure

1. In response to the differentiated climate risks faced by different regions and different types of urban and rural areas, promote targeted upgrading and retrofitting of water conservancy and flood-control facilities, disaster prevention and mitigation systems, energy and communications infrastructure, transport and inland waterway infrastructure, urban municipal facilities, rural agricultural production areas, and critical underground spaces. Strengthen cross-regional coordination in infrastructure upgrading and retrofitting, and systematically enhance capacity to cope with extreme weather and climate-related disasters.

2. Launch a dedicated national initiative to revise engineering construction standards for climate resilience. Priority should be given to standards for urban drainage and waterlogging prevention; flood protection for underground spaces, seawalls, and embankments; lifeline infrastructure; ports and waterways; and energy facilities. Differentiated technical standards and requirements should be developed in accordance with climate change trends across different types of regions, providing targeted guidance for upgrading and retrofitting infrastructure and lifeline infrastructure.

6.3 Link Climate Adaptation Capacity Assessments with Differentiated and Targeted Local Climate Adaptation Strategies

Regions vary significantly in their exposure to climate risks and in their socio-economic and development conditions. Preferences for interventions are influenced by culture, tradition, and knowledge of alternative solutions. The impacts of climate change and the prominent challenges for adaptation exhibit marked spatial differentiation. Therefore, it is not feasible to address adaptation gaps in different regions with identical measures and technical standards. It is essential to identify local adaptation priorities through climate adaptation capacity assessments and to carry out adaptation actions in a timely manner, tailored to local physical, social, cultural, and economic conditions and the preferences of the local population.

1. Develop differentiated adaptation policy packages by risk type, taking due account of the local socio-economic conditions and intervention preferences. Coastal urban agglomerations should focus on sea-level rise, storm surges, saltwater intrusion, and coastal wetland degradation, advancing the construction of levees, estuary tidal barriers, and interconnected raw water networks. In China, the Chengdu-Chongqing region and the middle and upper reaches of the Yangtze River should focus on high-temperature drought, hydropower fluctuations, and peak energy load risks, developing virtual power plants and restoring traditional small-scale water conservancy facilities. The northwestern and northern warming-wetting regions should prioritize adaptation to local torrential rains and flash floods, update outdated drainage standards, revise rainfall intensity formulas, and address drainage and flood-control deficiencies. The northeast and the Qinghai-Tibet Plateau should pay special attention to permafrost and glacier degradation, ecosystem shifts, and infrastructure stability.

2. Promote NbS systematically. Integrate wetlands, tidal flats, floodplains, blue-green sponge-city

solutions, ecological sea dikes, mangrove coastal protection, and small-scale water conservancy facilities into the resilient infrastructure system to achieve coordinated progress in engineered flood and drought protection, ecological buffering, and urban renewal. Improve river sediment management to avoid accumulation in reservoirs, bed and bank erosion in downstream stretches, and coastal erosion. Stimulate the natural accretion of sediment that is essential for the development of coastal wetlands.

6.4 Establish and Improve a Coordinated and Synergistic Mechanism for Climate Adaptation

The hazards caused by climate risk are notably cross-sectoral, cross-regional, and cross-departmental. Climate adaptation challenges often propagate to other sectors and regions through complex interlinkages, further amplifying risks. Isolated adaptation actions can undermine the effectiveness of interventions. Therefore, it is necessary to establish an overarching coordination mechanism for climate adaptation actions that involves international, cross-departmental, cross-administrative, and cross-basin collaboration, as well as cooperation among multiple stakeholders, including government, businesses, and the public.

1. Strengthen coordination in climate observation, forecasting, and early warning. Integrate data from meteorology, hydrology, oceanography, geology, territorial space, population, industry, transport, energy, infrastructure, ecosystems, and disaster losses to form a publicly accessible, nationally unified, dynamically updated climate risk spatial baseline map. This map should serve planning and site selection, revision of engineering standards, disaster early warning, insurance pricing, fiscal and business investment decisions, and joint basin operation. Promote a shift in interdepartmental collaboration from information sharing toward joint assessment, joint early warning, joint emergency planning, and coordinated recovery operations—"building back better."

2. Improve coordination mechanisms for climate adaptation in key sectors. Establish a coordination mechanism for building a climate-adaptive society under the leadership of the State Council, bringing together departments responsible for ecology and environment, development and reform, finance, natural resources, housing and urban-rural development, water resources, transport, health, emergency management, meteorology, energy, and financial regulation. Priority should be given to addressing prominent issues such as insufficient policy coordination across departments and fragmented project implementation, while jointly strengthening the capacity to adapt to climate change in key areas, including ecosystem protection, agriculture and food security, personal and public health, infrastructure and logistics, and urban human settlements.

3. Establish cross-regional and cross-river basin coordination mechanisms for climate adaptation. In response to the spatial transmission of climate risks, establish cross-administrative adaptation coordination mechanisms at the scale of river basins and urban agglomerations. For example, multi-objective joint operation mechanisms covering flood control, water supply, power generation, navigation, and ecology should be established in major river basins such as the Yangtze, Yellow, and Pearl rivers, as well as in major urban agglomerations.

4. Integrate the climate resilience of inland waterway transport into national climate adaptation and economic development strategies. The reliability of inland waterway freight transport is essential for economic development and for the security of supply chains, food, and energy. Enhancing the climate resilience of inland

waterway transport requires a systemic approach that integrates infrastructure renewal, digital upgrading, operational management, and long-term planning. Priority should be given to strengthening climate resilience capacity through forecasting systems, digital technologies, flexible fleet development, and coordinated river-basin governance. At the same time, climate adaptation measures for inland waterway transport should be coordinated with broader objectives such as water security, ecological restoration, energy transition, and regional economic resilience to maximize overall benefits.

6.5 Uphold Climate Justice, with a Focus on Strengthening the Climate Resilience of Vulnerable Groups and Less-Developed Regions

1. Establish community-level climate risk inventories and tiered protection mechanisms for vulnerable populations, with a particular focus on older people, children, people with chronic illnesses and disabilities, outdoor workers such as delivery and construction workers, low-income households, and users of sensitive spaces such as underground facilities. Give due attention to gender justice in climate adaptation. Ensure women's and other marginalized groups' right to meaningful participation in community-level, regional, and national adaptation decision-making, and establish mechanisms for gender-disaggregated data collection, monitoring, and evaluation. Ensure equitable access to the benefits of adaptation and prevent climate risks and adaptation costs from being shifted onto vulnerable groups, non-beneficiaries, or next generations.
2. Strengthen policy, project, and investment support for climate adaptation actions in less-developed regions, rural areas, small and medium-sized cities, and small towns. Based on the results of climate risk and adaptation capacity assessments, take targeted measures to strengthen climate resilience.
3. Develop a gender-responsive and socially inclusive monitoring, evaluation, and learning system, with gender and social inclusion indicators and using gender-disaggregated data to quantify climate change impacts on vulnerable and marginalized groups and to check the effect of interventions on these groups.

6.6 Improve the Fiscal and Financial Support System for Climate Adaptation and Attract Diverse Actors to Invest in Climate Resilience

Climate adaptation actions require large and long-term investments. Some projects have strong public-good attributes, and their benefits are difficult to internalize. Relying solely on government fiscal funding is unsustainable. It is urgent to build a funding guarantee system that combines public funds with market mechanisms and participation by multiple actors.

1. Establish a dedicated national climate adaptation fund or designate specific budget lines for adaptation across existing financial channels. These channels include the central government budget for investment, special-purpose bonds, urban renewal initiatives, ecological conservation and restoration projects, and post-disaster recovery efforts. This will ensure stable and sustainable financial and policy support for local climate adaptation actions.

2. Promote innovation in instruments such as resilient infrastructure bonds, catastrophe insurance, parametric insurance, agricultural drought insurance, and eco-environment-oriented development. Adapt accounting rules for businesses to support their private investment in adaptation measures. Allow for long depreciation periods and create bonuses for companies that invest in adaptation measures. Incorporate climate and extreme weather risk into policy-based insurance terms and expand coverage.

3. Develop a universal and comparable accounting framework and evaluation rules for the comprehensive benefits of climate adaptation. Incorporate multiple benefits and co-benefits of adaptation measures into investment decisions to break the inertia of "prioritizing mitigation over adaptation" in fund allocation.

6.7 Raise Public Awareness and Participation in Climate Adaptation and Foster Society-Wide Synergy for Adaptation

Building a successful climate-adaptive society ultimately depends on the risk awareness and the participatory capacity of the whole society. Due to the insufficient public understanding of climate change and adaptation options, the implementation of relevant policies and measures has been relatively slow. Even in countries and regions where the public generally acknowledges that climate change is occurring, there is still a widespread underestimation of the pace of climate change and the urgency of adaptation measures. Therefore, it is essential to vigorously enhance public awareness and knowledge of climate vulnerability and adaptation options and encourage broad public participation in adaptation actions. It is recommended to incorporate climate risk education into the national education system and conduct regular disaster prevention drills and science outreach through community, school, and enterprise networks. Establish a knowledge-sharing platform for climate disaster cases, establish coping and recovery capacity and adaptation experiences, and foster a disaster-prevention culture of "knowing the risks and being able to respond."

6.8 Deepen South–South and East–West Cooperation on the Development and Exchange of Adaptation Expertise and Experiences

1. Leverage the similarities in climate conditions and adaptation practices between different regions of China and many regions around the world to expand cooperation networks with international research institutions and government agencies. Create enabling conditions for mutual visits by Chinese and international experts, data sharing, experience exchange, and joint research, and draw on global experience to inform policy-making in China and vice-versa.

2. Strengthen South–South and East–West cooperation on climate adaptation by summarizing and promoting China's experience in areas such as climate-adaptive city development and sponge-city construction, and by organizing technical seminars and training programs for other countries. These efforts should enhance China's influence in global climate adaptation and support other countries in strengthening their climate adaptation capacity.

References

[1] WORLD METEOROLOGICAL ORGANIZATION. State of the Global Climate 2025 [R]. Geneva: WMO, 2026.

[2] The Guardian. At least 35,000 excess deaths recorded in Europe's back-to-back heatwaves [N/OL]. (2026-08-25).

[3] UNFCCC. Adaptation Action Newsletter [EB/OL]. (2026-04). https://myemail-api.constantcontact.com/Adaptation-Action-Newsletter.html?soid=1137422682642&aid=bj6YqS95g2A.

[4] United Nations Framework Convention on Climate Change (UNFCCC). (2010). The Cancun Agreements.

[5] United Nations Framework Convention on Climate Change (UNFCCC). (2015). The Paris Agreement.

[6] Intergovernmental Panel on Climate Change (IPCC). (2023). Climate Change 2023: Synthesis Report. Geneva: IPCC.

[7] World Bank. (2025). Mobilizing Nature-Based Solutions for Disaster and Climate Resilience. Retrieved July 1, 2026, from https://www.worldbank.org/en/results/2025/07/10/mobilizing-nature-based-solutions-nbs-for-disaster-and-climate-resilience.

[8] World Bank. (n.d.). Country Climate and Development Reports (CCDRs). Retrieved July 1, 2026, from https://www.worldbank.org/en/publication/country-climate-development-reports.

[9] C40 Cities. (n.d.-a). C40 Cities Adaptation Planning Resources Guide.

[10] C40 Cities, & World Resources Institute. (n.d.). Inclusive Planning Roadmap: Indicators Guidance—C40 Cities Inclusive Climate Action Indicator Module.

[11] C40 Cities, & Ramboll. (2019). Measuring Progress in Urban Climate Adaptation: Monitoring, Evaluating and Reporting Framework.

[12] WHITE HOUSE. (2023). National Climate Resilience Framework [R/OL].

[13] Grantham Research Institute on Climate Change and the Environment. How climate laws create impact [EB/OL]. (2025-10-22). https://www.lse.ac.uk/granthaminstitute/news/how-climate-laws-create-impact/.

[14] CCICED (2024) *Green Development and Climate Adaptation for Urban and Rural Areas*. Special Policy Report, China Council for International Cooperation on Environment and Development. Green Development and Climate Adaptation for Urban and Rural Areas - CCICED

[15] Yating HOU, Weiming XIE, Jiaheng YUAN, Xianye WANG. Response characteristics of the evolution of Chongming Dongtan wetland in the Yangtze River Estuary to sea level rise[J]. Journal of East China Normal University (Natural Science), 2025, 2025(2): 42-54.

[16] YU H H, ZHOU C Y, KE X S, PANG Y S. Characteristics of heatwave and heavy rainfall in Sichuan-Chongqing Region and corresponding adaptive strategy[J]. Yangtze River, 2024, 55(11): 146-154.

[17] Chundie Yan, Yang Li, Quanliang Chen, Xin Zhou, Wei WangXiao Li, Yun Zhu, Xinyue Cao, Guolu Gao, The record-breaking compound heatwave and droughtevent in 2024 over the Sichuan Basin, Southwest China, Atmospheric and Oceanic Science Letters (2026), doi: https://doi.org/10.1016/j.aosl.2026.100786

[18] WANG Xuejia, LI Xiehui, HUANG Jian.Analysis of the Spatiotemporal Variation Characteristics of Summer Heatwave Events in the Sichuan-Chongqing Region over the Past 35 Years[J]. Journal of Chengdu University of Information Technology,2026,41(01):134-140.

[19] CHEN Z S, GAO Y F, ZHAO S M. Analysis on Spatial-temporal Characteristics of Climate Change in the Cheng-Yu Economic Zone During 1960—2017 [J]. Journal of China West Normal University (Natural Sciences), 2019,40 (3) : 296-303.

[20] Sun B, Wang H J, Huang Y Y, et al., 2023.Characteristics and causes of the hot-dry climate anomalies in China during summer of 2022[J].Trans Atmos Sci,46(1):1-8.

[21] YANG G, HUANG H, SU Z C, et al. Practices and reflections on defending against severe summer and autumn droughts in the Yangtze River Basin[J]. China Water Resources, 2023, (11): 8-11.

[22] ZHANG Xiang, WEI Yanfang, LI Siyu, LIANG Da. From drought disaster towards drought disaster chain: state of art and challenges[J]. Journal of Arid Meteorology, 2021, 39(06): 873-883.