China Council for International Cooperation on Environment and Development

CCICED

SPECIAL POLICY REPORT

Green Development and Climate Adaptation for Urban and Rural Areas

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

Green Development and Climate Adaptation for Urban and Rural areas

Climate Adaptation in a Changing World

CCICED Special Policy Study Report

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Executive Summary

The escalating risks posed by climate change make it imperative to urgently implement systematic climate adaptation measures. Climate change in interaction with non-climate drivers (demography, economic and land use development, existing policies and societal systems) is a risk multiplier for densely populated regions, cities and rural areas, in river basins, deltas and coastal areas. The increase in frequency and intensity of weather extremes due to climate change all over the world leads to severe economic damage, casualties and the disruption of communities, challenging disaster management systems and long-term adaptive capacities. This study assesses the experiences of governments and others with disasters due to weather extremes and adaptation to climate change until today. Information was collected through field visits in some typical regions in China and NW-Europe, combined with the findings of empirical studies and case studies retrieved from literature. The study places climate adaptation in the context of longer-term resilience; outlines an assessment framework; and proposes priorities for improving climate resilience in densely populated areas and urban and rural development.

Key Findings

1. Climate change and the intensity of weather extremes like heat waves, storms, peak-precipitation, flooding and drought already **exceed** today's disaster management capacities of regions and cities **('adaptation gap'**). Our field visits in China, The Netherlands, Belgium and Germany confirmed this, with explicit examples of disruption by multiple years of drought, extreme rainfall events (water bombs*)*, and extreme river discharges.
2. Climate adaptation and dealing with long-term climate-related uncertainties is **an additional challenge for governments and societies.** The current understanding of the urgency of climate adaptation, the prevalence of gaps in climate adaptation capacity, and how to systematically carry out climate adaptation actions is in many respects not sufficient. Based on empirical studies from the Chengdu-Chongqing urban agglomeration in the upper reaches of the Yangtze River, the Taihu Basin in the lower reaches, the Pearl River Delta, as well as international case studies in the Rhine, Meuse and Scheldt River basins, the i**mportant gaps** in climate adaptation included: i) insufficient capacity of urban and rural spatial patterns to adapt to climate change; ii) inadequate regulations, procedures and standards to address climate change and build back better; iii) lacking cross-departmental coordination of urban disaster prevention work, and the overall coordination function of the emergency management department is not fully utilized; iv) low risk awareness and risk resistance of community residents; v) insufficient mechanisms of regional cooperation.
3. Conducting climate adaptation assessments is crucial for identifying key challenges, adaptation gaps, and priorities. The concept of **five critical capacities** for climate adaptation provides a constructive framework for assessing and improving the physical and institutional capacities to **reduce the climate adaptation gaps**. These capacities aim at i) adapting and improving the **disaster risk management** systems by improving *threshold capacity*, *coping capacity* and *recovery capacity* and ii) improve **adaptive and transformative capacity** in the policy and decision-making processes to deal with the long-term future challenges. **Ten enabling conditions** are critical for strengthening these capacities.
4. **Climate adaptation is not a stand-alone issue** but requires integration in development strategies across many policy domains and across scales, from national to local. The findings support the need to **better tune sectoral and spatial policies** at all levels. **Integrated diagnostics and climate resilience**

stress-tests should become the basis for improving policy coherence, increasing public and stakeholder participation and measuring performance. The transition from a fragmented, primarily reactive approach towards an integrated anticipating approach will require a huge effort for all governments and societies. Building commitment and trust by well-organized and participative processes reaching out to the local communities and other stakeholders is essential to make the change.

5. Climate adaptation offers comprehensive benefits, not only reducing the risks associated with climate change but also presenting significant opportunities to promote green development. Successful examples of spatial adaptation projects are found in **combining grey and nature-based solutions**, maximizing the multiple benefits and additional return flows while minimizing the potential damage of extreme weather events. Implementing climate adaptation measures can drive technological innovation, attract investment in infrastructure improvement, strengthen urban resilience, and ecological restoration, and accelerate the achievement of green development goals. Compared with climate mitigation actions, the long-term financial-economic benefits of climate adaptation are often difficult to quantify due to a lack of data. Therefore, while **local authorities lead** in their own urban and rural development, long-term **commitment and support** of the **national governmant** throughout the entire adaptation process, from planning, construction and operation to disaster relief and post-disaster reconstruction, is of critical importance to accelerate adaptation across regional and local scale.
6. Many practitioners emphasize that the design and implementation of policies to adapt to climate change should **consider the unequal vulnerabilities of specific groups and regions** to cope with climate change and engage in adaptation efforts. This report highlights the connection with rural development and, specifically in China, the potential of the policy notion of *Common Prosperity*.
7. The **national government has a critical role** in helping to both improve the disaster management capacities on regional and local scale and as well as helping to develop and support long-term adaptive and transformative approaches in the decision-making process about future economic, social and spatial developments and investments. **Priorities** include:

   i) strengthening the prediction and early warning capacities, establish a disaster response mechanism for local and regional/river basin coordination, and enhance awareness and disaster preparedness capabilities of urban and rural communities;

   ii) improving the resilience of disaster prevention facilities and critical infrastructure to extreme weather disasters, and strengthen the adaptability, redundancy and backup of lifeline facilities;

   iii) carrying out coherent assessments of climate adaptation challenges (stress-tests) on local, regional and national scale to identify the main climate risks, potential adaptation pathways and the short- and long-term adaptation capacity shortcomings faced by the region or specific locations;

   iv) changing the mode of urban and rural spatial planning and construction, strengthen the reservation and protection of urban natural storage space for water, following the paradigm 'water and soil steering';

   v) ensuring an institutional framework where structurally funded, independent, multidisciplinary research is conducted on climate change and its impact at national, regional, and local levels, and provides ex-ante and ex-post evaluations on the effectiveness and efficiency of climate adaptation policies at all scales.
8. As urban spatial layout **endures for centuries**, it is of critical importance that **from now on** all authorities, from national to local level, are fully **transparent** in how climate adaptation is addressed

in their development decisions and in planned urban and rural design. **No-regret actions** accelerating climate resilient development include re-assessing planned public and private investments and better rebuild after a disaster. Existing laws, regulations and insurance practices however may hamper this.

9. The **financing of adaptation is challenging today's way of working**, procedures, methods, regulations and funding. As to financing climate adaptation, much has to be discovered yet. Business-as-usual developments and investments may lead to maladaptation, high societal disruption and economic losses, may increase the risk of stranded assets in high-risk locations and may reduce the solution space for future generations. It is of critical importance to explore how new financial spaces can be created to stimulate and support adaptation across sectors and scales. This aspect is still lacking within CCICED.
10. As to science, societal and economic integration and policy development, climate adaptation is still in its infancy **. Further international collaboration and exchange of experiences across countries, regions and cities will be of critical importance** in building *collective intelligence* and support effective learning in improving disaster risk reduction, in developing effective adaptation strategies on the short- and long-term and in creating financial foundations to facilitate this new direction and support a transformative climate resilient development.

Main recommendations:

1. National, regional and local governments should urgently elevate the political and governance priority of adaptation as climate risks are increasing and disaster losses are huge.
2. The national government should build a systematic policy framework for short- and long-term action, from the central to the local level, across regions/basins and sectors, and with active participation of society, industry and local communities.
3. The national government should establish a climate adaptation assessment framework and process to identify gaps in climate resilience and provide a solid foundation for urban and rural areas to assess, monitor and improve their adaptation policy and capacity.
4. The national government should pay attention to social equity and gender and should enhance the climate adaptation capacity of especially less developed regions and vulnerable groups.
5. CCICED should continue to strengthen international knowledge exchange on climate adaptation policies and practices, as climate adaptation is still in its infancy as to science, societal and economic integration and policy development.

Key words：

Climate adaptation, resilience, capacities, enabling conditions, case studies, lessons learned from disasters, stress-testing, equity, multi-scale, multi government, multidisciplinary adaptation planning and design.

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Climate Adaptation in a Changing World

1. Introduction

Climate change is already here, now. The years 2014-2023 became the hottest decade on record, with more frequent and more severe extreme weather events cause casualties, economic damage, social disruption, loss of biodiversity and reduced harvests all around the world [1]. Humanity and nature already suffer from floods, droughts and heatwaves to a degree never seen before. And the trend of global rising temperatures that is driving these changes will continue for the decades and centuries to come [2]. This trend will cause more adverse impacts, including sea level rise, shortages of water resources and water quality problems. While the reduction of greenhouse gas emissions – climate mitigation – is essential for reducing the future risk of climate-related disasters, it must be combined with immediate adaptation strategies to effectively manage the current and anticipated impacts on humans and nature [2].

While climate change is a global issue, adaptation needs are location-specific. Cities face increasing climate risks due to high concentrations of population and economic activity. In particular the heavily urbanized and industrialized estuarine delta regions, such as the Yangtze River Delta, Pearl River Delta, and Rhine-Meuse-Scheldt River Delta, have in recent years experienced huge loss of life and property as a consequence of mega-rainstorms, mega-floods, extreme droughts, extreme heatwaves. The countryside is also facing a changing climate, affecting the rural population and the harvest yields they depend on. Cumulatively, reduced harvest creates the risks of regional - or even global - famine. Due to climate change, agricultural production practices must change too.

Integrated watershed management is more important than ever because of problems such as increasingly frequent floods and water scarcity during droughts. Therefore, water management in downstream areas must be balanced with water management upstream to prevent flooding after heavy rainfall as well as to ensure drinking water supply in times of drought, while maintaining and navigability of rivers through all seasons. In order to comprehensively address the problems posed by climate change, international, interregional and inter-organizational cooperation is needed to ensure the effectiveness and timeliness of climate adaptation measures. Moreover, measures must be taken with care for biodiversity, as loss of biodiversity puts pressure on human resilience, health and harvest yields. The social consequences of climate change are not to be underestimated. The most vulnerable groups in society – elderly, women, children - are the hardest hit by the impacts of climate change. Equity is important for climate adaptation; equity between regions, countries and between generations. The standard of living in rural areas is lower than in cities. Access to education and healthcare is more restricted. Consequently, the ability of the local population to invest in necessary adaptation measures is more limited.

The progressive nature of climate change, combined with already densely populated area's increases difficulty of action. At the same time, due to their social and economic strength and importance, densely populated urban and rural areas can become transformational centers for climate adaptation. Many initiatives and plans have been launched in recent years around the world, such as the Delta Decision for Spatial Adaptation issued by the government of the Netherlands in 2015, the Sigmaplan in Flanders, Belgium, and the National Climate Change Adaptation Strategy 2035 jointly issued by 17 government departments in China in 2022, as well as pilot projects for the construction of climate-resilient cities. This is a good start for climate adaptation action. However, there are still problems such as insufficient early warning capacity for the superimposed multi-system risks brought by climate change, insufficient adaptive capacity of urban space and critical infrastructure, and insufficient systematic and cross-sectoral synergy of work.

This Special Policy Study (SPS) focuses on how to enhance climate resilience in the urban and rural planning and construction sector. One of the objectives of the study is to provide an assessment framework for climate adaptation that is appropriate for urban and rural planning and construction, to identify gaps in urban and rural climate resilience, and to propose and prioritize interventions for climate adaptation. The study explores how different countries have responded to climate change and weather-related disasters and what lessons can be learned from their existing developments. Information was collected during field visits in China and Northwestern Europe – See annexes E and F - as well as through a wide network of experts that was consulted. The study focuses on the necessary capacities to build climate resilience around climate adaptation goals, as well as measures and approaches to strengthen these capacities.

The study identified the need for immediate climate adaptation action, the urgency of conducting urban climate resilience assessments, the urgency of fostering collaboration among stakeholders, including government and society, and the need to incorporate scientific knowledge on social equity and on long-term and short-term climate change into decision-making on climate adaptation. This is done through the following structure.

Chapter 2 introduces a conceptual framework to systematically assess gaps in climate resilience. The framework identifies five capacities (threshold capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity) and a set of enabling conditions that can be used to evaluate the climate resilience of a specific case area.

Chapter 3 provides illustrative cases of adaptation policies and practices for climate change. The chapter includes cases in different geographical locations (deltas and high-altitude), the impact of recent extreme weather events and the need for change towards the future.

Chapter 4 focuses on lessons learned from the response to extreme events worldwide. It illustrates that the need for adaptation is global. While effects can be devastating, it also creates the global possibility to learn from different nations and to incorporate good examples in future policy making.

Chapter 5 addresses equity aspects and addresses the need to take actions in a fair manner that empowers and protects the vulnerable.

Chapter 6 focuses on the geography, time scale and institutional arrangements that impact the governance structure to handle climate change. It includes insights in the relation between cities and regions as well as insights in balancing short-term and long-term action related to the five capacities and their enabling conditions.

Chapter 7 introduces a systematic way of climate stress-testing and adaptation planning, using the five capacities and their enabling conditions for creating climate resilience as an assessment framework to identify gaps and weaknesses in climate resilience, thus creating a solid basis for accelerating adaptation interventions planning and implementation.

Chapter 8 recommends immediate action to address climate change and to use long-term perspectives as leading insights for action. It flags the need to collaborate between different layers of government and to minimize the boundless impacts of extreme weather events and to take action in a way that is fair, for the vulnerable, to nature, and for future generations.

2. Conceptual Assessment Framework for Climate Adaptation

In the current context of heightened climate change risks and prevailing climate resilience gaps, an assessment framework is needed to systematically evaluate climate resilience and adaptation policies and practices in different countries and regions. This framework is also meant to analyse the lessons learned from climate disasters and narrow escapes. It is applicable at different spatial and temporal scales, from local district to river basin and from flash flood producing rainfall events to slowly increasing hazards from sea level rise or increasing drought risk. The assessment is to be based on an analysis of the local geographical situation, on lessons learned from disasters in the past and on a systematic analysis of the multiple climate risks, taking expected future social and physical geographic changes into consideration. The assessment ought to result in actionable recommendations for the government, businesses and residents.

2.1 Climate adaptation resilience assessment methods

In recent years, in order to promote the effective implementation of climate adaptation measures and accelerate the transition, international organizations such as the United Nations, national governments such as USA and EU, 100Resilient Cities [3], academia and consultants and launched a wide variety of tools to assess (a) the need for adaptation, (b) the benefits of climate adaptation measures and (c) the enabling conditions and quality of the tools to accelerate implementation . Some of these tools support a qualitative evaluation of climate risks and adaptation opportunities, while other tools provide quantitative assessments; some come from a disaster risk reduction background, while other framework have their roots in the evaluation of sustainability. Without the intention of being complete reference can be made to IPCC [4], The Fifth U.S. National Climate Assessment [5], EU Adaptation Strategy [6], Leeuwen et al. [7], UNISDR [8], De Graaf-van Dinther and Ovink [9], UNDRR [10], The White House [11] and Arcadis [12].

Despite this fragmentation of climate adaptation assessment frameworks, three phases of climate adaptation and resilience can be identified: (1) Preparedness and precaution, (2) Relief and (3) Recovery/rebuilding. Rather than contributing to a further fragmentation, it was decided to use a framework that can “host” elements from other frameworks, work with them all and help align these, tailored to phases of disasters, the geographical and political, cultural and policies context. The assessment framework should allow for long term perspectives, as investments in infrastructure in general have a lifespan of decades to even centuries, while the climate is changing, and future demands are unknown. The framework should build on an in-depth analysis of the physical, ecological, social and economic systems and their dynamics, locally and at river basin scale, as well as on an assessment of the climate vulnerability of the existing system, of trends in society that will have an influence on this vulnerability.

The framework should not only be focussing on disaster risk reduction, for ‘sudden’ disasters like floods and droughts, but also include slow changes like sea level rise and the consequences of increasing average temperatures. It should be helpful in identifying potential policy pathways to enhance resilience, including short term adaptability as well as long term transformative changes and the enabling conditions needed for such fundamental changes in, for example, governance structure, financing, standards and legislation.

2.2 Five capacities and their enabling conditions for creating climate resilience

The various types of risks resulting from climate change are intensifying, and the frequency of extreme weather and related disaster events continues to increase in China and around the globe [2]. The objective of climate adaptation is therefore to build climate resilience capacity. Climate resilience capacity is needed to plan and implement interventions that first of all should minimize the risk of extreme weather events and sea level rise. These interventions, when green and selected smartly, can also produce significant economic, social and ecosystem services and benefits. Maximizing these positive effects while minimizing the risks is the core challenge of climate adaptation. In that sense, climate adaptation is more than mere disaster risk reduction.

To build climate resilience capacity, five types of capacity should be included [9]. An assessment framework for building climate resilience in urban and rural areas can be underpinned around assessing their threshold capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity, as well as examining the impacts of the enabling conditions that create the capacity for change.

2.2.1. Five capacities for climate resilience

A brief outline of the five capacities is given below. An extensive description of the capacities and their enabling conditions can be found in Annex A.

1. **Threshold capacity**

Refers to the capacity to cope with disaster risk thresholds established in urban and rural areas to avoid disaster losses due to extreme climate events. For example, in flood risk management, the threshold for rivers to cope with flood flows can be increased by constructing river embankments and increasing the flood discharge capacity of rivers. The determination of maximum thresholds for disaster prevention requires the assessment of design standards for disaster prevention that take into account both past historical disaster data and future-oriented trends in climate change, sea level rise and other changes.

2. **Coping capacity**

Refers to the ability of an urban or rural area to reduce disaster losses following a disaster caused by extreme weather. This includes, for example, the ability to reduce human and economic losses in the case of floods, or the ability to avoid water losses in the case of drought disasters. Factors influencing resilience include the presence or absence of measures to reduce disaster losses, effective early warning systems, public awareness and education, and rational management mechanisms for disaster prevention and relief.

3. **Recovery capacity**

Recovery capacity is the capacity of urban and rural areas to recover from a disaster to a state consistent with or better than the state before the disaster ("Build Back Better"). The objective of this capacity is to focus on achieving rapid and effective disaster recovery and reconstruction. Influencing factors include inputs such as financial resources, technology, and specialized personnel. Depending on the spatial scale of the disaster's impact and its severity, recovery events range from weeks to decades.

4. **Adaptive capacity**

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. Improving the long-term adaptability of infrastructure and maintaining an open and diverse design of climate adaptation measures all contribute to increasing adaptive capacity.

5. **Transformative capacity**

This capacity refers to the ability of the current social, economic and governance system to transform and pro-actively change itself in the face of expected disaster risks, such as climate change impacts, by changing into a new system with different system characteristics. Transformative capacity is society's capability to create an enabling environment that leverages adaptation.

2.2.2. Enabling conditions for five capacities

Enabling conditions are needed to be able to take action in strengthening the five capacities. If these conditions are insufficiently met, adaptation of existing infrastructure and practices will be hard, if not impossible. Enabling conditions needed for leveraging the five capacities include [13, 14, 15, 16]

- Sense of urgency: Informed public, industries and decision makers on facts and figures in an appealing narrative, driving the will to act.
- Systems approach beyond jurisdictions, human-made borders, but looking at the whole environmental/subsurface/water systems, economic dynamics and societal structures.
- Capacity development: Knowledge and skills of individuals, communities, and organizations to develop, implement and maintain resilience creating interventions.
- Trusted knowledge, data and information; Independent research and open access, transparent data and information, shared with all stakeholders, feeding risk- and opportunity-informed decision making.
- Financing: Adequate, coordinated funding to implement, operate and evaluate policies and interventions. Fair and just distribution of the financial burdens and benefits.
- Citizen's engagement: Citizen's and NGOs' involvement in the definition, co-creation, implementation and assessment of interventions.
- Policy, legal & regulatory framework: Policies, legislation, regulations, planning strategies and standards spur implementation and maintenance of interventions.
- Innovation: New methods, practices, and products to solve existing problems, and create new value. Creativity, research by design and best practices testing.
- Public-private system collaboration: Public-private cooperation and industrial symbiosis to develop and improve interventions. Early-stage public funding to create new markets
- (Fair) sharing of risks and rewards: Equity and inclusion. Mechanisms to fairly allocate risks and benefits, protect the vulnerable and include the silent people.

2.2.3. Concluding remarks

As can be seen, the threshold, coping and recovery capacity are related to disaster risk reduction, but now including the seizing of opportunities that will create added value to an area. The adaptive capacity is aimed at the flexibility of infrastructure, to be easily adaptable to future new conditions and requirements. And the transformative capacity relates to the human systems, the political and governance infrastructure and their power to steer the enabling conditions that result in systemic changes in spatial developments, economy and/or society.

3. Major Case Studies: Examples of Climate Adaptation Practices

Climate adaptation actions have been widely taken in countries around the world after suffering from climate disaster. And, aware of the expected climate change and its impact on the weather, countries, regions and local authorities have taken a more pro-active attitude; they have started to try and make the environment more resilient to extreme weather, rising sea level, an increase in average temperature and related consequences. In particular densely populated river basins and deltas are increasingly vulnerable to extreme weather events, such as the Chengdu-Chongqing region in the upper reaches of the Yangtze River in China, the Taihu Lake Basin, the Pearl River Estuary region, and the Rhine-Meuse-Scheldt urbanized deltas in North-western Europe, all of which have been challenged by severe extreme weather events in recent years. This chapter addresses the four case areas mentioned above and provides the results of these case studies in China, North-west Europe and the European Union, their struggle with disasters, their adaptation efforts, the *adaptation policies put in place so far and the gaps in their policies and practices when evaluating these from the perspective of the required five capacities and the enabling conditions for creating a climate resilient environment.*

A more extensive description of the cases is available in Annex BI and CI, while Annex E and F provides a report of the findings collected during the work visits to both areas in June/July 2024.

3.1 Case 1: Climate adaptation in the Chengdu-Chongqing area

3.1.1. Trends in climate change

The Chengdu-Chongqing area is characterized by a humid subtropical monsoon climate and high-altitude plateau climate, with an average annual temperature ranging from 4 to 20.9°C and annual precipitation between 800 to 1200 mm. Over the past 50 years, the region has experienced a fluctuating upward trend in temperature, with an average increase rate of approximately 0.14°C per decade, while precipitation has shown a linear decrease, with a decline rate of about 17.5 mm per decade. The frequency of extreme weather events, such as heatwaves and heavy rainfall, has increased, particularly in the southwestern areas. The occurrence of rapid shifts between drought and flood has decreased, but their intensity has risen, highlighting the intensification of climate change effects.

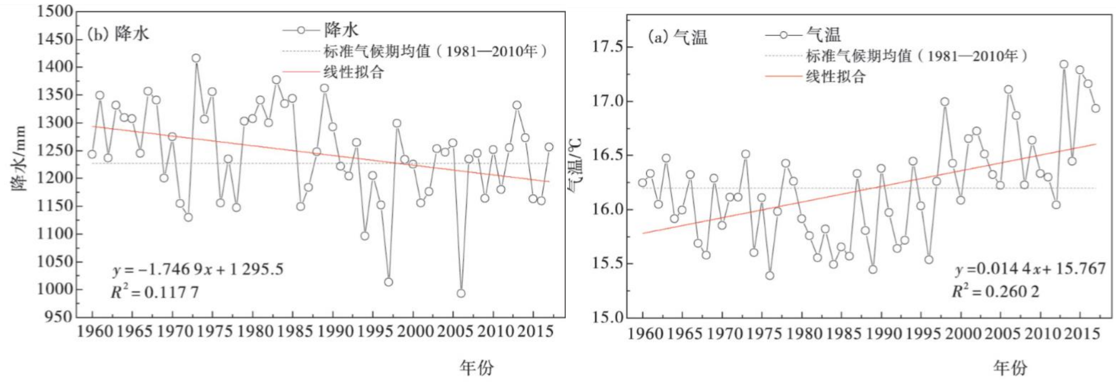

Figure 3.1. Statistics of precipitation(left) and temperature(right) trends in Chengdu-Chongqing area in 1960-2017.

3.1.2. Major disasters and issues arising from climate change

(1) Short-term heavy rainfall triggers flooding.

Summer rainstorms are a frequent extreme weather event in Chengdu and Chongqing, exacerbated by global climate change and the urban "rain island effect." Recent years have seen an increase in extreme meteorological and hydrological events, particularly affecting the mountainous city of Chongqing at the confluence of two rivers. This has led to the dual threat of localized torrential floods and river flooding. For instance, in July-August 2020, prolonged and intense rainfall in the upper Yangtze River basin caused 32 rivers, including the Tuo, Jialing, and Qingyi, to exceed alert levels, resulting in a significant flood in Chongqing. This disaster impacted 2.63 million people across 15 districts and counties, causing direct economic losses of 2.45 billion yuan.

(2) High temperatures and droughts trigger mountain fire disasters.

Chengdu-Chongqing area is rich in forest resources, subtropical broad-leaved evergreen forests, with the Chengdu-Chongqing area in recent years, high temperatures, drought and other extreme weather continues to appear, forest fires show more frequent situations. Chongqing 2022 has 32 forest fires, Beibei, Banan, Fuling, Dazu, Tongliang, Kaizhou, Fengjie and other 12 districts and counties in August 17-August 26 concentrated outbreaks of hill fires. The time to extinguish a single mountain fire was as long as 1-5 days, and the total area over fire reached 22.62 square kilometers (3023.5 acres of victimized forest area).

(3) High temperatures and droughts have triggered energy shortages.

The Chengdu-Chongqing region's energy structure relies heavily on hydropower, coal power, and natural gas, with hydropower comprising nearly 80% of Sichuan Province's total energy production. Seasonal climate variations significantly impact power generation, with a notable decrease in capacity during the dry season, leading to power shortages. Additionally, over 30% of Sichuan's annual power generation is exported to other provinces, exacerbating local supply tensions, especially during periods of extreme heat and drought. In the summer of 2022, Sichuan experienced prolonged extreme temperatures, reaching up to 44°C, coupled with severe drought. This led to a significant increase in cooling demands, with air conditioning accounting for up to 26% of the total power load. Meanwhile, precipitation was 43% below the historical average, resulting in a drastic drop in hydropower generation by over 50%, from 900 million to 440 million kilowatt-hours, creating a critical power supply gap.

(4) High temperatures and droughts have triggered reductions in agricultural production.

Despite significant investment in agricultural technology and capital, the total grain output in the Chengdu-Chongqing area increased from 42.71 million tons in 2003 to 46.9 million tons in 2023. However, the impact of climate change has gradually weakened overall grain production, with extreme weather conditions, particularly drought, leading to periodic reductions in yield. Drought is now the primary cause of reduced grain production. The peak agricultural water use period from March to May does not align with the region's rainfall patterns, exacerbating water shortages. Additionally, extreme weather shortens the development cycle of pests and diseases, expanding their impact and severity. In 2022, persistent high temperatures and drought from June to October severely affected Sichuan Province, impacting 7.62 million people across 138 counties and damaging 522,000 hectares of crops. This led to direct economic losses of 4.8 billion yuan, marking the most severe agricultural impact in the past decade.

(5) High temperatures and heat waves threaten health and safety.

Extreme and prolonged high temperatures have become a significant issue in the Chengdu-Chongqing area, particularly in Chongqing, where summer heatwaves are increasingly frequent and intense. These conditions have led to higher demand for drinking water and electricity, while droughts, water shortages, and reduced power generation have made access to essential resources difficult, especially for vulnerable populations. Prolonged exposure to high temperatures can cause heatstroke, dehydration, and exacerbate cardiovascular, cerebrovascular, and respiratory diseases. In the summer of 2022, Chongqing experienced a historic heatwave lasting 41 days.

3.1.3. Overview of priority climate adaptation measures in place

(1) Promote disaster prevention and mitigation projects.

China has basically built a group of reservoirs in the upper reaches of the Yangtze River with the Three Gorges Reservoir at its core, with a total flood control capacity of about 38.7 billion cubic metres, effectively playing the role of stopping floods and cutting peaks and staggering peaks; it has continued to promote the construction of river embankments to meet the standards and enhance the ability to defend against floods; it has organized the excavation of fire protection zones and optimized the layout and design of infrastructure, and has upgraded the level of operation and management of the infrastructure, and so on.

(2) Strengthening climate monitoring and early warning.

For example, new ground meteorological monitoring stations have been built, and an integrated meteorological observation system consisting of ground meteorological observation stations and high-altitude meteorological observation stations has been established. It has strengthened risk research and identification, organized geo-engineers and grid clerks to carry out flood and rain "triple checks", refined the granularity of heavy precipitation warnings, and enhanced climate change monitoring, early warning and risk management capabilities.

(3) Improving emergency response mechanisms.

These include the implementation of a daily dispatch system for disaster situations at the municipal level, the formulation of technical guidelines such as the Technical Measures for Responding to Grain and Oil Crop Production in Hot and Drought Weather, making full use of water conservancy facilities to increase the capacity for emergency irrigation, organizing late-autumn production to make up for the poor, organizing drought-resistant agricultural service teams to go deep into the countryside, and strengthening the capacity for regional coordination and the mobilization of personnel and materials, among other things. During the "8-20" flood of 2020 (the largest incoming flood since the construction of the Three Gorges.), 251,000 people were evacuated and 132,700 people were relocated. During the high-temperature hill fires of August 2022 in Chongqing, the emergency response was activated in a timely manner, and three forest firefighting and rescue headquarters in Gansu, Sichuan, and Yunnan, with a total of over 1,500 people, were mobilized to provide rescue services.

(4) Enhancing the adaptive capacity of economic and social systems.

The Chengdu-Chongqing region has already carried out relevant power and energy projects to optimize the supply structure of power and energy and increase the regional power coordination and security capabilities. At the same time, new emergency water sources have been developed to provide emergency water supply for remote areas with serious water shortages, thereby enhancing the adaptability to climate change. In addition, the “Chongqing City Climate Change Adaptation Action Plan” and the “Sichuan Province Climate Change

Adaptation Action Plan" have been issued, proposing to promote the green development and transformation of the regional economy and society through climate adaptation.

3.1.4. Current gaps in climate adaptation

(1) Threshold capacity

The Chengdu-Chongqing region has insufficient capacity to deal with various climate disasters. In terms of flood disaster response, the flood responding pattern of "people retreat when water advances while people advance when water recedes" has not been effectively promoted, and the compliance rate of flood prevention and bank revetment projects in the central urban area of Chongqing for once-in-50-years flood events is less than 50%. In terms of forest fire response, the adaptability of forest structure is insufficient, with a lack of fire-resistant and drought-resistant tree species, and the construction of firebreak systems needs to be improved. In response to crop failure caused by drought, the selection of crop varieties in some areas of the Chengdu-Chongqing region is not adapted to climate change, lacking resistance to diseases, pests, drought and flood. At the same time, due to the lack of systematic protection and restoration of the "pond-paddy field" system, partial destruction of ponds, paddies and canals has led to a decline in the regulation capacity for drought and flood.

(2) Coping capacity

Firstly, the capacity for climate change risk prediction is not strong, and the capacity for precise identification, assessment and planning response to risks is relatively weak. The regional climate estimation model in the Chengdu-Chongqing area is not perfect, and the climate prediction model is rudimentary, which restricts the ability to warn about risks. For instance, during the rare major flood in Chongqing in August 2020, due to the overdue forecast information, there is not enough time to transfer materials in time, exacerbating the losses from the disaster. A climate disaster risk map system has not yet been established, and there is a lack of disaster-targeted real-time identification and control systems for disasters. In addition, it is impossible to accurately identify the spatial scope and affected intensity of the disaster-stricken region before and during the disaster, resulting in a hysteresis in planning and emergency plans.

Secondly, there is room for improvement in public awareness of disaster prevention and relief as well as climate change response. For instance, during the rare major flood in Chongqing in August 2020, some merchants at risk, due to an underestimation of the flood's severity and a mentality of luck, refused to evacuate, ultimately suffering from losses due to the disaster. In the rural areas of the Chengdu-Chongqing region, there are limited conditions for information dissemination, and the farming community finds it difficult to obtain the latest climate change information and scientific knowledge. For example, during periods of high temperatures and drought, some farmers consider the disaster to be a natural phenomenon that cannot be avoided, lacking proactivity and enthusiasm for response. There is insufficient attention to highly vulnerable groups; during the high-temperature disasters from 2020 to 2022, government and health institution propaganda was mainly targeted at employers, focusing on high-temperature allowances, heat holidays and the protection of the rights and interests of the migrant worker group, lacking care for the elderly, children and other highly vulnerable groups.

Thirdly, the basic functions of urban lifeline systems such as power supply, water supply and drainage are still difficult to ensure. For example, forest fire prevention access roads are narrow and steep, making it difficult for large vehicles and machinery to reach the mountainous areas, resulting in untimely delivery of rescue supplies during mountain fires. The scope of the main water supply pipeline network in the Chengdu-Chongqing region is relatively small, which cannot supplement water sources for the vast rural areas. At the same time, mountainous rural areas lack alternative water sources, and a water resource allocation network that combines "large, medium, small and micro-scale" facilities has not been formed, leading to difficulties in drinking water for mountainous rural areas during heatwaves.

(3) Adaptive capacity

Firstly, there is a deficiency in the adaptive capacity of key facilities, including flood control projects, ultra-high voltage direct current (UHVDC) projects, agricultural irrigation projects, urban cooling facilities, emergency drinking water projects and other aspects. For instance, the UHVDC project systems such as Gansu Electricity, Tibet Electricity and Xinjiang Electricity entering Sichuan have not yet been formed. The sewage facilities and pipeline network along the river have insufficient resistance to pressure, and the agricultural water conservancy projects and irrigation systems are not comprehensive enough.

Secondly, the impact of climate on power supply is significant. Chongqing has limited potential for the development of its own energy resources, and the clean energy available for development and utilization is very limited. Sichuan's energy structure is relatively singular, with the main energy supply coming from hydropower, and power generation output is significantly affected by climate. In addition, the power transmission in the Chengdu-Chongqing region mainly focuses on outward transmission, accounting for about 30% of its own hydropower generation, and there is a lack of emergency energy security.

(4) Transformative capacity - the capacity to change

There is a lack of inter-departmental collaboration and smooth information sharing in the Chengdu-Chongqing region. The joint dispatching mechanism for water resources and energy across regions is yet to be improved. During droughts and floods, it is difficult to achieve overall dispatching and coordination in flood control, agricultural irrigation and other aspects. The regional linkage mechanisms for forest fire rescue and disaster relief need to be perfected. Besides, the public's understanding of and participation in climate change adaptation actions are relatively weak, and green and low-carbon mode of production and lifestyle have not yet been widely promoted.

3.2 Case 2: Climate adaptation in the Taihu Lake basin

3.2.1. Trends in climate change

In recent years, the Taihu Lake basin has experienced a significant increase in rainfall during the flood season, along with a rise in extreme weather events, leading to an elevated risk of low-probability natural disasters. Overall, annual precipitation has increased, with the area around Taihu Lake, the Pudong and Puxi districts, and the western part of the Hangzhou-Jiaxing-Huzhou region seeing the greatest increases. At the same time, there is a clear warming trend across the basin, with the impact of heatwaves in Shanghai intensifying, setting multiple high-temperature records in 2022.

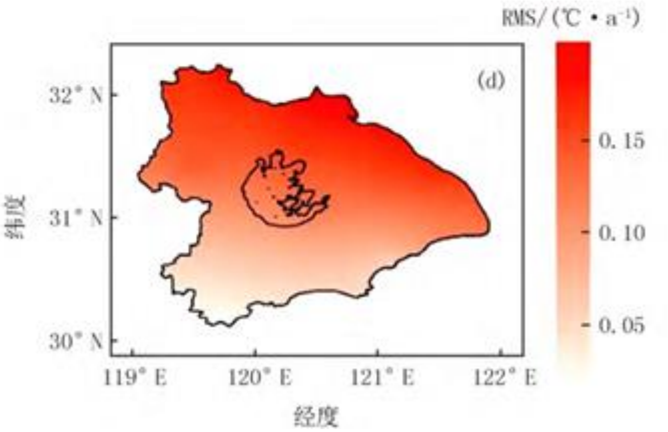

Figure 3.2. Spatial distribution of mean temperature increase in the Taihu Lake basin from 1990 to 2018

3.2.2. Major disasters and issues arising from climate change

(1) Frequency and intensity of extreme rainfall have increased significantly, and multiple events have shifted the focus of flood defense.

Strong convective rainstorms are prone to cause localized pluvial flooding in the city. Data from Shanghai between 2004 and 2015 show that thermal convective precipitation occurs on average every 11 days during summer under the influence of subtropical high pressure. For example, during the heavy rainstorm on July 21, 2023, central Shanghai, Qingpu District, and Northern Minhang District experienced six hours of continuous rainfall, with 71 stations recording over 100mm of rain within two hours. The Minhang District saw a peak one-hour rainfall of 121.5mm, surpassing the city's drainage capacity and resulting in severe waterlogging, with depths reaching up to 120cm in some areas and an average water depth of 0.23m.

Typhoons are frequent, and "wind, storm, tide and flood" are the most serious disasters. Since 2010, Shanghai has experienced two major events where all four factors coincided: Typhoon "Fitow" in 2013 and Typhoon "In-Fa" in 2021. During Typhoon "In-Fa," the combination of high astronomical tides and upstream water from the Huangpu River pushed water levels at Mishidu Station to a record 4.79m, exceeding previous highs by 20cm, and posing significant challenges to the Huangpu River embankment's safety.

(2) Increasing impact of the compound disaster chain of extreme heat wave and hydrological drought, such as flood season reversal and salty tide intrusion.

The persistent high temperature and low rainfall will easily lead to "flood season reverse dryness" in the basin. 2022 July-October precipitation in the Yangtze River Basin as a whole is more than 40% less than the same period of the normal year, and locally 80% less, and local high temperature weather exceeds 40 days. Under the background of abnormal changes of drought and flood superimposed on global warming, the extreme hydrological events of high temperature and low rainfall over a long period of time and "flood season reverse dryness" should be emphasized.

The intrusion of salty tide affects the safe and stable supply of raw water from the Yangtze River in Shanghai. During the incursion of salty tide in the Yangtze River Estuary, the salty water intrusion will cause the chlorine concentration in the intake of the water source in the Yangtze River Estuary to exceed the standard, which will seriously affect the water quality of the water source. Monitoring data shows that in 2022, the incursion of the salty tide in the Yangtze River Estuary will cause the number of consecutive days of non-take of water in the three water sources along the river in Shanghai to exceed 27 days, which will greatly restrict the city's water resources security.

(3) Shanghai and other coastal cities in the lower reaches of the Yangtze River are under increased threat from sea level rise

Continued high temperatures exacerbate the threat of sea level rise. Continued warming has further increased the rate of sea-level rise, intensifying the risk to coastal cities such as Shanghai, Hangzhou and Ningbo. According to the observation data of Wusong tide gauge station, the rate of rise during 1912-1960 was 0.92mm/a, and has accelerated significantly from 1960 to the present, reaching 2.03mm/a. It is expected that by 2050, the sea level will rise by 160mm compared with that of 2020, and the existing flood control standard of 1 in 1000 years of the flood control wall of the Huangpu River will be lowered to 1 in 150 years, and the river and sea defenses are facing a severe test.

3.2.3. Overview of priority climate adaptation measures in place

(1) Taking the large polder as a unit, continuously expanding the scope of urban flood protection and defense standards.

Through the small dikes into large dikes, joint dikes and dikes, etc., the flood control standard of important cities in the basin basically reaches the standard of once in 50 years and above. As of 2020, a total of 3,195 dikes have been built in the basin, with a total flood-discharging power of 20,664 m3/s. A single large dike has expanded from 10-20 square kilometers to 50-150 square kilometers nowadays, and its flood-discharging modulus has reached more than 3 m3/s/km2, which is 2.1 times higher than the average level of flood-discharging in the basin.

(2) Gradual expansion of urban ecological space and increased ability to adapt to high temperatures.

Under the global trend of carbon neutrality, the Taihu Lake Basin has increased green space in cities by expanding the area of green space and improving the green space coverage rate. Municipalities are actively carrying out green space expansion projects, both to effectively curb urban sprawl and to mitigate the urban heat island effect. In 2022, the greening rate of the built-up areas in the basin will reach 41 per cent, an increase of 12 per cent compared with 2010, exceeding the national average (39 per cent).

3.2.4. Current gaps in climate adaptation

(1) Threshold capacity

First, the local flood control and drainage facilities in response to catastrophes there are short of capacity. At present, Shanghai's flood control engineering system is basically perfect, but there is still 236.4 kilometers of the main drains (47.4% of the city) that has not yet reached the standard of one in 200 years; about 90 kilometers of the Huangpu River flood control wall is insufficiently high, the peripheral sluice gates and pumping stations planning and implementation of the rate of only 72% and 43%; of rainwater drains in the center of the city only 19% meets the standard of one in 3-5 years, etc. In 2021, during the “Hana” typhoon, there were waves and overflows in some sections of the upper and middle sections of the Huangpu River. In 2021, during the “fireworks” typhoon, Huangpu River in the upper reaches of the local section of the flood control wall appeared waves and overflow; in Pu Nan East part of the area flooding is serious, exposing that the regional flood control capacity is still insufficient.

Secondly, the reduction of natural regulatory spaces and the intensification of aggressive construction have exacerbated the risk of urban waterlogging. According to the analysis of land use changes, the area of construction land increased by 56.0% and 40.3% respectively in the two stages of 2000-2010 and 2010-2020, while the second and third-level river channels, which play an important regulatory role, sharply decreased by 19.9% and 38.3% respectively. This has led to an acceleration of confluence velocity and an overall reduction in the regulatory capacity of the basin; in addition, affected by the combination, consolidation and construction of polders, the flood regulation and storage capacity of the river network outside the polders is less than 20% of the total amount of once-in-100-years floods in the basin (16.3 billion m^3), and the operation and scheduling of the polders are difficult to give full play to the regulatory and storage effect within the polders, still taking the drainage needs of the towns themselves as the priority.

(2) Coping capacity

Firstly, there is room for improvement in the level of early warning and prediction of sudden meteorological disasters and extreme disasters. In 2020, the effective alarming time for sudden severe weather in Shanghai was advanced to 42 minutes, only 2 minutes higher than the national average. Taking July 21, 2021 as an example, the Shanghai Meteorological Center issued a blue rainstorm warning signal at 15:51, predicting that most areas of the city would have short-term heavy rainfall of more than 35mm per hour within 6 hours. At 16:02, a yellow rainstorm warning was issued. From 16:00 to 18:00, there were 71 stations with rainfall exceeding 100mm actually, and some areas had already exceeded the red rainstorm warning standard. Moreover, ss the interconnectivity and coupling of emergencies continue to strengthen, the interaction and superposition of various emergency risks increase the complexity of emergency handling. Although Shanghai currently has a relatively complete single disaster risk prediction system, it is relatively insufficient in simulating and predicting extreme disasters and interrelated disasters such as "four-in-one" events (namely the circumstances where typhoons, rainstorms, high tides and floods occur simultaneously or continuously).

Secondly, although the emergency plan system framework has been basically established, the linkage and precision are not high, and the comprehensive guidance role has not been fully exerted. Taking Shanghai as an example, the current comprehensive security plans are difficult to adapt to the urban operation status under extreme disaster scenarios; for instance, special plans for meteorological disasters, marine disasters, tourism emergencies and others were mostly formulated before 2015 and have not been timely adjusted according to emerging safety issues, advancements in disaster prevention and mitigation technologies and similar factors, thus the comprehensive guidance role in disaster response needs to be strengthened.

Thirdly, the guidance role of planning related to resilience in disaster prevention to particular spaces such as high-risk regions and grassroots governance units is in sufficient. The current comprehensive disaster prevention plan only considers the city-district-subdistrict (township) three-level disaster prevention zones, lacking detailed guidance in emergency energy redundancy design, emergency material distribution channels, the conversion of community space from peacetime to emergency use in the community level and other safety monitoring and controlling system. In addition, for areas with high risk and high vulnerability, less consideration is given to the spatial needs of the elderly and vulnerable groups in disaster response.

Fourthly, the safety and disaster prevention supporting facilities are insufficient at the community and grassroots levels, and the public's awareness of disaster prevention is not strong. Currently, in the construction of a 15-minute living circle in cities, there is less consideration for climate adaptation and the need for safe resilience, and the supporting facilities for disaster prevention and reduction are insufficient. The construction of comprehensive and professional talent teams for disaster response at the grassroots level such as subdistricts and communities is relatively weak, and there is a significant difficulty in the practical operation of community emergency plans and a lack of experience in emergency plan drills. The organization of emergency publicity and education is “fragmented”, and residents lack sufficient understanding of the risks they face, and do not pay enough attention to enhancing the disaster response capacities of individuals, families and communities.

(3) Adaptive capacity

Firstly, the flood prevention standards between upstream and downstream cities in the basin are inconsistent, making it difficult to manage intercity rainstorm and flood in a coordinated manner. Currently, upstream cities such as Wuxi and Jiaxing have a flood prevention standard of once-in-300-years in their central urban areas, while Shanghai, part of the downstream area, has a standard of once-in-200-years for its central urban area, and the upstream suburban area of Shanghai's Huangpu River has a standard of once-in-100- years. It can be seen that there is a lack of coordinated flood prevention standards between upstream and downstream cities.

Secondly, the linkage capacity among water sources is relatively weak, and the impact of continuous high temperatures combined with rising sea levels poses risks to water supply safety. Affected by factors such as global climate warming and sea level rise, the risk of intake points encountering salt tides has increased; in addition, the water quality of the Huangpu River's upstream water sources is at risk due to factors such as heavy metal contamination in upstream water inflows and pollution from ships. However, the current water sources of the Yangtze River and Huangpu River in Shanghai, as well as their raw water systems, are relatively independent and weakly interconnected, making it difficult to meet the challenge of timely allocation of water sources in case of a failure in a particular water source.

(4) Transformative capacity -the capacity to change

Firstly, there is insufficient understanding of the various new environmental changes brought about by climate change. In recent years, the geographical environment of the Taihu Lake basin has undergone significant changes, but the current understanding of the mechanisms behind the formation of extreme natural disasters and potential hidden dangers at the basin level is still insufficient. For example, affected by factors such as the reduction of upstream sediment and changes in tidal power, the Qingcaosha Reservoir in Shanghai faces the risk of embankment structure collapse, which seriously threatens the safety of urban water supply.

Secondly, the overall coordination function of the emergency management department has not been fully exerted. At present, some local emergency coordination organizations within the basin, such as the Emergency Committee and the Disaster Reduction Committee, have their executive offices set up in different departments, which makes it difficult to efficiently exert the coordination functions, including professional command, material allocation and force coordination. There is a need to further improve the multi-departmental coordination mechanism.

3.3 Case 3: Climate adaptation in the Pearl River Estuary region

3.3.1. Trends in climate change

Climate change in the Pearl River Estuary has led to an increase in both the frequency and intensity of heavy rainfall, with storm centers shifting toward highly urbanized areas. The occurrence and magnitude of extreme precipitation events have risen significantly. At the same time, sea level rise, in combination with storm surges, threatens low-lying coastal areas, particularly affecting regions such as the Tan River, the Pearl River estuary, and surrounding areas.

3.3.2. Major disasters and issues arising from climate change

(1) Extreme rainstorms

Climate warming has increased the frequency and intensity of extreme rainfall in urban areas, leading to an increase in the frequency and extent of flood disasters in urban areas. Heavy rainfall and flooding disasters not only causes direct losses in the flooded areas, but also indirect losses to surrounding areas and facilities due to knock-on effects. In many cases, indirect losses even exceeds direct losses.

Take the "9.7" extreme rainstorm in Shenzhen in 2023 as an example. The city's average rainfall of 281.7 millimeters, the largest for the Luohu 466.2 millimeters. The city's 31 reservoirs exceeded the flood limit level. It triggered disasters such as extensive flooding, river overflow, flooding of underground space, landslides, etc. The city was flooded over 18 square kilometers, more than 220,000 people were evacuated, and 220 public building basements and 7 subway stations were inundated with water.

(2) Sea level rise

The disaster effect of sea level rise is related to the geological structure of the coastal zone system, land geomorphology, coastal types, coastal sediment dynamics, hydrodynamic conditions and other conditions, which will strengthen the role of surges, tides and waves and other ocean dynamics, exacerbate the occurrence of salty tide disasters in the estuarine coastal areas and prolong the duration of salty tides. Due to the higher water levels along the coast, the natural drainage capacity of the city decreases, and the urban sewage discharge is difficult or even backed up, increasing the difficulty of flood discharge and drainage, and aggravating flood disasters.

Take the case of sea level rise in the Pearl River Estuary as an example. According to data from the Hong Kong Observatory, the average rate of sea level rise in Victoria Harbour from 1954 to 2023 is 31 millimeters per decade. The China Sea Level Bulletin shows that in 2022, the coastal sea level in the Pearl River Estuary will reach its highest since 1980, 138 millimeters higher than normal (1993-2011), and also higher than the average coastal sea level in China (94 millimeters higher than normal). Taking Shenzhen Shekou as an example, assuming that the sea level rises by 1 meter in 2100, the return period of the highest tidal level of once in 100 years will be reduced to less than one in 10 years, and the highest tidal level of once in 50 years and once in 100 years will be 3 meters and 3.3 meters, respectively, which will threaten the safety of coastal protection facilities.

(3) Saltwater upwelling and water crisis

Insufficient flow of freshwater rivers in years of climatic drought and seawater backflow are the main reasons for the formation of salty tides in the estuaries of the Pearl River Delta. The rise in sea level, the indiscriminate mining of river sands and the reduction in the flow of water in the rivers due to the sharp increase in the use of water for production and domestic purposes are the driving factors for the further expansion of the upward intrusion of salty tides. When the salty tide extends upstream to the water intake of water supply plants, it will affect the normal public water supply, which is hazardous to human health, and can also affect the normal production of industrial enterprises. At present, the water supply sources of PRD cities are mainly river water intake, with water withdrawal accounting for more than 50% of the total water consumption, the storage capacity of local reservoirs and emergency back-up water sources are insufficient. The amount of externally transferred water is even more seriously insufficient, accounting for less than 10% of the total. Therefore, during the dry season, the intakes of water from the rivers are highly susceptible to the impact of the salty tides. On the other hand, due to the high concentration of population and economic activities, the total water demand of the cities in the Pearl River Delta is high, which puts enormous pressure on the existing water supply system.

Since the end of 2021, rainfall in the Pearl River Basin has been persistently low, and the Pearl River Basin has suffered the most severe drought in 60 years. The water inflow of major rivers is 30%-70% less, including the Dongjiang and Hanjiang rivers, which are 70% less. In 2022, around February 15, high tide levels coincided with the astronomical tidal wave. The tide difference was large, superimposed on the unfavorable Northeast wind conditions of grade 6 to grade 7. The salty tides intruded deeply into the estuarine areas of the Pearl River Delta, many times. According to the Marine Disaster Bulletin of the South China Sea Region, the intrusion distance of the salty tide in the Pearl River Estuary was more than 60 kilometers at the farthest. As a result, the water supply safety of some areas in Zhuhai, Zhongshan, Dongguan and Guangzhou has been challenged.

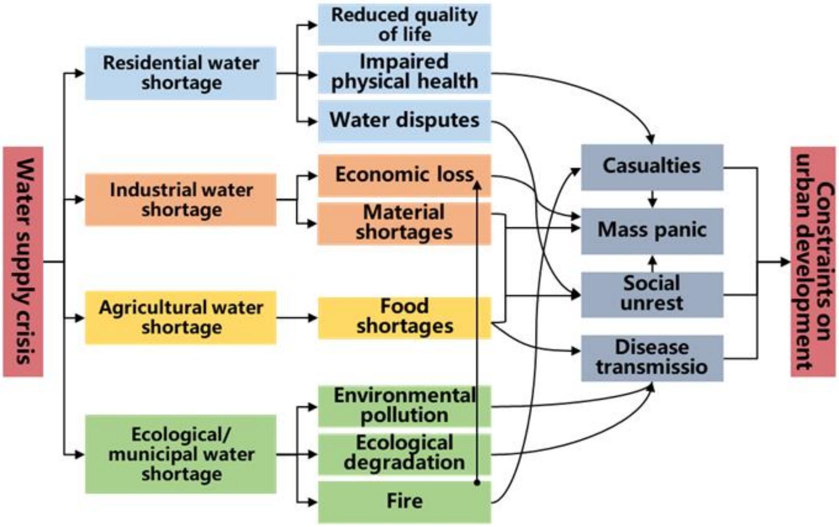

Figure 3.3. Schematic Dissemination of the Disaster Chain of Water Supply Crisis in the Pearl River Delta

3.3.3. Overview of priority climate adaptation measures in place

(1) Pearl River Basin Sectors Link Up to Cope with Salt Tide Intrusion Disasters

During the 2022 Pearl River Delta salty tide intrusion disaster, the Ministry of Water Resources instructed a basin-based unit to release water from a cluster of reservoirs in the Xijiang and Dongjiang river basins in order to replenish the downstream river part and suppress salty water intrusion. The Pearl River Water Resources Commission was commissioned to collaborate with the Fujian, Guangxi and Guangdong Water Resources Departments to implement water dispatching of the Northwestern River, the Dongjiang River and the Hanjiang River to focus on replenishing water to the downstream and suppressing salty water, so as to make the limited water resources play the greatest drought relief benefits.

(2) Guangdong, Hong Kong and Macao cooperate closely to carry out climate response and maritime emergency rescue.

In 2019, the Guangdong Provincial Government and Hong Kong set up the Hong Kong-Guangdong Co-operation Group on Environmental Protection and Climate Change, which is dedicated to improving regional air quality, protecting the water environment, forestry care, marine resources care and combating climate change in the Pearl River Estuary. In 2024, The Guangdong Provincial Government signed the "Framework Agreement on Guangdong-Hong Kong-Macao Co-operation in Emergency Management and Greater Bay Area Co-operation in Emergency Rescue Operations" with Hong Kong and Macao. Management Co-operation and Greater Bay Area Emergency Rescue Operation Co-operation Framework Agreement" with Hong Kong and Macao to strengthen the co-operation and exchanges among Guangdong, Hong Kong and Macao in emergency management and rescue.

(3) Hong Kong and Shenzhen Joint Social Forces to Address Climate Change - A Case Study of Mangrove Protection and Restoration

Learning from international experience and strengthening cooperation with Hong Kong, cities such as Shenzhen have begun to actively introduce NGO organizations that have also begun to join in the protection and management of mangrove forests. For example, the Mangrove Foundation (MCF), which has developed in Shenzhen, is the first environmental protection foundation initiated by the private sector in China, and the only non-profit social organization in mainland China that operates and maintains mangrove nature reserves and mangrove parks. In 2020, the Shenzhen Municipal Government signed a Framework Agreement on the Cooperation for the Protection and Development of the Coastal Wetlands of Shenzhen Bay with the MCF, with the aim of creating a Shenzhen model for coastal wetland protection model for global wetland conservation.

3.3.4. Current gaps in climate adaptation

(1) Threshold capacity

Firstly, the resilience of urban spatial structure is insufficient. The urban spatial form cannot adapt to extreme rainstorms, and the local overflow capacity of some flood discharge channels is insufficient, causing upstream water levels to rise and leading to poor drainage; some urban constructions are located in low-lying areas, which are prone to regional flooding disasters.

Secondly, the disaster prevention capacities of urban vulnerable nodes such as underground spaces are not strong. For example, the Shenzhen subway system is designed to a once-in-100-years flood prevention standard, but the flood prevention standards of interconnected underground walkways, parking lots, shopping malls and other facilities are lower than that of the subway, becoming a weakness in waterlogging prevention. Cities in the Pearl River Delta such as Shenzhen and Guangzhou have multi-functional underground transportation super complexes like Gangxia North and Chunfeng Tunnel, which are deep, extensive and complex in business types, have many hidden risks, and pose great difficulty in escape and disaster relief.

(2) Coping capacity

Firstly, there is a shortage in the monitoring and early warning capacities for meteorological disasters. Although the overall monitoring and early warning capacities for meteorological disasters are leading, and a three-dimensional observation network with high spatial and temporal resolution has been established, which is applied to urban disaster prevention and reduction work,. There are still shortcomings in the early warning capacities for specific areas such as transportation facilities. A large number of infrastructures under high operational intensity have increasing hidden safety hazards, and the pressure for disaster prevention and control is increasing year by year. In case of encountering extreme weather such as heavy rain, collapses are prone to occur. At present, the detection of facility hidden dangers is mainly based on manual inspection, and the timeliness and comprehensiveness of traditional detection methods are insufficient while the application scope of advanced detection methods is limited.

Secondly, the disaster resilience of major infrastructures such as urban lifeline projects needs to be enhanced. During the heavy rain event on September 7, 2023, in Shenzhen, several communities were suffered from water and electricity outage caused by water and power supply facilities flooded for the second time, and the shortage of emergency drainage facilities led to the inability to quickly drain the floodwater, preventing the timely repair of water and power supply facilities, and making it difficult for residents to restore their lives and business production activities quickly, also resulting in economic losses.

Thirdly, there is a need to enhance the disaster prevention awareness among communities and residents. During the heavy rain event on September 7, 2023, many communities suffered from severe waterlogging and flooding of underground garages. The failure in organizing the transfer of vehicles in advance led to a large number of vehicles being submerged, resulting in property losses for residents. Although meteorological and emergency management departments had issued emergency early warning announcements through text messages, television and WeChat in advance, there were still instances where residents did not take timely shelter during the red alert period and businesses did not cease operations as required, leading to injuries.

(3) Recovery capacity

The quantity and pumping capacity of drainage facilities allocated internally within the underground spaces in some cities is insufficient. The reserve and inter-departmental dispatch mechanisms for flood control equipment like water pumps are not well-established, leading to an inability to promptly restore facilities like underground parking lots after they are flooded.

(4) Adaptive capacity

Firstly, the risk of annual storm surges and flood disasters in coastal cities is exacerbated by rising sea levels, leading to a decrease in the actual flood and storm surge disaster prevention capacities of cities. The tidal protection level of major infrastructures such as nuclear power plants does not meet the design level requirements. Under the long-term impact of rising sea levels, there is insufficient awareness of unconventional disasters that may occur in the future.

Secondly, there is an insufficient capacity to adapt to salt tide intrusion and coastal erosion, making coastal ecosystems more vulnerable to damage.

(5) Transformative capacity -the capacity to change

The systematicness of disaster prevention work and inter-departmental collaboration still need to be further improved. The coordination of flood prevention within regions and river basins remains to be perfected. There are disparities in the management standards between upstream and downstream as well as left and right banks of cross-regional rivers in the Pearl River Delta. When basin-type floods occur, flood disasters are easily transmitted between the upper and lower reaches of the basin. The regional coordination mechanism of water resources in the Pearl River Delta needs to be improved. When urban water supply is insufficient due to the upward movement of salt tides, there are deficiencies in the river basin's water resource allocation mechanism.

3.4 Case 4: Climate adaptation in the Rhine-Meuse-Scheldt delta

The Rhine-Meuse-Scheldt delta involves three countries, numerous regions, provinces, water authorities and hundreds of cities and municipalities. Each jurisdiction has its own government, legislation, regulations, practices and culture and is governed by European legislation and practices. Despite all the differences, climate adaptation remains a priority for them. The region is flat and low-lying, but densely populated, highly urbanized, industrialized and agriculturally intensive. This makes their vulnerability or damage sensitivity so high that climate hazards are economically and socially unacceptable. Extreme weather events and near-misses have been on the rise over the past few decades, and exposure to extreme weather and sea-level rise will be severely exacerbated, making adaptation to climate change imminent.

The EU, countries, regions, municipalities and water authorities have all developed laws and regulations to facilitate adaptation, and accumulated knowledge, experience and skills on adaptation measures and their effectiveness, implementation and maintenance needs. They are all planning and implementing adaptation projects, large and small, and all have budgets for them, focusing mainly on rivers, alluvial deposits and coastal flood control, and less on drought and heat and the associated problems of water quality, salinization, navigability, land subsidence and wildfires.

Europe aims to make climate adaptation locally based, systemic and inclusive (EU Mission on Adaptation to Climate Change), focusing on 1) supporting regional and local governments in their local efforts to strengthen physical and social resilience; and 2) investing in strengthening the adaptive capacity of large river systems, lakes and coastal defences. Concentrating on strengthening preventive capacity (raising thresholds for the occurrence of disasters), investments aimed at avoiding damage from extreme events; less attention seems to be paid to the below-capacity, resilience, adaptive and transformative capacities needed to create climate resilience.

1. Threshold capacity; damage prevention

Detention capacity or sponge capacity is recognized as key to avoiding damage during periods of extreme rainfall, droughts and heat waves; on the one hand, it avoids peak discharges and floods, and on the other hand, it allows water resources to meet basic water needs. Significant funds have been invested in creating more retention capacity along the Rhine tributaries, the Maas, the Scheldt and their tributaries to withstand flooding. Detention for drought is often linked to groundwater resource management and surface water salinity control, and is another target of national climate adaptation policies and investments, such as the Flanders Blue Deal and the Dutch Delta Freshwater Program. The spatial integration of detention measures is challenging as it requires significant demands on the land.

2. Coping capacity

Planning and design goals should include minimizing damage from extreme events that exceed the threshold or design capacity of the water supply system, such as the "water bomb of 2021" and the drought of 2018. Using such extreme events to test climate stress in urban areas and regions, as the Netherlands has done, is an important first step towards risk dialog and adaptation. As seen in and around Essen Eschweiler, Germany, redistributing important critical infrastructure, vulnerable populations and functions to the safest places in the region proves difficult in practice due to existing urban structures, vested economic interests and competition for space. Smart buildings and infrastructure can help to reduce the risk of damage caused by extreme weather in both urban and rural areas. New building codes are being considered in Germany and the Netherlands but are not yet fully implemented. Effective early warning and contingency planning are equally important to minimize damage, as the July 2021 floods in the Ruhr and Al-Elft river basins in Germany sadly demonstrated.

3. Recovery capacity

Throughout the Delta region, preparations for disaster recovery are limited. In some cases, such as in Flanders, the financing of recovery is partly covered by private insurance; usually, the national government has to cover the losses. And, as seen in Germany and Belgium, "rebuilding better" is not always allowed. The statute states that you must rebuild only what was lost. Recovery organizations and psychosocial help for traumatized victims can be strengthened. Research in Germany has shown that socially disadvantaged groups are more vulnerable to the effects of extreme weather than highly educated, affluent and healthy social groups. Such inequalities should be taken into account in disaster recovery.

4. Adaptive capacity

Rigid, grey adaptation measures are robust and have a long service life. However, an excessively long lifespan may be counterproductive when new conditions and/or emerging social needs are taken into account. Research in the Netherlands has shown that most nature-based blue-green solutions are better able to adapt and/or form a new equilibrium when local conditions change in the future. In order to minimize the damage caused by extreme events (i.e., resilience) while maximizing the benefits and ecosystem services provided by blue-green infrastructure, innovative and smart combinations of green and grey infrastructure are currently being developed across Europe. Smart green roofs and urban water buffers in The Hague, the Netherlands, are good examples.

5. Transformative capacity -the capacity to change

As demonstrated by the Dutch Delta Program, the Blue Deal and Sigma projects in Flanders, the flood recovery activities in North Rhine-Westphalia and Rhineland-Palatinate, and the EU Climate Adaptation Missions, climate adaptation is a continuous and collaborative learning process that requires research into new solutions, pathways and methods. Research-Based Design (RBD) has proven to be a valuable approach to this complex challenge, creating innovative solutions that are flexible in the long term. Adaptation-targeted 'design research' in the Netherlands is based on scenario studies such as the Territorial Outlook 2023 and the Delta Scenario, which show the future spatial developments that could result from potential decisions. This approach allows experts to co-develop plans in collaboration with local stakeholders. Local urban adaptation projects in the Netherlands have shown that co-development of plans can help to raise public awareness of issues and deepen understanding of the characteristics of interventions.

New planning and design principles are (will be) being introduced, e.g. the Dutch National Policy Brief "Water and Groundwater Sphere", which includes the principle that climate issues must not be shifted, neither spatially, to neighbouring areas, nor temporally to the next generation, nor from private land to public space. Currently, the public sees adaptation to climate change as a government responsibility. People and businesses are aware of climate change, but not of the need to prepare for more frequent and severe extreme weather events, and there is still a lack of understanding and outreach about the prospects for existing actions. Sustained funding for adaptation measures is crucial. In contrast to the irregular funding of the Sigma program projects in Flanders, Belgium, the Dutch Delta Fund provides continuous financial support. Long-term budgets reserved for adaptation measures also provide continuity in promoting government-social capital partnerships, knowledge research and innovation.

It is widely recognised that the replacement of the existing, rapidly aging infrastructure provides interesting opportunities for adaptation. An implicit obligation to consider climate adaptation as an essential element in such urban renewal and rural redevelopment project is found in the European flood directive and in the water assessment (“watertoets”), obligatory part of the environmental permitting system in the Netherlands and Belgium.

3.5 Concluding discussion

From the cases of the four regions, the prevailing climate change challenges to cities include: 1) the overall increase in the frequency and intensity of extreme weather (especially extreme precipitation), which exacerbates the risk of flooding in urban spaces; 2) the intensification of various types of disaster risks brought about by sea level rise, which, when combined with the overall seaward development trend of coastal cities, amplifies the risks posed by climate change; 3) the high temperatures of heat waves that not only trigger hill fire disasters and energy shortage crises, but also add to the heat island effect of high-density development in cities, which intensifies health and even life hazards to citizens and 4) extreme droughts, threatening not only the supply of water to the city for domestic and industrial use and irrigation of urban green, but also the quality of local surface waters and the shipping transport of goods.

Despite the great differences among regions in terms of geographic conditions, climate, population, welfare, and political and administrative systems, these four regions have revealed very similar challenges and similar deficiencies in their ability to cope with the climate crisis, including: 1) insufficient resilience of the urban spatial pattern in adapting to climate change, and insufficient ability to solve the problem on the basis of blue and green nature; and major infrastructures, such as the urban lifeline projects, are aged and not designed for future climate conditions; 2) Insufficient social awareness of all kinds of new environmental changes brought about by climate change; regulations, protocols and standards for addressing climate change still need to be upgraded; 3) Insufficient cross-sectoral synergies in urban disaster prevention, the overall coordination function of the emergency management department has not been brought into full play, and the level of early warning of sudden meteorological disasters and prediction of extreme disasters needs to be upgraded; 4) Insufficient risk awareness among community residents, their ability to assess climate risks, and their options for risk-reducing interventions (5) The mechanism of regional cooperation has yet to be improved, and inter-city, regional and river basin wide climate crisis response plans have yet to be connected; (6) In comparison to mega-cities, the risks faced by small and medium-sized cities, small towns and villages due to climate change are also intensifying because of a lack of financial resources and backward infrastructure construction.

In order to address these challenges, it is important to further understand location-specific climate vulnerabilities and to determine whether climate adaptation measures can meet the needs of local urban and rural development and improvements in the lives of the population. Capacity-building actions to strengthen the five capacities needed to address climate change in urban and rural areas – the threshold, coping, recovery, adaptive and transformative capacity - will not be homogenous and undifferentiated. There is an urgent need to develop **climate adaptation strategies** that **are locally adapted but coherent**.

4. Lessons from disasters: how to deliver precaution, relief and rebuilding

Climate-related disasters and their aftermath provide valuable lessons on how to prepare for, respond to and recover from disaster in a better way; all essential lessons for creating a climate resilient environment. This chapter provides reflections on a global assortment of such cases of learning – mostly learning triggered by things that went seriously wrong. From the multitude of case analyses available a handful with explicit lessons were selected and summarized here, in keeping with the CCICED's global coverage and extra detail for China. The reflections on these cases are based on this report's assessment framework with five capacities and ten enabling conditions. For presentation purposes, cases and findings are grouped according to three typical phases and terminology commonly used in disaster risk reduction:

Precaution and Preparedness (directly related to Threshold capacity and Adaptive capacity, and to all enabling conditions)

Relief – aid, compounding risks, vulnerabilities (directly related to Coping capacity, and to all enabling conditions)

Rebuilding – adaptation, resilience, innovation (directly related to Recovery capacity, Adaptive capacity and especially Transformative capacity, as well as all enabling conditions)

Figure 4.1 sketches the relation between the capacities, the enabling conditions and disaster risk reduction; this also sketches the logical flow of the chapter.

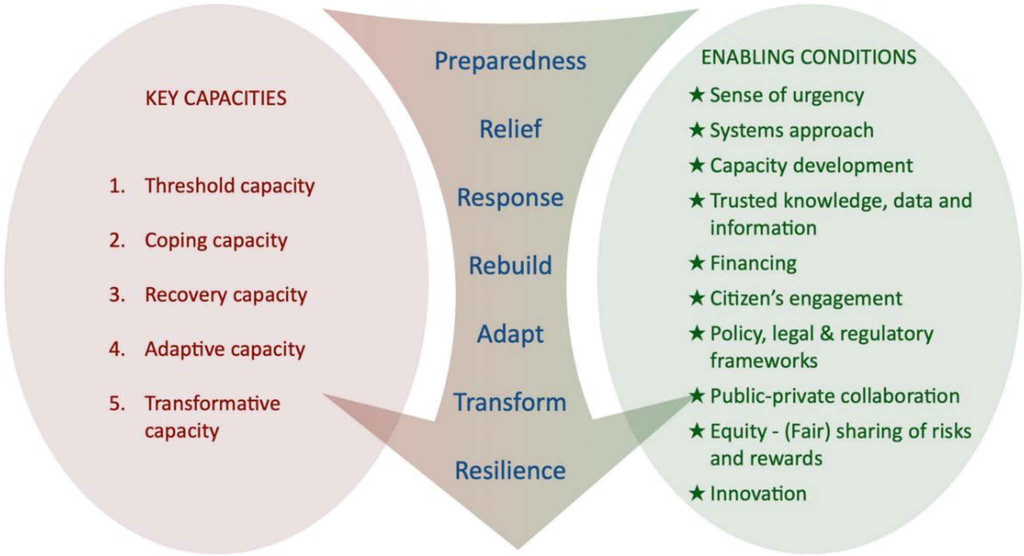

Figure 4.1. Phases of disaster risk reduction and its common terminology related to the five key capacities to develop climate resilience and their enabling conditions

For this chapter the four major cases portrayed in Chapter 3 have been considered, as well as sixteen other cases (all listed in Box 4.1). Of these, eleven are summarized in this chapter itself. Details can be found in the annexes to this report. Each case has been analyzed, as far as applicable, in terms of weaknesses exposed and inspiration gained.

Box 4.1. Cases analyzed for this Special Policy Study

Major Cases (Chapter 3)
Case 1: Climate adaptation in the Chengdu-Chongqing area
Case 2: Climate adaptation in the Taihu Lake basin
Case 3: Climate adaptation in the Pearl River Estuary region
Case 4: Climate adaptation in the Rhine-Meuse-Scheldt Delta

Precaution & Preparedness
Case 5: The "July 20" extremely heavy rainstorm Disaster in Zhengzhou, Henan Province in 2021
Case 6: Early Warning For All(United Nations)
Case 7: Bangladesh – Early Warning Systems
Case 8: Singapore – Water Wise

Relief – aid, compounding risks, vulnerabilities
Case 9: Rare and catastrophic flood in Chongqing on August 20th, 2020
Case 10: California wildfires
Case 11: Repeated flooding in Nairobi
Case 12: Flooding and Rebuilding in the Aachen region 2022

Rebuilding – adaptation, resilience, innovation
Case 13: Extremely heavy rainstorm disaster in Beijing Tianjin Hebei in 2023
Case 14: New York – Hurricane Sandy Response
Case 15: Flanders – Post Floods, Preparedness / Resilient Waterland

Other cases
Case 16: High temperature and drought disasters in the Sichuan Chongqing region
Case 17: Mozambique – Partially Prepared
Case 18: Peru – Flood Resilience Task Force
Case 19: Water At The Heart Of Climate Action
Case 20: Water As Leverage -- Innovative Preparedness

More analyses of flooding-related cases: https://www.zurich.com/knowledge/topics/flood-resilience/zurichs-flood-resilience-program

4.1 Precaution & Preparedness

Enhanced early warning capabilities, and the systems actively preparing societies for the impacts of disasters have proven to be a cost-effective and reliable approach. By enhancing digital monitoring and systems of risk detection, developing and improving emergency response plans in collaboration with affected communities, and improving public awareness on risks, lives can be protected from the impact of natural disasters. Previous studies have shown that countries with high early warning coverage (including governments ownership and public awareness) have disaster mortality rates eight times lower than those with limited coverage [17]. With disastrous events, only 24 hours advance notice is needed to reduce significant damage by 30% [18]. Globally, due to this lack of appropriate warning systems and disaster preparedness capabilities, extreme events related to climate, weather, and water have caused people in Africa, South Asia, South and Central America, as well as on small island states, suffering more than 15 times more from deadly hazards [19].

4.1.1 Case 5: The "July 20" extremely heavy rainstorm Disaster in Zhengzhou, Henan Province in 2021

From July 17 to 23, 2021, Henan Province experienced a rare extremely heavy rainstorm. The event led to serious floods, especially on July 20. Zhengzhou suffered heavy casualties and property losses. Insufficient preparedness in the prevention of, preparation for and response to flooding has been an important cause of the seriousness of these impacts. The problems included insufficient ability to issue timely and unambiguous warnings; attention to the extreme meteorological information was inadequate. In addition, the emergency response was late, and not soundly linked to the flood warnings. It was unclear who had to respond and how to respond. In contrast, the earliest city in the region to initiate emergency response, Denfeng City, did so 17 hours ahead of Zhengzhou City, and suffered the smallest number of deaths and missing persons among the four cities in the area. Furthermore, local media did not do a good job alerting the public, and the public's awareness of flood risk and their options to avoid danger was not strong. This is illustrated by the pattern of casualties: most of the people who died or went missing had continued their normal activities or had returned shortly after evacuation and then died.

4.1.2. Cases 6 and 7: Early Warnings For All and Bangladesh – Early Warning Systems

In March 2022, United Nations Secretary-General António Guterres [20] initiated the global Early Warnings for All Initiative, to ensure within five years universal protection from hazardous weather, water, or climate events through life-saving early warning systems. The need for early warning systems across the world only increases. Not only does climate change exacerbates the impact of our disasters, it also increases the vulnerability of our socio-economic and environmental systems. By now, over 30 countries including Bangladesh, Maldives, and Sudan have joined the Early Warnings for All program to carry out implementation work in disaster warning and preparedness, monitoring, and emergency response plans [19]. China, where a comprehensive meteorological observation system has been established to strengthen the assessment of the impacts and risks of climate change adaptation, is still prone to significant losses in the face of major natural disasters due to inadequate preparedness, early warning and prevention.

WMO, UNDRR, ITU and IFRC with partners developed a people-centered Multi-Hazard Early Warning System (MHEWS), as an integrated information system for upcoming weather or climate events, while supporting institutions and communities in preparedness, relief and response actions. MHEWS is based on (i) Disaster risk knowledge; (ii) Detection, observation, monitoring, analysis, and forecasting; (iii) Warning dissemination and communication; (iv) Preparedness and response capabilities [19].

Bangladesh leapfrogged from a nation suffering from disasters, to one being fully prepared, capable of moving millions of people out of harm's way, in the lead up to disasters. Thanks to Bangladesh's successful Cyclone Preparedness Program (CPP) – an early warning system where more than 76,000 volunteers, half of whom women, with the best available data on forecasting go around to even the most remote communities and guide everyone across the country to multifunctional shelter-infrastructure. This is an example of community-led mobilization at a scale unprecedented, anchored in national policy and legislation to ensure consistency, continuity and commitment [21].

4.1.3. Case 8: Singapore --- Water Wise

Singapore from its independence saw itself confronted with freshwater dependency and embarked on a bold water resilience approach. This laid the groundwork that married Singapore's freshwater security approach to its resilience strategy. Singapore's four National Taps refer to the four sources that Singapore relies on for its water supply [22]: 1) water from local catchment, 2) imported water, 3) high-grade reclaimed water (NEWater), and 4) desalinated water [23]. Singapore implemented a three-pronged water management system to meet the growing water demand: collect every drop of water; reuse water endlessly; and desalinate more seawater [24].

4.2 Relief – aid, compounding risks, vulnerabilities

Providing relief is a key component of disaster risk reduction. This includes actions taken directly before, during or immediately after a disaster to save lives, reduce health impacts, ensure public safety and meet the basic needs of people affected (UNDRR) [25]. Actions include the need to establish an emergency management system that can respond quickly, provide on-site assessments, conduct search and rescue, medical treatment and safe evacuation. Post-disaster provides a series of logistical challenges including providing temporary shelters, food, access to water, sanitation, medical and psychological support and repairing essential infrastructure including communications. These types of aid need to reach the areas most affected and the most impacted populations. Often, tailored responses are required for the most vulnerable populations including the poor, elderly, children, disabled and the injured. A timely response can halt secondary disasters such as the spread of diseases, after a flood event.

By way of contrast, a case for Nairobi, case 11 included here, is in which no positive actions or learning can be reported. In fact, it is a negative case of flooding that impacted informal settlements the most, because they were in riparian zones at risk from floods. This was followed by evictions with no recourses for these extremely vulnerable communities.

Effective relief requires strong government responses and capacity building support for communities and individuals to be able to respond appropriately in a post disaster context. Often, this requires institutional coordination across scales, for example, in the case of Chongqing, case 9 below, both at the local level and with national and international governments. There are also clear roles for civil protection, police and fire services including search and rescue, protecting people and property after a disaster. Civil society and the public have a strong role to play to provide reliable information, resources, mutual aid and to coordinate with local authorities for successful execution. Relief work will often last much longer than the initial days post-disaster and can support community resilience such as in the case of California, case 10 below.

4.2.1. Case 9: Rare and catastrophic flood in Chongqing on August 20th, 2020

On August 18-20, 2020, due to heavy rainfall upstream, the Yangtze River area in Chongqing suffered floods. Hundreds of thousands of people were affected over a wide area, including the main urban area of Chongqing, and direct economic loss was large. Subsequent measures taken to cope with disasters include a joint approach to dispatching excess water in the basin and ensuring ample retention capacity. This was reached through extensive departmental consultation and coordination *at basin-scale level*. In addition, emergency management and evacuation systems at various levels were linked: city, district, street, and community levels. Over and above this, the prevention concept has shifted from engineering resistance to coexisting with floods. For example, this has been used in preparing flooding responses in the low-lying area of Ciqikou Ancient Town: personnel and property retreat when the flood comes;when the flood recedes, personnel and property return.

4.2.2. Case 10: California wildfires

The Rim Fire in California started on August 17, 2013 and burned over 1041 km^2, becoming the third largest wildfire in California history and one of the most severe fire events in terms of its rapid growth, intensity, size and smoke. It resulted in significant impacts to the local economy, threatened access to clean water, disrupted the lives of thousands of people, and damaged air quality. With funding from a federal program (National Disaster Resilience Competition, coming from Rebuild by Design), a combination of local, state and federal agencies collaborated to address unmet recovery needs and build long-term resilience. The program applied a systems approach to address forest recovery, economic recovery and community building. Two community resilience centers were built as evacuation centers for future disasters and during other times have been used as warming and cooling centers, charging stations for medical equipment during power outages, commercial kitchen for local small business product production, as local meetings facilities for community groups and nonprofits and for job training. This model is now being replicated across the state.

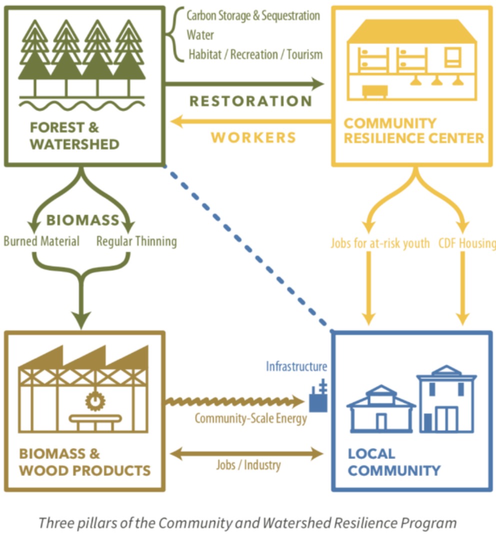

Figure 4.2. Community and Watershed Resilience Program, California [26] The diagram shows the program's system-wide perspective considering forest recovery, economic recovery, and community building.

4.2.3. Case 11: Repeated flooding in Nairobi

In spring 2024, rains linked to El Nino 2023 triggered flash floods in Kenya that killed at least 228 people, left 72 people missing, and displaced more than 212,000 people. Over the period 1961 – 2018, Kenya recorded 21 major flood events, with most of the rainfall anomalies occurring in the more recent years. In the Nairobi area, the flooding events kept revealing critical weaknesses in urban planning, drainage systems, and emergency response mechanisms. The socio-economic losses from these events are staggering. In Nairobi, the floods have exacerbated the living conditions in informal settlements such as Kibera, Mukuru and Mathare Slums, where inadequate infrastructure and poor drainage systems leave residents exposed to the impacts of heavy rainfall.

This widespread destruction by the floods has revealed the urgent need for comprehensive flood management and mitigation strategies with government agencies, non-government agencies, and community groups working towards enhancing early warning systems, improving infrastructure and drainage systems, promoting sustainable land use practices, strengthening disaster preparedness and response, enhancing risk communication and public awareness as well as fostering cross-sectoral collaborations and partnerships. Significant gaps remain in policy formulation, implementation, and coordination among stakeholders. There is, therefore, a pressing need for a comprehensive, evidence-based policy framework that addresses the root causes of flooding, the consequences of extreme weather events and integrates sustainable solutions [27].

4.2.4. Case 12: Flooding and Rebuilding in the Aachen region 2022

The floods of mid-2021 caused widespread damage and loss of life in West Germany. The event had a probability of once in 400 years. It occurred in a moderately hilly area with small rivers. A multi-institution project is tasked with scientific monitoring of the reconstruction. Its recommendations point to an obvious need for smarter engineering, including a rethink of the region’s many small bridges. The critical role of land use on hillsides and in narrow valleys is underlined once more, as is the need for good general access to risk information and for really fast warning in emergency situations; active preparedness and training at local level, even if these events are deemed to happen once in a lifetime. Rebuilding of individual houses and small businesses seems to have happened mostly in much the same location and type as they were, due to rigid insurance policy, thus perpetuating risk. Monitoring and support extend to mental impacts of the disaster and to the role of social networks at the scale of communities that live by the river and are formed by it.

4.3 Rebuilding – adaptation, resilience, innovation

Around the world, only learning by default and disaster seems to be common. Becoming faster in learning and deploying that knowledge for preparedness, relief and rebuilding, innovative at scale and across the world is a big challenge. Climate preparedness offers a return on investment of five to ten times or more, accounting only for the losses prevented, and risks reduced. Considering the investment opportunities and added value – from better health, increased security, improved ecology, a decreasing gender gap and strengthened youth capacity – the benefits are numerous [28,29,30,31].

To sufficiently deal with disasters, both prevention and repairing are essential. All over the world, the impact shows vulnerability - human-made systems like cities built on hard structures are simply not fit for the future. Recent urban growth worldwide has largely been in the zones with largest flood risk [32]. Adequate capacity to hold the rains overflowing our storm water facilities is missing, parks or green roofs to mitigate heat island effects are lacking; sewage systems are not good enough to stand up to extreme events etc. This is devastating for climate resiliency, with disastrous impacts on marginalized communities and the biodiversity system, undermining food security and economy. It is doubtlessly important to learn to do better, to understand whether to mitigate or adapt, to prepare before responding and to invest in a sustainable future, leaving no one behind. Lessons learnt are however costly. Practice shows that it is time to change course now, with resilient and innovative actions, tackling social, economic, cultural and ecological challenges.

4.3.1. Case 13: Extremely heavy rainstorm disaster in Beijing Tianjin Hebei in 2023

After the Beijing Tianjin Hebei extremely heavy rainstorm disaster in 2023, the Chinese government acted along multiple lines. One line is planning guidance, led by the National Development and Reform Commission to organize the compilation of the "Plan for Enhancing Disaster Prevention and Reduction Capacity in North China Region with a Focus on Beijing Tianjin Hebei". Next to the reparation of damage, including the reconstruction of water conservancy facilities in river basins, strengthening the meteorological monitoring network in key areas, and improving urban drainage and flood prevention facilities. Other lines of government response in the same vein include increased investment and the issuing of more treasury bonds and an acceleration of projects, bringing facilities up to standard by 2024 and improving urban drainage capacity.

4.3.2. Case 14: New York – Hurricane Sandy Response

Hurricane Sandy battered the Northeast coast of the United States in 2012, wreaking havoc across the region. President Obama’s Hurricane Sandy Rebuilding Taks Force’s ambition was to use the recovery of Hurricane Sandy to leapfrog towards a state of resilience. It launched Rebuild by Design, part policy process, part rebuilding program, and part design competition, bringing together all levels of government, stakeholders and residents to innovatively design and develop new standards of regional resilience . Ten teams of architects, urbanists, engineers, scientists and activists engaged with communities and government agencies. In 2014, the federal government awarded US$ 930 million to state and local governments to implement the six winning designs. Rebuild by Design’s key insights can inform innovative, comprehensive and inclusive development of vulnerable regions across the world [33, 34, 35, 36]. Rebuild by Design was scaled up nationally through the National Disaster Resilience Competition (see California, case10).

4.3.2. Case 15: Flanders – Post Floods, Preparedness / Resilient Waterland

After extreme flooding in July 2021 across the rivers Maas and Demer, the Flemish Government appointed a multidisciplinary Expert Panel on flood protection. To protect Flanders and define the desired level of water safety, the Panel’s advice ‘Resilient Waterland’ formulated a strategy with 10 coherent actions, almost precisely matching the enabling conditions identified in Chapter 2 and represented in Figure 4.1. These include: water security goals; water, soil and climate security as lead factors in spatial planning; four cross-sectoral regional programs; a knowledge and innovation program. The Expert Panel’s advice was the start of a recalibrated systemic approach for water safety and water security in Flanders [37].

4.4. Summary of lessons and gaps

4.4.1. Zooming out before zooming in

Disasters are X-ray examinations of cities, and this holds true for climate-related disasters, too. Climate change is a risk multiplier, aggravating things in the city that were anyway not right. Knowing history, it is obvious that urban development and land-use planning of a nation is an essential process of human beings constantly adapting to the environment and finding safe places. In the context of accelerating climate change, it is therefore mandatory to zoom out, and strategize, considering a longer period of time, a wider geographical area, and more levels of extreme scenarios when planning spatial adaptation.

Firstly, from a longer historical perspective, disasters have always accompanied urban development. Learning from disasters is not just about learning from one or two disasters, but also about learning from history. Therefore, it is necessary to review major disaster events in history and learn traditional wisdom. A great help in this is modern scenario analysis, enabling to assess the potential problems that cities may encounter in extreme situations, in order to determine the scope of impact, the vulnerability of various systems, and possible measures to be taken. This must be done associated with a city's design safety standard in terms of return period flood or history flood.

Secondly, disasters not only come from within the city, but also from outside, especially from river basins. It is necessary to conduct climate adaptation assessments at different spatial scales, including the basin scale, evaluate the risks of cities and the mutual influence between upstream and downstream, left-hand-side bank and right-hand-side bank. Taking joint consideration of environmental protection and eco-system restoration requirements is required for high quality spatial development in addition to keeping safe, and find overall balanced solutions.

4.4.2. Immediate lessons and injunctions

On this wider canvas, what can be learned from our selection of actual disasters, and the learning that took place, or did not? Seven important overall lessons can be extracted.

1. By focusing on ‘disasters’ this chapter highlights the **important opportunity – post disaster – to create an exception** to rules and habits – and the methodologies for creating these exceptional processes – that ‘normally’ stand in the way of progressive action, collaboration and unorthodox thinking, all needed to leapfrog for resilience.
2. Essential while rebuilding, and essential to maintain, is **a strong orientation on the future,** not the past. The cases in this chapter include examples with an orientation towards a better, more resilient future, with innovative approaches and tools to explore the future and test ideas.
3. Risk-informed planning and delivery of infrastructure and services is key in addressing vulnerabilities. Tools are becoming available, as this report illustrates. Thus, information on climate risks should be **mainstreamed into spatial planning** and the delivery of urban infrastructure and services, while strengthening local capacity and celebrating successes.
4. Learning requires pausing and thinking, after the event. This is often a difficult decision, given the turbulence and agony caused by the disaster, and the expectation of firm and immediate action. But **understanding what went wrong**, in engineering terms and otherwise, is essential to build back better [38, 39].
5. Learning from disasters is costly and painful. This is especially so if the lessons remain limited to the very location where something went wrong. Learning from what happened elsewhere, and **joining forces** is of course much preferred. Important and inspiring opportunities exist in

connecting to peer networks, joining UN-initiatives and sharing lessons across innovative approaches, like Early Warnings for All and Water as Leverage [40].

6. Cases also showed that **innovative technologies** at all levels of the information flow from monitoring to decision making (e.g. stress-testing, on-line monitoring network, early warning system, flood/drought risk assessment, water infrastructure regulation and digital twin technologies), are essential to adopt to risks caused by either climate change or other factors. The application of innovative technology can buy time, operationally and strategically.
7. All cases illuminate the importance of **governance and process**: strong institutions; political will and leadership, trust and ambition. Short-term agendas are a huge roadblock to adaptation planning. Climate resilience requires connection of national principles and resources to local specifics, opportunities and needs; broad engagement and equity, across all divides and structures; and room for creativity and experimentation.

On balance, momentarily focusing away from adaptation in its strictest sense, the litany of events, damages and personal losses recorded in the cases analyzed reminds of an important saying by US President Obama: "We are the first generation to feel the effect of climate change and the last generation who can do something about it". He said so almost twenty years ago, underlining the importance of mitigation and adaptation in one go [41]. In fact, the governments of major countries around the world, such as China and the United States, have begun to pay more attention to climate adaptation. In January 2024, Chinese President Xi Jinping published an article proposing to enhance the ability to adapt to climate change and maintain the safety bottom line for building 'beautiful China'. While this SPS was conducting its work visits, the current US president and vice-president focused again strongly on adaptation to climate change, framing it as a national long-term challenge, especially in terms of innovation [42].

5. Equity and gender aspects; due consideration for vulnerable people and areas

There is ample evidence that, in the context of climate change, socially and economically disadvantaged regions and populations are disproportionately affected by the adverse impacts of climate change, leading to further inequity (the `climate justice' agenda). A focus on social and gender equity[1] is therefore needed in climate adaptation.

5.1 Social inequities in climate change

A large body of evidence shows that socially and economically disadvantaged people suffer more from extreme weather events and by climate change impacts, such as women, elderly, children [43, 44]). Studies have repeatedly found that economic resources and policy engagement are key drivers of the ability to cope with climate risks [45]. The ability to live climate-resilient lifestyles depends on socio-economic variables that determine people's ability to relocate to safer areas, secure assets, get access to amenities, services, and social protection. Existing poverty and severely deficient housing and basic services (such as water, sanitation, electricity) as seen in informal settlements, exacerbate people's vulnerability to climate change impacts and trap them further in poverty. With over 1.1 billion people globally living in slums or informal settlements and an additional 2 billion expected to live in such conditions by 2050 [46], providing low-carbon, climate resilient infrastructure and services is a critical requirement to minimize impacts on those most vulnerable.

5.1.1. Urban-rural and regional disparities

Worldwide urban-rural and regional disparities are evident and sharp disparities exist even between urban areas. Less developed areas face bigger challenges in coping with climate change Due to relatively poor infrastructure, limited economic resources and inadequate public services, rural and underdeveloped areas often lack adequate capacity to cope with extreme weather events and climate disasters such as flooding, extreme heat, and landslides, as well as long-term impacts of climate change (e.g., sea-level rise and ecosystem degradation). Urban areas typically have better infrastructure, stronger economies and richer resources, which enables them to invest more effectively in climate adaptation measures (flood protection systems, energy efficiency of buildings, adding green spaces). However, rapidly growing urban areas in less developed and lower-income countries of Asia and sub-Saharan Africa face the triple challenge of lack of basic infrastructure and public services, growing populations, and increasing climate hazards like extreme heat and flooding.[23] In addition, they are seeing an influx of climate migrants coming in search of economic opportunities due to droughts and other climate impacts in rural areas. It is not only the smaller cities that are growing the fastest, but also large cities in these regions that find themselves resource-constrained and unprepared to adapt.

At the same time, the vulnerability of rural and less developed areas to climate change involves demographic issues (young people moving to cities for career reasons). Rural areas usually have a higher proportion of elderly – and in the case of China also relatively more children and women –, groups that can be seen as more vulnerable. In addition, the degradation of agricultural land, such as soil salinization, and the instability of water supply sources threaten agricultural production and exacerbate the vulnerability of these areas. These problems affect livelihoods and pose a threat to food security and ecological balance.

5.1.2. Gender disparities: global background related to vulnerabilities

Research about gender disparities in *adaptation* to climate change is extremely limited [47]. But multifaceted data from around the world show that women are more vulnerable to climate change and suffer disproportionately from the multiple impacts of climate change, including disaster casualties, displacement, gender-based violence, and violations of livelihoods and multiple rights. Moreover, considering that other vulnerable groups also face high vulnerability similar to women, this report focuses on vulnerable groups in a broader sense, including, for example, women, children, elderly and unrepresented groups. Such differences have to be factored into the design and implementation of adaptation policies.

For example, according to the United Nations Environment Program, 80% of those displaced by climate change are women [48]. In the face of climate change risks, the health of pregnant, poor, marginalized and rural young women is most affected. During the floods in Pakistan, nearly 700,000 pregnant women had no access to maternal health care, lacked food, security or basic medical care for themselves and their newborns, and experienced a sharp rise in spontaneous abortions [50].

In addition to being at greater risk of disasters, women also lack adequate migration capacity and resources to respond to disasters [51]. Many poor women live in remote areas and have difficulty accessing adequate government financial support and services [52].

5.2 Climate adaptation actions may further widen social inequities

Several studies show that existing climate adaptation actions may exacerbate existing inequities[47, 53]. Climate adaptation actions are often seen as the responsibility of the government rather than the public interest of society. It resulted in limited public participation in the decision-making and implementation process and vulnerable groups such as less developed areas or women being neglected or excluded from climate adaptation measures. Especially rural areas and smaller cities, due to infrastructure shortcomings, and lack of government attention, struggle to obtain the necessary resources to address the challenges posed by climate change. For example, there is a lack of funds for the construction and maintenance of disaster prevention facilities, and inadequate and untimely relief when faced with disasters. Adaptation action also often does not consider the specific needs of the most vulnerable population groups. This includes women who face greater burdens from climate change in situations of poverty due to care-giving responsibilities [50] children, the elderly, those living in unserviced informal settlements, and low-income outdoor workers working in construction, street vending, waste collection, and transport operations.

Overall, government bias in the formulation and implementation of climate adaptation policies is an important cause of increased social inequity. Unintended consequences of technocratic climate adaptation actions include social inequality, neglect of disadvantaged areas and groups, and irrational land use planning [54, 55]. The unbalanced distribution of resources not only exacerbates the gap between urban and rural development, but also weakens the ability of rural areas to the realization of an effective response to climate change – thus increasing the climate risks for urban areas as well. Further, with smaller cities and urban areas facing the greatest pressures of population growth and least capacity and resources for adaptation planning, the adaptation gap even between urban areas in the same country and between urban areas of less developed and more developed countries is very large (Summary for urban policymakers of the IPCC's 6th assessment report) [2]

5.3 Actionable improvements for social equity in climate adaptation

Social equity is the responsibility of all. Climate change adaptation policies should prevent further social inequities. In other words, in designing and implementing adaptation interventions 'do no harm' should be adhered to as a principle which is similar to the principle for the medical profession [56, 57] It is globally recognized in policy and academic circles that, when undertaking urban climate change adaptation policy and planning, on the one hand the planning process must be inclusive and involve everyone (IISD); on the other hand, interventions should be steered towards equitable policy outcomes, i.e., there is a need to identify the beneficiaries and disadvantaged of adaptation policy decisions, and to assess how it affects vulnerable groups [58]

Climate adaptation in rural situations often have a larger-scale regional impact. Both the Sigma Plan in Flanders, but also the agricultural experiments in the peatlands of the Dutch Green Heart, as well as the ecological recovery plans for the open pit mines in Germany, have a direct impact on their rural context as well as on the urban area of nearby urban conurbations. These plans show that urban and rural problems must be tackled in an integrated manner and indeed, peri-urban areas that span the space between rural and urban are critical for building resilience of cities and regions. This can start with small-scale local elements, where possible with as much input from residents and those directly involved. At the same time an overview of larger interconnections is needed, thus an integrated approach to interventions in the physical and social system is indispensable. For example, preservation and restoration of green and blue spaces (parks, farmland, forests, lakes, rivers, and other water bodies) offers protection from flood and heat risks at a city and regional level, while enhancing livability, public health, and generating economic opportunities for citizens. Spatial and land use planning that is informed by climate risks can help prevent new development in risk-prone locations and keep citizens out of harm's way.

Cases for ensuring social equity in climate adaptation[45]:

In July 2022, researchers at CANUE Canada launched the Healthy Plan. City tool. The tool visualizes health-related attributes of urban environments with socio-demographic data from the Canadian Census, providing interactive maps that allow users to overlay different features of urban environments (e.g., heat islands and tree canopy cover) with the proportion of potentially vulnerable populations (i.e., seniors, children, visible minorities, low-income individuals, or individuals living alone) in Canadian communities. The tool allows policymakers, planners, and advocacy groups to identify which communities would benefit most from added features (e.g., new parks or more trees and vegetation) or where interventions should be prioritized (e.g., locating cooling centres during extreme heat events).

The "photovoltaic poverty alleviation" project implemented by China, through the construction of solar power generation facilities in impoverished areas, not only provides clean energy for residents, but also helps poor families to increase their income through the proceeds of power generation. In addition, through its "green finance" policy, China has provided financial support for climate adaptation projects in rural and less developed areas, ensuring that these areas have access to the necessary resources to meet the challenges posed by climate change, thereby achieving a more balanced and equitable enhancement of climate resilience across the country.

Shared definitions, as well as co-learning are crucial for successful results [59]. Openness in information provision and combining knowledge from local communities with that from technical experts, helps to quickly get important stakeholders on board to realize sustainable transitions. Hence, a recommendation on improving inclusivity and equity is to stimulate co-learning during the whole planning and implementation process via public participation aimed to co-create a shared vision for the future. This will increase support and effectiveness of policies.

5.4 Common Prosperity policy as a tool

In 2021, China's Fourteenth Five-Year Plan and Vision 2035 Outline released common prosperity (共同富裕) as the cornerstone of the national policy framework, aiming to enhance social equity and regional balance and to narrow the gap between urban and rural areas. Common prosperity as a policy is part of China's Ecological civilization paradigm [60]. It represents a strategic shift from a focus on (urban) growth and wealth accumulation to a more balanced and inclusive development model by improving rural infrastructure (public services, digital connectivity, etc.), and reducing economic disparities. This has direct impact on sustainable spatial development and climate adaptation.

There are currently still significant differences between urban and rural areas in their approach to flood risks and adaptation measures [61]. Urban areas are in terms of population density and economy extremely vulnerable to flooding and extreme heat but not always better protected against climate change impact. Much investment is needed in climate-resilient infrastructure to withstand the three types of climate risk – namely agricultural drought risk, urban waterlogging, and coastal storm surges – that China is most likely to face in the future [62] During the annual flooding season rural areas are usually hit the hardest (Give2Asia, 2024).

Urban adaptation measures even sometimes have big spatial impact on rural areas, a form of environmental injustice. It's easy to forget that problems in rural areas affect everyone in terms of food safety [63, 64]. So, to ensure the equity of its climate adaptation policies, governments need to focus on the requirements of social equity and development and the promotion of people's well-being, carefully designing climate adaptation and investment planning, rationally arranging the implementation of actions and the allocation of resources and encouraging the participation of residents and social organizations in climate adaptation actions.

6. Experiences show: Action, knowledge and investment required at multiple scales

This chapter summarizes emerging insights for accelerating climate adaptation across different spatial scales and geographies (urban, rural, delta, mountainous, and hilly areas) and time horizons (long, medium, and short term). It highlights the vulnerabilities faced by each region, such as increased water supply challenges in urban areas due to extreme events and inadequate infrastructure, drought-related issues in rural areas impacting water and electricity supply, salt-tide intrusion in coastal urban agglomerations, and flood and landslide risks in mountainous and hilly areas. Changes in the institutional geography and financing mechanisms are needed to strengthen the enabling conditions needed for the five capacities required to create resilience. Various adaptation means and lessons learnt are summarized, to create a basis for the Recommendations.

Pertinent insights that have emerged across the case analyses in this report and in the reviewed literature, and during the work visits in China and in North-Western Europe are extracted and discussed. Next to the five key capacities for assessing ability, capacity and potential for adaptation to climate change, the specifics of the local situation and the local conditions should also be taken into account before formulating conclusions. Specifics include physical geography and hence specific risks, enabling/disabling conditions, as well as 'institutional geography', such as the relations between layers and pillars of government and the division of responsibilities between public authorities and private persons and organizations. Overall insights include:

- **A need to move fast**. This is in view of the existing adaptation gap in many situations, lead times to prepare interventions, and worrying climate projections. 'Lead times are increasing and warning times are decreasing'[60].
- **A need to move beyond fragmented and reactive approaches**, which lead to restore the status quo or, at best, incremental changes -- while a transformative change will likely be needed.
- **A need to be location-specific and build collective intelligence**. National governments and, for some aspects, intergovernmental organization like the European Union and the United Nations, have to lead especially in setting ambition levels, expanding and spreading scientific understanding and creative design, and requiring assessment and mandating collaboration at scales that match the challenges.
- **Strong coordination among different governmental bodies is needed**. Land use planning, development planning, infrastructure construction, stormwater management, flood control, greenspace management and community governance are all sharing parts of the responsibilities of adaptation work, but coordination mechanisms to make synergies are often missing at various levels.
- **Adaptation goals setting for multiple** purposes (for people, climate and biodiversity) would promote alignments and facilitate trade-off for implementation. Issues of equity should be considered when designing and implementing adaptation measures, because individuals' abilities to address climate change risks and to engage in adaptation vary.

Overall, this study illuminates promising and useful tools, approaches and networks to assess climate resilience at various levels of scale and support the planning of adaptation interventions. At the same time, weaknesses in knowledge are identified. For example, the economics and financing of adaptation to climate change seem under-emphasized in the current CCICED programme of work.

6.1. Emerging insights related to spatial scale

6.1.1. Urban Area

Climate adaptation tends to focus on urban areas and thus a broad range of case-specific vulnerabilities, adaptation gaps, lessons and inspiration was identified in the case studies. However, a persistent challenge remains moving beyond reactive responses to past events in specific locations and time-constrained circumstances. Room for improvement seems to exist in:

- Developing an ambitious and broadly supported mission-based approach [13]
- Learning from what went wrong, and went well, elsewhere – through peer learning networks such as C-40 Cities and The Nature Conservancy, common independent knowledge institutions such as Deltares, and UN facilities such as Early Warning for All
- Complementing city-based assessments with assessment of national or regional approaches – facilitating local initiatives and developing long-haul climate resilience. Promising examples have been identified in this report, through the case studies and work visits.

Specific insights include urban expansion increased water-related vulnerability:

- The increasing frequency of extreme events (storms, precipitation, river floods, high temperatures and droughts) poses a serious challenge to urban water management.
- Urban expansion and the rapid incorporation of peri-urban areas into city boundaries has resulted in more people living in metropolitan regions. This accelerated urbanization, however, has outpaced the development of essential water supply infrastructure. The mismatch between population growth and infrastructure adaptation has dramatically increased the vulnerability of urban water supply systems.
- Traditional water detention and management structures are dismantled to make way for construction in the process of urban expansion, further increasing flood hazards and the vulnerability of water supply capacity.
- Aging of the infrastructure for drainage, water supply and water quality management – and hence its need for replacement - is a rapidly increasing challenge for the near future. Moreover, this infrastructure was not built for the climatic conditions of the future.
-

Lessons Learned: Developing and Implementing Integrated Planning for Urban Development

To cope with the negative impact of climate change, urban expansion and urban renewal should consider medium- and long-term climate change impact. In particular, the very long-term territorial spatial planning needs to be redesigned, to give more weight to climate adaptation. Measures or strategies adopted include:

- Protecting the underground space in cities (e.g., parking lots, basements, shopping malls, train stations, and tunnels) as well as using it as a potential resource to build a more flexible and sustainable water management system, which can not only store water during extreme rainfall events but also reduce the vulnerability of water supply in the city. Considering the disaster-prone nature of underground space development, reasonable planning and safety control of underground space should be strengthened. The subsurface space requires careful spatial planning because the ownership of underground space between administrations can be complex.
- Investigating the risk of nature-based solutions failing under extreme conditions through stress

tests and considering the combination of nature-based, 'green' solutions with 'grey' engineering infrastructure. Combining nature-based, 'green' solutions with 'grey' municipal engineering infrastructure forms a multi-level, 'green-grey' flood prevention and floodwater utilization system (*also see details from Shanghai case in Chapter 3*).

- Minimize the damage of extreme events that overload the capacity of the drainage system. To achieve this, use solutions that maximize the day-to-day benefits and services for the residents and the ecosystem.

One example of a planning support tool providing practitioners with suggestions for adaptation measures in various aspects such as flood control projects, water resource management, and ecological protection is the Xiangtan Adaptation Support Tool. This system assists the user in the analysis of user-supplied data on rainfall, water level changes, soil types, and land use. It provided an effective tool for Xiangtan City to consider climate adaptation in urban expansion planning and can be tuned for other locations [61].

6.1.2. Rural Areas

Compared with the rural areas globally, rural areas in China face unique climate change challenges because of high population density, uneven water resource distribution, high agricultural dependency, weak infrastructure and urban-rural disparities. The climate-related challenges include health risks, agricultural production reduction; water-electricity cuts require more measures in rural areas. These measures would not only protect rural areas, but also protect urban areas for flooding, water shortages and water quality issues.

- Water resource management is required to become more efficient through improving traditional facility and expansion of rainfall collecting facilities (*good examples exist in Flanders, Belgium*).
- Drought requires more public awareness and participation. Many practitioners in Western Europe underlined the need for societal dialogue as the basis for adaptation to climate change, and, in turn, political mandate and information tools to support this dialogue.
- Social capital and community culture play vital roles in recovering from mental and social damages (*good examples in the Rur and Ahr-Erft basin, Germany*).
- Increasing the financial investment in rural areas to improve old infrastructure, agricultural production capacity, and water resource management, etc., to promote the fairness between rural areas and urban areas (*also see details in the chapter on <Equity Aspects>*).

6.1.3 Delta regions

There is a widely recognized consensus that, particularly in delta regions, (i) current strategies place excessive emphasis on short-term solutions. This focus often constrains the ability to design sustainable, long-term solutions, highlighting the need for a paradigm shift away from adaptive planning, which is reactive and incremental, towards planned adaptation, which proactively addresses future challenges. Additionally, (ii) there is a significant gap in the integrated understanding and appreciation of deltas, specifically regarding their dynamic and complex behavior. A system-based approach is crucial for managing these environments effectively, ensuring that solutions are both sustainable and resilient in the face of evolving climate conditions. Specific issues emerging from the cases include:

- Increasing salt-water intrusion in coastal urban agglomerations: Coastal agglomerations and regions are facing increasing saltwater intrusion, requiring costly workarounds - for example, connecting to inlets from multiple rivers, or freshwater infiltration into the ground - to guarantee future service levels. While saltwater intrusion is an age-old phenomenon, it is increasing and one of the early manifestations of sea level rise for local water managers in coastal areas and for agricultural adaptation. Countermeasures to salt-water intrusion include potentially costly engineering such as managed aquifer recharge, cross-river connectivity and off-shore freshwater lakes.

- Soil subsidence, other than in permafrost situations, always relates to ground water management (abstraction, level management in soft soil areas) and is a large complicating factor in flood risk management. It occurs in various megacities across the world, but also in peatland as in the Rhine-Meuse delta. Subsidence, rain or river-based flooding risks, and sea level rise add up and are climate-related. Especially when oxidation of peaty soils, typical in many delta areas, is part of the equation, subsidence can be fast and problematic. Lasting solutions would always deal with groundwater regimes, and thus with use of the land, for urban, agricultural or other economic purposes, or for nature.

6.1.4 Mountainous and Hilly Areas

Mountainous and hilly areas stand out as a category of their own, in particular in terms of flash flood and mudslide risks caused by extreme rainstorms. Fash floods and mudslides happen suddenly and are hard to predict, resulting in huge damages. In China, since 1949, more than 190,000 people have died by flash floods in mountainous areas. A recent example is the Sichuan Kangding flash flood and mudslide disaster: In the early morning of August 3, 2024, three villages in Kangding City, Sichuan Province, were hit by a short period of sudden and extreme rainfall, which triggered a flash flood disaster. The disaster resulted in the deaths of 12 people and 15 people missing.

Bridges and culverts in narrow valleys were found to considerably increase devastation during flooding and should be built back differently. Although space for detention is little, many decentral storage facilities can contribute to flood risk reduction. Reservoir construction in mountainous and hilly areas should take into account the risk of dam failure and climate change response, and, on a more general note, awareness of residual risk. ***(E.g. case 18, Peru Flood Resilience Task Force*.)**

6.1.5 Integrated River Basin Management

Integrated river basin management considers the river basin as a whole to formulate collaborative management and development plans. Interdependencies at different levels are considered such as basin level (upstream-midstream-downstream, left and right banks, mainstreams and river tributaries), urban-rural level (urban, rural and natural areas), as well as the administrative level (cities/municipalities, provinces or countries depending on whether the river is transboundary river). At the planning stage, coherence of the interventions at all spatial scales is essential for achieving the management goals and objectives set in the plan. The land use planning of the riparian land and the floodplain plays a key-role in the management of floods, droughts and water quality issues. At operation stage, both engineering and non-engineering measures of the basin management are essential for the coping capacity, i.e. to minimize the damage of extreme events. New tools and technologies for monitoring, early warning and real time control such as digital twin technology, big data and cloud computing are rapidly developing.

For example, by strengthening cooperation among provinces and municipalities, the comprehensive management of the Yangtze River Basin improves the ability of different regions within the Yangtze River Basin to defend themselves against extreme events such as heavy rainfall, floods and droughts. In the Yangtze river, the integrated operation of reservoirs plays a vital role in mitigating flood and drought. During the severe drought in 2022, the integrated operation of 51 reservoirs provided downstream 8.3 billion m^3 water. During the number 1 and 2 floods that happened in 2024, the reservoir groups in Yangtze river intercepted 233.5 billion m^3 water for mitigating the flood stress in the downstream part. In 2023, Hubei province published <Outline of Hubei Province's Integrated River Basin Management and Overall Development Plan>, highlighting the integrated river basin management at province level.

6.2. Emerging insights related to time horizon, investment and finance

6.2.1 Strategies at Different Time Horizons

Effective adaptation to climate change requires adopting and pursuing different, but consistent strategies for distinct time scales (long-term for decades, medium-term for months to years, and short-term for hours and days to months). Planning strategies are suitable for the medium to long term scale and contingency strategies for short-term scale. Major infrastructure and real estate developments that have not previously considered climate change need to be adjusted to improve their contribution to the threshold and adaptive capacity that is required for the long-term protection of a territory. Reviewing projects ‘in the pipeline’ is recommended, but can be problematic. The pain of revision must be weighed against the need to make up for time lost in adaptation.

- **A planning horizon of 2050 and an exploratory horizon of 2100** is recommended for planning and upgrading infrastructure such as flood defenses and water management systems, for urban expansion and urban and rural renewal projects. Long term climate impacts such as sea level rise, changing rainfall patterns and water resource changes impact their performance on the long run. Societal systems, too, often require long-term planning for change. Education systems are a good example. Experiences, in Europe anyway, indicate that vocational training, of hands-on staff, needs to keep up with the rapid developments in climate adaptation techniques. This does not only apply to engineering, but also to legal and communication aspects.
- **At the medium-term** (months to years) scale, measures such as adjusting building standards and optimizing transportation systems are needed to adapt to the challenges of climate change in the medium term, tuned with developments in technology, economic development and societal demands.
- **At the short-term** (hours and days to months) scale, contingency strategies such as establishing emergency response mechanisms, optimizing water resource dispatch systems and raising public awareness can be taken to improve the short-term adaptation capacity.
- **Keeping** the threshold, coping and recovery capacities **up to date** requires attention every 5-10 years. Assessments and stress-tests are to be repeated to find new gaps in the resilience of areas, systems and populations.

6.2.2 Investment and Financing Strategies

A new perspective to the revenue stream of climate adaptation:

- The economics and financing of investments in adaptation to climate change differ significantly from the economics and financing of mitigation of climate change. The difference is in the revenue stream, or its absence. Adaptation to climate change can avoid enormous damage and painful losses. Blue-green and grey interventions can also generate multiple ecosystem services and societal benefits. However, they hardly ever generate direct financial revenue stream and the cost-benefit balance tends to become positive only after several years.
- At project level, mixed public private financing approaches can sometimes be applied. Business models for leveraging adaptation funding in this way exist, and their accounting distinguishes between monetary cost and revenues, such as tax benefits from increased tourism, and non-monetary benefits, such as reduced risk of flooding. This however requires careful management of expectations, clear accounting of the various kinds of costs and benefits and clear legal agreements between the public and private partners in the project.

  For example, the China Three Gorges Corporation has participated in the ecological restoration and protection of the Yangtze River Basin through establishing an ecological compensation fund for environmental protection. Since 2013, the Three Gorges Group has carried out a series of efforts for rare fish habitat protection along the Yangtze River with the goal of "no net loss". It is conducive to maintaining aquatic biodiversity and improving the stability and resilience of the ecosystem for better adaptation to climate change. The group provides stable capital flow for ecological compensation projects with the help of diversified means such as green bonds and green financial products, promoting a double-win situation between ecology and economy. Meanwhile, it strengthens cooperation with the capital market, attracts more social capital to participate in green investment, and jointly promotes climate change response and the realization of sustainable development goals.
- Globally, there is an increasing focus on infrastructure investments to mitigate the economic impact of climate-related disasters and to support a sound recovery. However, there remains an overemphasis on grey infrastructure. This highlights an urgent need to demonstrate the economic viability of investing in sustainable Blue-Green Infrastructure (BGI) and to create an enabling environment for scaling up these initiatives. Infrastructure investments should not be limited to new projects and maintenance but should also include the upgrading and replacement of existing infrastructure to ensure resilience and sustainability in the face of future challenges.
- Adaptation could result in stranded infrastructural assets. This could be existing pieces of infrastructure that become obsolete or even new infrastructure with insufficient adaptive capacity. Adaptability to new, currently unknown climate conditions and other requirements is key to smart investments.
- The economics and financing of adaptation to climate change is not well covered in the current programme of work of CCICED and fall also somewhat outside the field of expertise of this SPS in the current reporting cycle.

Overhaul of infrastructure and building stock:

- The coming years will see a surge in overhaul of buildings and infrastructure, urban renewal projects and, sometimes, spatial layout and land use adaptation. In China, the need to overhaul or replace buildings and infrastructure typically seems to come quicker than in Western countries, because of the presumed less robust construction. For buildings in China, 30 years of age is often quoted in this context and large parts of Chinese cities have now reached this age. Shenzhen, most of it 30-40 years young, is a striking example.This contributes to an enhanced adaptation potential and explains the relatively high rate of ‘green transformation’ in China.
- In many Western countries, buildings and important infrastructure often date from shortly after the second world war. They, too, are now up for major maintenance, as well as review in the light of developments in technology, climate, energy-transition, demography and societal demands. This is yet another example of past developments in China having been compressed in time relative to elsewhere.
- The main opportunity, and a big challenge as well, is to use infrastructure overhaul wisely, considering its longevity and the expenditure involved. A useful strategic notion by the China-EU Water Platform reminds of the need to upgrade, or change, existing infrastructure and design and install new infrastructure and minimize the cost and maximize benefits, society-wide, across these two kinds of operation.

Current investment portfolios:

- The key challenge at present is to achieve an ambitious acceleration of adaptation to climate change within the current decade. Typically, good opportunities to improve climate resilience can be found in large-scale long-gestation projects that are initiated for non-climate reasons. For example, industrial renewal in China; large-scale housing development and urban renewal everywhere, or infrastructure overhaul as mentioned before. It will be necessary to review and adjust all major investment programmes in the pipeline for the area.
- Therefore, in many urban and peri-urban situations, it will be necessary to launch an acceleration programme, typically covering 2025-2035. Such an acceleration programme would identify specific climate risks - if this has not been done already - and assess performance on the five key capacities to adaptation as defined in this report and elsewhere. Creativity and pragmatism will be needed, as well as dedicated attention to the needs of vulnerable and non-represented groups to achieve equity and justice in climate resilience.

The financial industry and adaptation to climate change:

- Ill-orchestrated insurance practice like in Germany and The Netherlands can be a real impediment to building back better after disasters. In view of what went wrong and projected climate change developments, building back the same as was there before the disaster simply means building back worse (maladaptation). Recovery from a disaster provides an opportunity for improving resilience that ought to be seized.
- At the level of general oversight of the financial industry and its portfolios of lending and investment, national regulators are becoming more aware of climate risks, and are requesting lenders to assess and limit climate and biodiversity risks of their lending portfolios. Although this stepped-up oversight is by itself not generating adaptation capacities as defined in this report, it

does add to a business climate that is increasingly conscious of risks posed by climate change to old fashioned investments and makes investors aware of accountability on these aspects. The key organization on this is the Network of Central banks and Supervisors for Greening the Financial System NGFS. 139 regulators are members, including the People's bank of China [62].

6.3. Emerging insights related to institutional geography

6.3.1 Collaboration at National, Regional and Sectoral Levels

In adapting to unfolding climate change, ambitiously, effectively and fairly, a key challenge is to rise above fragmentation between departments in government bodies, between government bodies, between government and private sector agendas, and between world views. Collaboration across jurisdictions, relevant to adaptation to climate change, comes in many forms and shapes. The examples of the current SPS include: (i) a dedicated implementing body for work on Lake Taihu; (ii) regular collaboration between Guangdong province of mainland China, Hongkong and Macao; (iii) River Commissions in China; (iv) The European Commission with its water directives; (v) The International Rhine Commission, , with focus on coordinated monitoring and advice; (vi) Regional alliances like the Deltametropool as a joint hub for spatial planning and analysis by design, initiated and jointly maintained by four adjacent cities; and, contributing to a previous and related SPS: The Institute of the Gulf, operating in the Mississippi Delta near the gulf of Mexico. Varying widely in formal status and authority, all seem to have grown from working-level persistence and top-level mandate.

6.3.2 Knowledge Management

Because of the large funding involved, it is unavoidable that setting up and maintaining **scientific and advisory institutions** for adaptation to climate change is taken care of by national governments. Two critical conditions apply: stable funding, and a mandate to provide independent and unsolicited advice to governments and societal actors. Five tools, or approaches, are lauded in the cases analyzed and work visits made for this SPS. They are:

- Stress-testing: For understanding climate vulnerabilities (from being exposed to flooding, drought, heat and related consequences) in urban and regional situations stress-testing is available as a particular kind of tool. Core question is how, considering the five capacities, systems and organisations in a given area are capable of dealing with extreme scenarios. Stress-testing can be applied at various scales, such as a whole agglomeration, or plans for a transportation hub or a hospital campus. In the financial industry – where the term 'stress-test' originated - climate-related stress-testing seems to be accepted widely in Europe.

  For a useful and realistic result, stress-testing should also be applied to the area of the physical water system, the river basin, which normally is larger than a city, or comprise more than one jurisdiction. This may be complicated to organize but is important.

  Once applied to a whole region or even a small country, it is useful to make the results of stress-tests available to planners and the public at large. A good example is this on-line atlas: www.klimaatadaptatienederland.nl. A related inspiring overview of implemented adaptation measures can be found at www.climatescan.nl. The online atlas provides users with a wealth of information related to climate change adaptation. The information includes the latest research, practical tools and guidance, as well as up-to-date events. Thus, the online atlas provides opportunities for different groups to learn and understand climate change adaptation and raise public awareness [63].

- Broad-based scenario approaches: There is much to be gained from applying the full width of modern scenario-based analysis. In particular, spatially differentiated scenarios for the key undercurrents in society (technology, demographics, industrial shifts) enable to adaptation strategies with an integrated view of a territory, with a sufficiently long time horizon.
- Advances in strategically exploring and planning climate adaptation interventions. This is a complex challenge. Research by design and co-creative planning processes, involving experts from many disciplines and all direct stakeholders, are steppingstones to identifying crucial decisions to be made and creating widely accepted adaptation plans that add significant value to the livability of an area and the wellbeing of its residents.
- Advances in effective early warning: Effective early warning protects life from the impact of natural disasters. Recent years, the early warning systems developed vary fast worldwide. In March 2022, United Nations Secretary-General António Guterres initiated the global Early Warnings for All Initiative [64]. WMO, UNDRR, ITU and IFRC with partners developed a people-centered Multi-Hazard Early Warning System (MHEWS).
- For river basins, digital twinning technology has emerged as an excellent tool in increasing the adaptation to climate change. Through mapping the real world to digital world, the digital system can reflect the full life-cycle process of the corresponding real watershed. During extreme events, based on the real-time monitoring, digital twin river basin systems enable managers to forecast warnings, previews and preplans, risk assessment and decision support systems.

Periodic assessment:

- Periodic, systematic and authoritative assessment of climate risks and of adaptation capacities is essential to make things move, build alliances, engage citizens, check on equity and fairness, consider new information and technology. A climate change assessment system can systematically identify the climate risks and adaptation gaps faced by cities and regions. The assessment results provide a scientific basis for the formulation of effective adaptation strategies and plans.

In the context of China, two concluding comments pertain:

- First, the city level. A city climate resilience assessment system is both necessary, as stated above, and opportune. The opportunity exist in the form of the "City Health Examination" system of the Ministry of Housing and Urban-Rural Development (MOHURD), which currently provides the basis for the establishment of a climate resilience assessment system.
- Second, the national level. This level has remained somewhat under-exposed in the Chinese cases in this report. However, a robust, authoritative assessment of the national adaptation policy is essential as a base for national guidance and ambition, mandating collaboration between government bodies, motivating stable funding of adaptation programmes and knowledge development, firm decisions in spatial planning, and dissemination of information. This level of assessment should address the strategic, long-haul issues including adaptation to slow but important changes such as sea level rise or adaptation of agricultural practices in view of heat and drought.

7. Operational Assessment Framework for Adaptation to Climate Change

The conceptual assessment framework presented in Chapter 2 and used to distill the lessons from case studies and disasters in the past produced new insights on the gaps and weaknesses in climate resilience of the current situation, covering the physical as well as the institutional and governance aspects. Based on the experiences with the conceptual framework in the evaluation of the cases in Chapters 3 and 4, this chapter proposes to establish a generalized operational framework for climate adaptation assessment, which specifies comprehensive and consistent content and procedural steps for climate adaptation assessment in urban and rural areas in different countries, regions and cities.

7.1 Role of the operational assessment framework

Climate adaptation assessment is the link between the recognition of the need for climate adaptation and the planning of adaptation actions. A generic operational assessment framework structures this step. A uniform approach of the assessment process and a comprehensive, consistent contents of the analysis will result in robust adaptation plans for the local, regional and river basin scale. The application of the framework will allow for the identification of the main climate risks faced by urban and rural areas, and of the strengths and weaknesses in the five capacities and in conditions required for creating a climate resilient area. This analysis is input for the adaptation plan, for setting goals and objectives, showing the effectiveness of proposed climate adaptation measures and for supporting the identification of policy priorities for climate adaptation at the local, regional and river basin scale.

In the conceptual assessment framework, the five capacities and ten enabling conditions for resilience cover a wide range of potential weaknesses, including recovery capacity, long-term adaptability and the transformative capacity of society. Moreover, the approach recognizes the opportunities of climate adaptation, minimizing the potential damage of extreme events while maximizing the benefits and services provided by the proposed measures, taking a long-term perspective. This sheds new light on how to create a climate resilient environment and potential bottlenecks in timely realizing the adaptation that is needed. Therefore, it is recommended to integrate these five capacities in the assessment framework, to position these in the assessment process and in its contents, creating a solid basis for an adaptation plan and its successful implementation in practice.

7.2 Contents and steps of the assessment

Climate adaptation assessments need to be comprehensive, i.e., they need to integrate the impacts of climate change risks and adaptation measures on security, economy, society, environment and culture. Synthesizing relevant international climate adaptation assessment and planning practices at different levels, such as global (IPCC), national (USA, Netherlands, EU), and region/city (New York, Tokyo, Flanders region of Belgium), four tiers or steps are distinguished. Considering the geographic and socio-economic characteristics of the area, these four parts should be carried out sequentially, in order to form a comprehensive adaptation plan. Moreover, these four steps are to be taken at the local, the regional and the river basin scale, in a consistent and coherent way, taking into account the differences in local characteristics between cities, regions and basins.

7.2.1 Context and climate adaptation background assessment

The climate change trends and scenarios are to be studied and presented for all relevant spatial scales and major impacts faced by cities, regions and watersheds. Also, the basic characteristics and development trends of the project area are to be mapped and analysed, such as topography, land use, population and socio-economic patterns and future scenarios, infrastructure conditions and etc.

7.2.2 Climate Change Risk & Opportunity Assessment

Assess the climate change risks faced in cities, regions and river basins in terms of disaster hazards, exposure and vulnerability (terminology from IPCC, 2012[4]) by performing “climate stress tests” to study the impact of extreme climatic events. On this basis, the vulnerability of the community at the local, regional and river basin scale is identified, as well as the main challenges and weaknesses in the resilience of the physical and governance systems to cope with the risks. Also, an analysis is to be made of the synergetic opportunities that other developments provide to include climate resilience-strengthening interventions. For example, the energy transition, urban renewal, and technological innovation can be combined with adaptation interventions.

7.2.3 Assessment of a climate adaptation action plan

Starting from the goal of enhancing the climate resilience of the area, adaptation interventions can now be studied from the perspective of the gaps found in the five capacities to creating resilience (threshold capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity) and the weaknesses in the enabling conditions required to achieving these goals. Research by design is often used to produce comprehensive plan alternatives and distil the preferred options. Design teams with experts from a wide variety of disciplines and including relevant stakeholders are the best to co-create alternative solutions for the complex planning problem at hand. Potential climate adaptation alternatives should be subjected to an effectiveness and feasibility assessment. Equity in adaptation and public engagement are important aspects of drafting the adaptation action plan.

This step results in a climate adaptation plan that is coherent with the adaptation strategy and plans at the other spatial scales. This local plan should fit the city plan, the city plan should fit the regional plan and the regional plan should match with the river basin plan.

7.2.4 Performance evaluation of climate adaptation implementation

To be able to implement this plan the enabling conditions should be met. Substantial efforts and funding are often needed for this. Monitoring of the progress and ex-post evaluation of the performance are standard elements of good governance; these provide input for a new cycle of climate adaptation planning. Repetition of this cycle at least every decade seems recommendable, as new data continue to become available and new conditions and requirements will emerge over time.

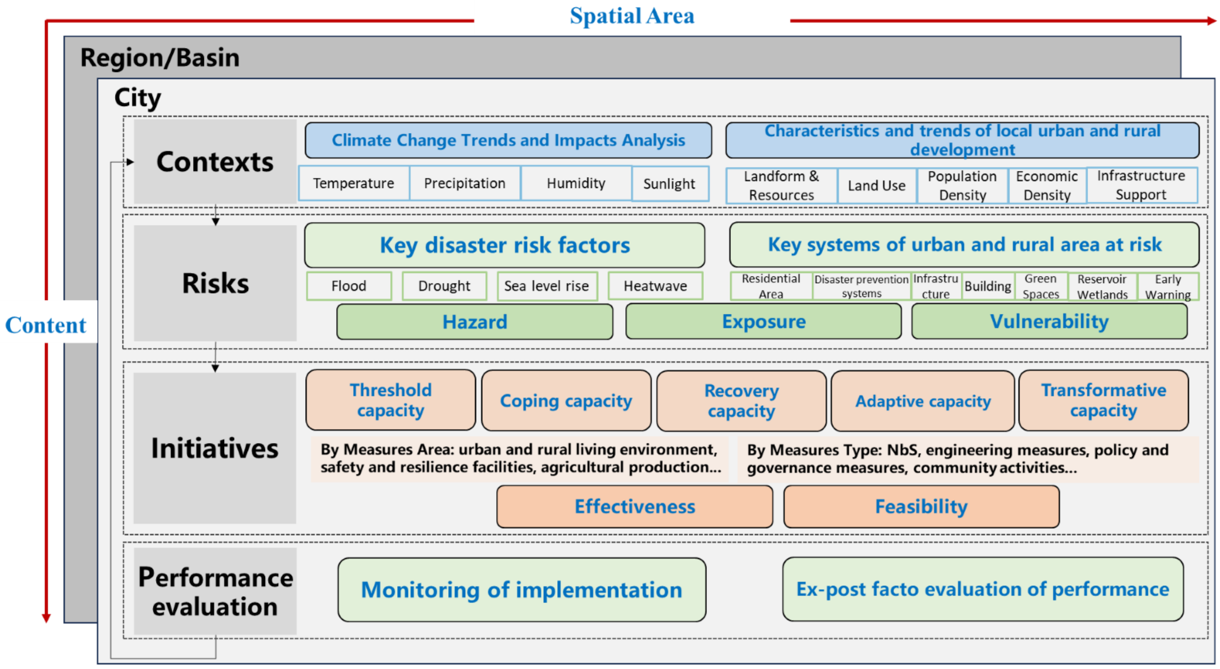

Figure 7.1 Proposed operational procedure to assess climate resilience and to plan adaptation interventions in urban and rural areas. Based on an analysis of the local situation, now and in the future, and on a vulnerability analysis to find the gaps in the five capacities required for a climate resilient environment, coherent adaptation plans can be made at the local, city, regional and the river basin scale.

7.3 Assessment challenges

7.3.1 Strengthen synergies to jointly conduct integrated assessments of climate resilience

Strengthening cross-regional and cross-sectoral synergies to jointly conduct integrated assessments of climate resilience in urban and rural areas at local to river basin scale is needed. Synergies between different regions and government departments is required in climate adaptation assessments. This includes defining a unified vision and goal for climate adaptation, integrating the risks and interests of different regions and sectors; establishing a unified framework and data and methodological basis for climate adaptation assessment through information-sharing; and establishing synergistic mechanisms across regions and sectors, as well as between different levels of governance and departments within cities, regions and ministries. It is necessary to shift from the sub-assessment of individual hazards and the "cost-benefit" evaluation of individual measures to a comprehensive, multi-objective decision-making assessment based on integrated risk & opportunity management, taking decisions despite the many uncertainties for the long-term future.

7.3.2 Identify key risks of area, adaptive capacity of facilities and transformative capacity of organisations

Different regions and areas should carry out climate change risk assessments based on their own geographical characteristics, focusing on identifying the key disaster risks and outstanding problems faced locally. Not only the risks to climate change are to be identified; also the adaptive capacity of key facilities and the transformative capacity of sectors and organizations is to be assessed. First, different regions and cities should carry out climate change risk assessments based on their own geographical characteristics, focusing on identifying the key disaster risks and problems faced locally. Second, the adaptive capacity and the longevity of the existing infrastructural facilities in urban and rural systems is to be quantified in the light of the changing exposure to extreme conditions and the changing vulnerability of their function. Are assets going to be "stranded" because of their age and inadaptability? And how is the transformative capacity of the sectors and organizations that have to change themselves, adopting new practices and business models? Are the enabling conditions sufficient to support these people in their transition towards their new future? A thorough stakeholder analysis and an analysis of the enabling conditions is an essential part of Risks and Opportunities assessment.

7.3.3 Analyse the correlation between different disaster risks; develop scenarios for adaptation

Climate adaptation planning should be based on different possible scenarios of climate change and other social, economic and technological developments. Scenario analysis for adaptation measures should be carried out and adaptation pathways identified. To conduct a comprehensive assessment, it is necessary to consider the short-term extreme weather risks as well as the risks resulting from long-term climate change, and. Attention should be paid to the correlation and interactions between different hazards and the interactions between different facilities and systems in urban areas and the river basin these are part of.

7.3.4 Differentiated assessments should be carried out based on spatial perspective

From the perspective of spatial geographic differences, a differentiated assessment should be carried out, taking into full consideration the great variability that exists between different regions in a river basin and between cities, city districts, villages and countryside, as well as the differences in climate adaptation capacity at the city level and at the community level. Priorities should be clarified for urban and rural settlements in different spatial regions, taking into account their own characteristics, such as estuarine delta areas, densely populated small to medium-sized watersheds, and ecologically fragile areas in the upper reaches of watersheds.

7.3.5 Assess the implementation feasibility and performance of climate adaptation measures

The conclusions of scientific research, financial funding analysis and other factors should be synthesized to assess the feasibility of implementing specific adaptation measures. However, the current cost-benefit evaluation systems have difficulties in estimating the benefits of interventions, in particular on the long-term benefits. This is partly due to the lack of reliable data on the performance of these measures, as well as on the lack of mechanisms for creating a balanced and fair distribution of the costs and the benefits over the beneficiaries. Long-term monitoring and assessment of the social, economic and ecological effects of climate adaptation measures and policies would help to improve these economic and financial evaluation models.

7.3.6 Equity in adaptation and public participation in climate adaptation assessments

Climate adaptation assessments should strengthen attention to less developed regions and vulnerable groups, and assess whether climate adaptation measures embody the principles of social equity and gender equality. Public participation should be strengthened in climate adaptation assessments and planning. The public, enterprises and other stakeholders should be encouraged to work together with government departments to carry out climate adaptation assessments, plan and implement adaptation measures.

8. Policy Recommendations

1. Climate risks are increasing and disaster losses are huge; action on adaptation is urgent.

Climate change is a risk multiplier. Already today the disruption of communities and the economic damage due to climate change and intensifying weather extremes exceed all scientific expectations, seriously threatening the safety of life and property of urban and rural areas. There is an urgent need to enhance climate resilience by raising climate adaptation to the level of the country's most important strategy, as in the case of climate mitigation and green low-carbon strategies.

1. National, regional and local governments therefore should urgently elevate the political and governance priority of adaptation to climate change across all relevant ministries and departments, accelerate climate adaptation in all policy domains, and enhance capacity-building in the five key dimensions of climate resilience (threshold capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity) from national to local level.
2. Climate adaptation strategies should address both the challenges of the increasing weather extremes and the slow-onset changes such as sea level rise, salinization, gradual warming, changing seasonal patterns of rainfall, water availability and ecological processes. Urban and rural authorities and communities should be supported throughout the entire adaptation process, from planning, construction and operation to disaster relief and post-disaster reconstruction.

2. The national government should develop a systematic and comprehensive policy framework for short- and long-term action, from the central to the local level, across regions/basins and sectors, and with active participation of the society, industry and local communities.

Climate adaptation is not a stand-alone challenge, requires both a location specific and river basin wide approach and should be integrated in all development strategies across policy sectors and scales. It should adhere to the action framework of national leadership, regional integration and synergy among multiple stakeholders, and establish a mechanism for coordinating climate adaptation actions across regions/basins and sectors. Priority actions are:

1. Develop and implement systematic and comprehensive climate adaptation programs and near-term action plans from national to local governments, based on the long-term goals for 2035, 2050, 2100 and beyond, and incorporate them into government development strategies at all levels and through all ministries and sectors.
2. Establish and commit to pro-active future oriented adaptation goals and targets across all policy domains, and establish a foundational system of regulations, administrative systems, financial and fiscal systems, policy systems and knowledge and data systems that effectively support climate adaptation strategies.
3. Create long-term stable adaptation funds as required by the long lead-time of adaptation strategies and implementation of measures, and coordinate government investment in different areas such as ecological restoration, disaster prevention and relief, and urban infrastructure construction.
4. Promote and support regional collaboration of climate adaptation strategies across administrative borders in key areas with high population and economic densities.
   For China, such key-areas are the Yangtze River Delta, the Guangdong-Hong Kong-Macao Greater Bay Area and the Chengdu-Chongqing region.

3. The national government should establish a climate adaptation assessment framework and mechanism to identify gaps in climate resilience and priorities for climate adaptation in key areas and facilities, and provide a solid foundation for urban and rural areas to monitor and improve their climate adaptation policy and implementation capacity

As the basis for climate adaptation policies and action plans, a localized framework for climate adaptation assessment in urban and rural areas is required, taking into account natural resources and conditions, climate change characteristics and the level of socio-economic development and the potential interaction with other institutional policy programs and assessments.

In China, for instance, the "City Health Examination" could provide a policy and regulatory context for this.

1. Address the actual risks and problems in climate adaptation assessments. Identify how resilient urban and rural communities are now and what are the resilience gaps. Priorities and implementation options for climate adaptation action should be identified by assessing the key climate risks, adaptation gaps in key areas and key facilities.
2. Evaluate existing laws, regulations, educational training programmes and funding mechanisms, based on climate adaptation requirements, and adjust these if needed.
3. Provide local and regional governments periodically with the latest insights from climate research, as well as the results of monitoring climate adaptation policies, at the national, regional, and local levels.

4. The national government should pay attention to social equity and gender issues in climate adaptation and should accelerate the enhancement of the climate adaptation capacity of less developed regions and especially vulnerable groups.

Social equity and gender research should be an important part of climate adaptation strategic research, policy and action. Particular attention should be paid to enhancing the climate resilience of underdeveloped regions, rural areas, small towns, and vulnerable groups and future generations. Priority actions are:

1. Raise the standards for disaster prevention infrastructure in vulnerable and underdeveloped areas as soon as possible, with increased financial investment to accelerate facility and capacity building.
2. Improve disaster relief services for vulnerable groups, such as disabled, elderly and low-income people.
3. Widely carry out publicity and popularization activities on climate adaptation, disaster prevention and mitigation to enhance public understanding of and support for climate adaptation and improve public participation.

5. Strengthen international cooperation and conduct joint multidisciplinary research to lay an important scientific foundation for climate adaptation

Climate adaptation is still in its infancy as to science, societal and economic integration and policy development. Further international collaboration and exchange of experiences across countries, regions and cities will be therefore of critical importance, focusing, amongst others, on basic theories and technical methods of climate change and climate adaptation, and encouraging scientific research institutions and third-party organizations to participate in climate adaptation assessment and research. For CCICED priorities are:

1. Strengthen sustained and in-depth international cooperation, to support learning from experiences around the globe and help to make leap-frog steps in climate adaptation policy development.
2. Conduct integrated, long-term and task-oriented policy research across disciplines and policy areas; and develop highly adaptive climate adaptation measures to avoid maladaptation in response to future development uncertainties.
3. Explore if the economy and financing of climate adaptation should be a new topic for CCICED as there are still major gaps in knowledge and experience hampering the implementation of climate adaptation.

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Chapter 7: No references

Chapter 8: No references