ROADMAP FOR INTEGRATED CLIMATE RISK MANAGEMENT

Climate Risk Management in China's Urban Infrastructure

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

MCII

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ACRI+

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EXECUTIVE SUMMARY

Climate Change, natural disasters and their associated impacts severely impact people around the world every year. Increases in exposure and vulnerability at a global level, linked to the multiple concurrent trends such as climate change, population growth and globalisation of supply chains are making it imperative to find strategies to manage disasters more holistically.

Integrated Climate Risk Management (ICRM) is an approach to dealing with the risk and manifestation of climate-related disasters. It is characterised by a holistic perspective with regards to the various components of risk management. ICRM differs from previous concepts in the disaster management paradigm that focused almost exclusively on response, and didn't pay significant attention to opportunities to reduce the incidence or potential impact of climate disasters.

This roadmap is developed from work undertaken on ICRM through the "Advancing Climate Risk Insurance plus" (ACRI+) implemented by the Deutsche Gesellschaft für International Zusammenarbeit (GIZ) GmbH and the Munich Climate Insurance Initiative (MCII). In China, the ACRI+ project is working with public and private stakeholders to improve the resilience of urban areas and especially urban infrastructure prone to mid-long term climate and disaster risks.

The roadmap focuses integrated risk management that aims to identify potential hazards and to reduce the impact and vulnerability by strengthening the coping and adaptation capacities of the society, according to the results of risk analysis. An integrated risk management approach also requires to establish risk transfer solution to prevent risk residue and prevent new risks.

The roadmap is based on a pilot project in urban infrastructure in the Lishui City of China, which enables pilot city government to access climate risk transfer solutions as part of their integrated climate risk management mechanism, to improve the climate resilience of urban critical infrastructure and to systematically reduce the impact of climate risks on the economic, social and fiscal system.

Currently, there are significant barriers to implement integrated climate risk management and scale up risk transfer in the urban context in China. The roadmap identifies some of the major gaps, and suggests actions and measures that could be followed to address them. The roadmap makes recommendations about short, medium and long-term adaptation actions for different implementers in local government departments to solve specific problems with clear responsibilities.

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LIST OF ABBREVIATIONS

ACRI+	Advancing Climate Risk Insurance plus
BMU	Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (Federal Ministry for Environment, Nature Conservation and Nuclear Safety, Federal Republic of Germany)
CNY	Chinese Yuan
FYP	Five-Year Plan
DRM	Disaster Risk Management
ECA	Economics of Climate Adaptation
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für International Zusammenarbeit GmbH
ICRM	Integrated Climate Risk Management
ICRM project	"Promoting Integrated Mechanisms for Climate Risk Management and Transfer" project
MoHURD	Ministry of Housing and Urban-Rural Development
MCII	Munich Climate Insurance Initiative
MEE	Ministry of Ecology and Environment
NAP	National Adaptation Plan
NDC	Nationally Determined Contributions
PSCCAC	Pilot Scheme for Construction of Climate Adaptation Cities
RCP	Representative Concentration Pathway
NDRC	National Development and Reform Commission
UNFCCC	United Nations Framework Convention on Climate Change

Introduction

1

1.1 PURPOSE

This document provides guidance and technical support to policymakers and other stakeholders involved in the identification, management and reduction of climate risks, and the impact of climate-related disasters in urban development in China.

Background

Paired with rapid urbanization, China is one of the most climate vulnerable countries in the world. Intensified extreme weather events have posed major risks to China's economic and social development, resulting in immediate direct losses, huge additional fiscal risks and ultimately costs. Governments intend, in cooperation with other stakeholders, to adopt different policies and measures in response to trends, fluctuations and adverse events with the aim of reducing losses as much as possible.

Department of Climate Change, Ministry of Ecology and Environment (MEE, formerly settled in National Development and Reform Commission, NDRC) launched the Pilot Scheme for Construction of Climate Adaptation Cities (Aug, 2016, NRDC, climate change department [2016] NO.1687, PSCCAC) with the intention of promoting 28 National Climate Adaption Pilots across China. Climate adaptation actions are implemented by Chinese government, including disaster forecast, disaster management system, catastrophe insurance and weather-index insurance, etc. International experience and analysis tools for climate change risk assessment and cost-benefit analysis of adaptation measures will effectively enhance urban resilience against climate risks, especially in key infrastructure (public buildings, communication system, transport, energy, water, etc.) and upgrade the full risk management capacities of pilot cities.

The roadmap discusses practical adaptation measures to seek the policy solutions for mitigating climate risks in urban development: implement integrated risk management approach, foster preparedness and expand risk transfer solutions. It focuses mainly on key infrastructure, though with some references to other uses of urban facilities.

Sources and audience

The content is primarily sourced from work undertaken through the "Advancing Climate Risk Insurance plus" (ACRI+) project that is funded by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU)), Federal Republic of Germany. ACRI+ is implemented by the Deutsche Gesellschaft für International Zusammenarbeit (GIZ) GmbH and the Munich Climate Insurance Initiative (MCII).

The primary audience for the roadmap is policymakers and government officials, particularly within the Ministry of Ecology and Environment Protection and Ministry of Housing and Urban Construction at the national level and municipal governments at local level. Additionally, institutions who influence and engage with China's climate adaptation policy and initiatives are targeted, in particular national policy advisors in academics.

A potential secondary audience is a wider set of stakeholders working on climate adaptation and climate risk management across urban development in China, for whom the roadmap could provide useful guidance in terms of developing an integrated approach on climate management.

1.1 INTEGRATED CLIMATE RISK MANAGEMENT

Integrated climate risk management is a continuous process of risk analysis, reduction, transfer as well as strengthening preparedness and response, which are depicted in the outer layer of Figure 1. The process aims to identify potential hazards and to reduce the impact and vulnerability by strengthening the coping and adaptation capacities of the society, according to the results of risk analysis. An integrated risk management approach also requires the establishment of a risk transfer solution to address residual risk and prevent new risks.

Specifically, a risk transfer solution not only provides risk analysis and risk assessment on all levels, but also protects the society and individuals from the potential financial burden of asset and livelihoods losses in case of adverse weather events, thus facilitating economic growth. By transferring some of the risk to a third party, it can provide a buffering capacity to shocks and prevent knock-on effects causing further losses.

Figure 1: Integrated and climate risk management cycle

ICRM differs from previous concepts in the disaster management paradigm that focused almost exclusively on response, and did not pay significant attention to opportunities to reduce the incidence or potential impact of climate disasters. The imperative to broaden this perspective comes from increases in exposure and vulnerability at a global level, linked to the multiple concurrent trends such as climate change, population growth and globalisation of supply chains (MCII 2017). A further advantage of the ICRM approach is that it enables alignment of Disaster Risk Management (DRM) agenda, as exemplified in the Sendai Framework on Disaster Risk Reduction, with the climate change and sustainable development agendas, codified at a global level by the Paris Agreement and Sustainable Development Goals respectively.

Integrated Climate Risk Management in urban infrastructures in China

2

2.1 ECONOMIC CONTEXT IN CHINA'S URBAN INFRASTRUCTURE SECTOR

Urban infrastructure is the material basis of China's new urbanization, which is characterized by overall planning of urban and rural areas and integration of urban and rural areas. Urban infrastructure also provides the foundation for urban social and economic development, improvement of human settlements environment, improvement of public services and safe operation of the city. The infrastructure system is thus of great significance for the urbanization process in ensuring a city layout, complete with adequate facilities and functions to support quality urban life.

Overview

Urban infrastructure is of great importance to support the rapid development of urbanization. During the 12th Five-Year Plan (FYP) period (2011 – 2015), the investment in urban municipal infrastructure in China continued to increase, with a cumulative investment of 95 trillion Chinese Yuan (CNY), an increase of 90% over that in the 11th FYP period (2006 – 2010). Municipal infrastructure construction has been steadily promoted and service level has been continuously improved, which strongly supports the process of the new urbanization in China.

However, China faces key constraints in fulfilling the requirements by new urbanization. Insufficient investment is widening the gap between supply and demand of urban infrastructure. Uneven development and differences in service quality are significant between the western regions and eastern regions. Low industrial concentration in small and mid-sized cities is incapable of supporting urban infrastructure to provide efficient and qualified service.

The Government of China is committed to continue its investment in urbanization and urban infrastructure development by addressing these challenges in further urbanization. The goal is set in Outline of the Thirteenth FYP for National Economic and Social Development (2016 – 2020) that by 2020, the population of permanent residents in the urbanization rate reaches 60%.

Amongst the other ministries, National Development and Reform Commission (NDRC) and Ministry of Housing and Urban-Rural Development (MoHURD) set policy framework and instruct all level departments to work on the goals. Following key policies issued by the State Council[1], the two ministries are mandated to plan and implement urban infrastructure investment projects with their subordinate units at "all levels".

Urban infrastructure and economic development

China's economy is heavily boosted by urban development and urban infrastructure investment is an important economic sector in China. Statics[2] indicates that in 2017, infrastructure investment was 14 trillion CNY, increasing by 19.0%, accounting for 22.2% of fixed assets investment. With another 11 trillion CNY invested in real estate industry, the total investment in generable urban infrastructure development reaches 40% of fixed assets investment, representing 30% of the country's GDP.

Beyond its contribution to the national economy, urban infrastructure plays a critical role as a foundation of China's new urbanization, especially for China's rural population. Municipal infrastructure is the material basis of the new urbanization, which supports the targets of „300 million people", indicating: „ 100 million agricultural migrants settled in cities and towns", "100 million people living in shacks to be renovated" and "100 million people to be urbanized near the central and western regions".

1 "National New Urbanization Plan (2014-2020)," and "Some Opinions of the State Council on Further Promoting the Construction of New Urbanization (2004-2020 "Guo Fa [2016] 8")

2 National Bureau of Statics, 2017, People's Republic of China 2017 national economic and social development statistical bulletin

Potential

National Plan on urban infrastructure planning and construction for 2016 – 2020[3] was developed by MoHURD and NDRC in 2017 to instruct relevant departments to mobilized resources for investment and construction of major projects at the national and sub-national level. The Plan specifies indicators in transportation, utility tunnels, water, energy, sanitation and green land. It also defines 12 tasks, including the constructions of multi-level barriers for water supply, the comprehensive renovation, drainage and waterlogging prevention system, sponge cities, garbage resource utilization, green space and the promotion of a Smart City model.

In particular, this plan is intended to put emphasis on risk management in safe operation of the city and urges that urban security should been significantly improved. Priority is given to strengthen the construction of municipal infrastructure, improve the capacity of municipal infrastructure to deal with various risks, and improve the operation standards and management of municipal infrastructure. To achieve this, cities should improve the public security system of municipal infrastructure and set up a contingency plan to improve the system and mechanism of prevention and response.

2.2 MAINSTREAMING CLIMATE CHANGE INTO URBAN DEVELOPMENT POLICY AND PLANNING

Description and relevance of urban infrastructure sector

China is characterized by large population, high urban population density, high economic concentration, complex climatic conditions and a fragile ecological environment, which is heavily influenced by climate change. At the same time, China is in the process of rapid industrialization and urbanization, boosting the increase in the economic value in all mega-cities. The urbanization process reached 58.5%[4] in 2015 and is expected to increase to 60% in 2020[5]. Economically, china's investment in infrastructure continues to increase, the infrastructure investment reached RMB 10.659 billion in 2017, an increase of 8.6% over the previous year[6].

Climate change will continue to have a major impact on the construction and development of the cities, especially for infrastructure security on urban energy, transport, water, communications and public buildings. Since the 1990s, China's annual direct economic losses caused by extreme weather and climate events have exceeded 2,000 billion CNY on average and more than 2,000 people died[7] due to the consequences of floods and windstorms mainly. The increasing extreme climate events have threatened the safe operation of infrastructure in a more systematic way. Damage of infrastructure can lead to secondary and derivative disasters, loss of public and private assets, interruption of business operation and long-term impact on economic development, which is fully paid by Chinese governments.

3 NDRC & Mohurd, 2017, National urban infrastructure construction 13th Five-Year plan, http://www.mohurd.gov.cn/wjfb/201705/W020170525053420.pdf

4 Outline of the Thirteenth Five-Year Plan for National Economic and Social Development (2016-2020)

5 Thirteenth Five-Year Plan for National Economic and Social Development (2016-2020) that by 2020,

6 2017 Statistics Bulletin of the National Economic and Social Development of the People's Republic of China, National Bureau of Statistics

7 Statistics from Ministry of Civil affairs.

However, China's implementation on climate adaptation is on the initial exploration stage. It is urgent to strengthen the top-level design from the national level, to carry out policy guidance and to encourage exploration and innovation; in addition, climate risk management that is emphasizing on climate risk transfer and prevention shall be promoted on all local levels throughout urban planning, infrastructure construction and government operation.

In response to increasing climate events and the urgent needs on improving cities' climate adaptation ability, the national government has called for pilot projects in climate adaptation cities, according to the Action Plan for Urban Climate Adaptation and PSCCAC. China intends to promote 28 National Climate Adaption Pilots that have been instructed to work on city adaptation planning, conduct climate risk analyses, adopt climate adaptation measures and work with international organizations when needed.

2.3 CLIMATE CHANGE IS THE RESPONSIBILITY OF MEE

Climate change policy and institutional framework in China

Climate change is the responsibility of MEE and the department of Climate Change affiliated to MEE is responsible for tackling climate change and greenhouse gas emission reduction, with support from other relevant ministries. The department is mandated to comprehensively analyse the impact of climate change on economic and social development, organize and implement the national strategy to actively respond to climate change and take the lead in formulating and coordinating the implementation of major objectives, policies, plans and systems for controlling greenhouse gas emissions, promoting green and low-carbon development and adapting to climate change in China. The department, with the support of the environment protection bureau at all level, guides associated departments, industries and local authorities for the overall implementation. Amongst all national policies, Nationally Determined Contributions (NDCs) is of the strongest commitment communicated to international society. China's first NDC[8] includes the following actions and objectives until 2030:

- To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early;
- To lower carbon dioxide emissions per unit of Gross Domestic Product (GDP) by 60% to 65% from the 2005 level;
- To increase the share of non-fossil fuels in primary energy consumption to around 20%; and
- To increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level.

8 NDRC, 2015, China's Intended National Determined Contribution, https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/China/1/China's%20INDC%20-%20on%2030%20June%202015.pdf

Addressing climate change risk in urban areas

NDRC and MoHURD jointly released the Action Plan for Urban Adaptation to Climate Change to coordinate the work and enhance the capacity building of climate change adaptation on city level. This has put an explicit emphasis on mainstreaming climate risk management in urban planning and construction in each provincial or municipal departments that involved. The China Meteorological Administration (CMA) continued to work with MoHURD in the assessment of urban rainstorms while adding revised rainstorm formulas and rainstorm profiles for 146 cities[9], conducted impact assessment of extreme events, and issued the Outline of the Construction of Urban Meteorological Disaster Prevention and Mitigation System and Public Weather Service System.

The joint announcement by NDRC and MoHURD on PSCCAC lists the following aspects as the main targets of the pilot scheme, which includes strengthening the concept of urban adaptation, improving monitoring and early warning capabilities and carrying out key adaptation actions. Other activities include:

- carry out climate change risk analysis in key sectors and areas, strengthen the information construction and big data application, improve the emergency response linkage and social response system, realize the sharing and effective transmission of forecast and warning information of all types of extreme climate events;

- strengthen the construction of monitoring and early warning platforms for climate and meteorological disasters as well as collection of all necessary information;

- carry out key adaptation actions: the city's action plan for climate change adaptation should be carried out, the layout of urban infrastructure design should be optimized to deal with extreme weather events such as heavy rainfall, high temperature, drought, typhoon, freezing and haze. Also the multi-climate change management system for governments, businesses, communities and residents should be completed;

- improve the safe operation of water, transport, energy and other infrastructure under climate change scenarios; arrange urban functional areas and overall planning of infrastructure construction to effectively guarantee the safety of the lifeline system of urban operation.

Regarding Disaster prevention and alleviation, The Communist Party of China Central Committee and the State Council has issued the Opinions on Promoting the Reform to Systems and Mechanisms for Disaster Prevention, Mitigation and Relief and the General Office of the State Council issued the National Comprehensive Disaster Prevention and Mitigation Plan (2016 – 2020). Ministry of Civil Affairs also put into effect the Guiding Opinions on Supporting and Guiding the Participation of Social Forces in Disaster Relief to explore the public-participation mechanism for disaster relief, and began to create the social database and information platform which has covered 20 national social organizations and 633 local social organizations. A series of six special training sessions for disaster relief were organized and more than 440 employees from social organizations and civil affairs departments were trained.

9 China's Policies and Actions for Addressing Climate Change in Urban area (2017)
LIU Zhao, Support for climate security, 2017, http://www.cma.gov.cn/2011xwzx/2011xqxxw/2011xqxyw/201701/t20170112_385973.html

Challenges facing climate risk management

While there is an institutional framework for DRM described above, many of the government entities whose mandate and activities influence DRM in practice do not recognize or identify it as such, and therefore limit the influence and coordinating power of DRM frameworks. Many sectoral government departments and entities have not explicitly been instructed that DRM is in their planning and priorities; and for those that have, there tends to be a primary focus on response ('emergency management'), rather than the prevention and reduction of risks and building systemic resilience.

Additionally, there are human resource and institutional capacity challenges on implementation and enforcement. This is also true at the regional level: while comprehensive on paper, DRM system is severely under-resourced and therefore has limited effectiveness, before a newly-reformed Ministry of Disaster Response Management is put into effect.

2.4 CLIMATE CHANGE PROJECTIONS AND THE MAJOR HAZARD IN CHINA

China's climate is complex and diverse. The continental monsoon has remarkable impact on the climate that fluctuates violently. Corresponding to the overall trend of global climate change, the average temperature in China has risen significantly. In the past 100 years, the increase rate of annual average temperature in China is slightly higher than globally during the same period, but the warming has been particularly evident in the past 50 years. Precipitation and water resources are more unevenly distributed in time and space with increased fluctuations in regional precipitation, resulting in exacerbated extreme weather events.

According to The Third China National Assessment Report on Climate Change[10], China will continue experiencing an increase in temperature, precipitation and sea level. The level of natural disaster risk in China stays relatively high, and is highly sensitive to climate change. The results are supported by the facts:

- the average temperature increase in China's land area was 0.9 – 1.5°C over the past century (1909 – 2011), which is higher than the global average of 1°C – 3.7°C;
- there is no significant trend in the national average precipitation change in the past 100 years and 60 years, but the regional distribution difference is obvious. In the western arid and semi-arid areas, the precipitation has continued to increase in the past 30 years. The average increase rate of precipitation in China is 2% – 5%, and that in North China may increase by 5% – 15%;
- the coastal sea level of China rose by 2.9mm/year during 1980 – 2012, which is higher than the global average;
- from 1970s to early 21st century, the glaciers in China decreased by about 10.1%, and the area of permafrost reduced by about 18.6%.

Heavy rain, strong storm surges, and large-scale drought as the major climate hazards will occur more frequently and severely, and especially the flood intensity and sea level will continue to rise. Amongst them, flood is considered one of the most challenge hazards relevant to climate change. Regions with high flood hazard levels are mainly located in Southeast China, while the vulnerability to flood hazards is high in eastern China[11].

10 LI Hongce, China released Climate Conference The Third National Assessment Report at UN Climate Change Conference Paris 2015, Technology Daily, 2015-12-7

11 XU Ying, et al, Projected Flood Risks in China Based on CMIP5, Advances in Climate Change Research 5(2): 57-65, 2014

For the future period 2016 – 2050, an increase in evapotranspiration is found all over China, while an increase in precipitation is apparent in the southern river basins. Under RCP2.6[12], drought events of longer duration and with higher frequency are projected in the southwest and southeast of China. Under RCP4.5 and RCP8.5, a continuing tendency toward more dry conditions is projected along a dry zone stretching from the southwest to the northeast of China. More frequent flooding events of longer duration are projected in the south-western river basins. For all future flooding, extended submerged areas are predicted, especially for events with long-term duration.

2.5. VULNERABILITY OF THE INFRASTRUCTURE SECTOR TO CLIMATE CHANGE

The overall findings in The Third China National Assessment Report on Climate Change[13], show that climate change brings about more negative impacts, in particular adverse impacts on the quality and quantity of food, wter resource, marine environment and ecology and the urban area. The adverse impacts of climate change are significantly permeating various economic and social sectors.

The impact of climate change on urban development mainly manifests in an increase in high temperature heat waves, heavy rains, haze and other disasters, indicating strengthened the trend of drought in the north and Southwest has been, increased intensity of landing typhoons, and the risk of saltwater intrusion in coastal area. In addition, climate change delivers various impacts on different regions and different types of cities, including long-term problems such as drought, water shortage, sea level rise, heat island effect. Vulnerability becomes a more significant issue when emergency problems of different extreme weather and climate events, and climate change risks aggravated by improper urban planning, construction and management.

The impact of climate change on cities has become increasingly prominent and will continue to affect cities in all aspects including the operation of the lifeline system, the quality of the living environment, the safety of life and property of residents and ecological security.

It has therefore already influenced and will continue to affect the sustainable development of urban planning, construction and economy, and society.

As China is a country prone to a variety of natural disasters, flooding is the major meteorological disaster affecting many regions, and is therefore selected as the main climate hazard of the China pilot project. Furthermore, cities are more vulnerable to climate change due to the extremely rapid increase in exposure values, i.e., the high population density and concentration in economics. 40% of China's population and 70% of gross agricultural product are directly threatened by flood disasters. Floods in China cause huge losses to the national economy. Over a period of 1990 – 2010, the total loss takes over 3% of annual GDP and 40% of the loss caused by natural disasters. In 2013 flood caused annual direct economic losses of CNY 188.38 billion (27 billion USD)[14].

12 Meinshausen, M., S. J. Smith, K. V. Calvin, J. S. Daniel, M. L. T. Kainuma, J.-F. Lamarque, K. Matsumoto, S. A. Montzka, S. C. B. Raper, K. Riahi, A. M. Thomson, G. J. M. Velders and D. van Vuuren (2011). "The RCP Greenhouse Gas Concentrations and their Extension from 1765 to 2300." Climatic Change (Special Issue), DOI: 10.1007/s10584-011-0156-z, freely available online (PDF) (HTML); RCP stands for Representative Concentration Pathways, in order to emphasize that their primary purpose is to provide time-dependent projections of atmospheric greenhouse gas (GHG) concentrations.. There are four pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6 - the last is also referred to as RCP3-PD.

13 LI Hongce, China released Climate Conference The Third National Assessment Report at UN Climate Change Conference Paris 2015, Technology Daily, 2015-12-7

14 Statistics from Ministry of Civil affairs.

However, it is important to acknowledge that socio-economic factors contribute to vulnerability mostly, beyond China's extreme exposure to climatic hazards.

Even if the majority of China's efforts in Climate Risk management is put in the phases of response and recovery, financial preparation is insufficient. Special funds supported by fiscal budget for natural disaster relief only restores an average of 6 billion CNY each year, which is not comparable to an annual average loss relevant to natural disasters of about 25.18 billion CNY[15]. More evidently, total expenditure for disaster relief accounts only 5% to the direct economic loss of flood disasters on average, indicating a significant lack in financial preparation.

Awareness and capacity factors are also very significant, and generally tend to be heightened in the central and western regions in China. These factors include insufficient knowledge in climate adaptation and integrated risk management, inexplicitly in adaptation measures and tools as well as less innovation in mobilizing resources or personnel in implementing the requirements instructed by MEE and MoHURD, including climate risk analysis, risk preparation and prevention, overall planning on urban adaptation, etc.

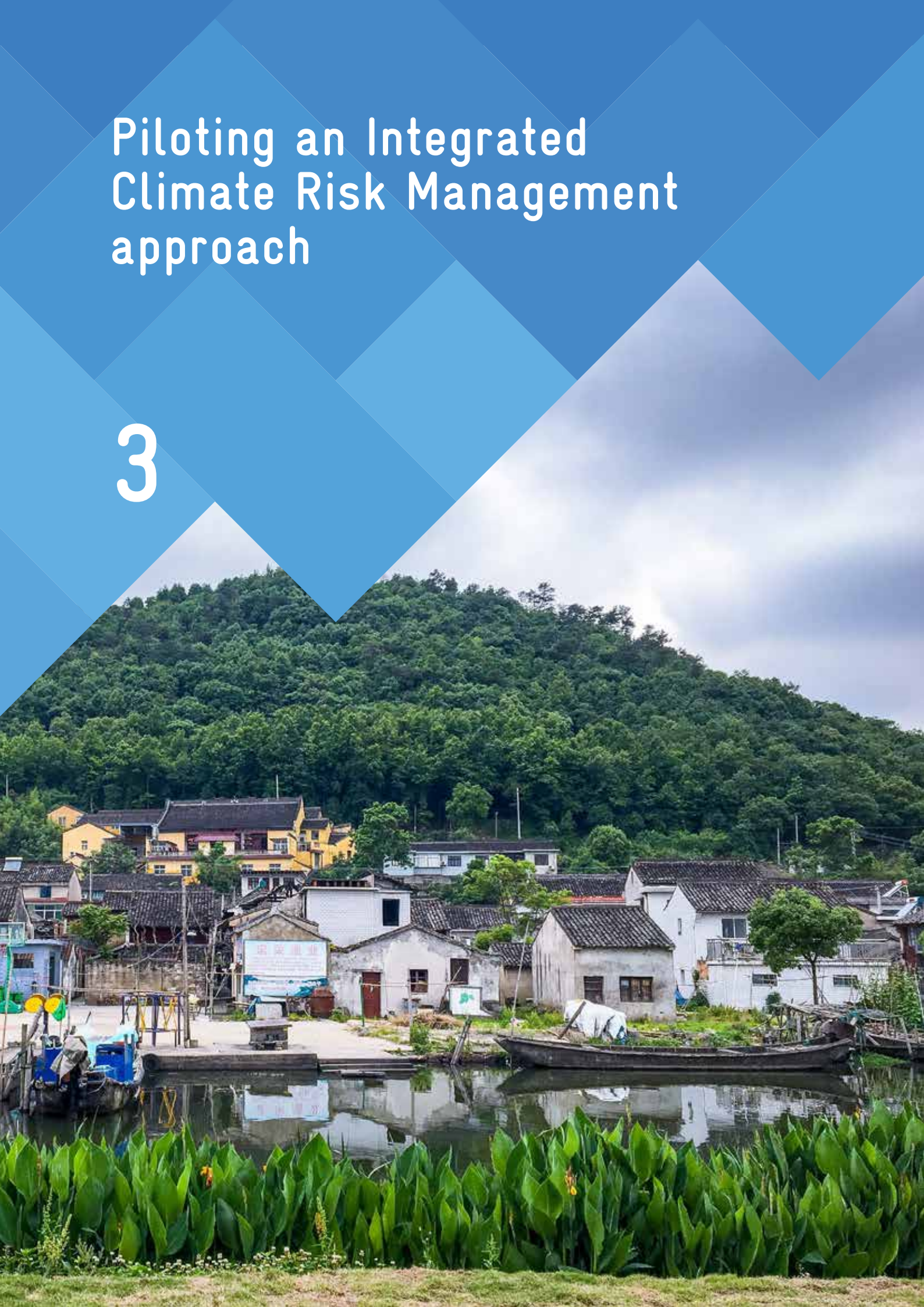
Challenges in limited capacity and resources for DRM system, as mentioned above, are explicit at all levels. This situation is to be soon improved with maximum likelihood as the newly-reformed Ministry of Disaster Response Management in June 2018, has put an emphasis on institutional arrangement, which is mandated to adopt integrated risk management that resources are equally distributed into each phased of risk management.

Urban infrastructure and residents are the most vulnerable, and they become more and more vulnerable due to the rapid urbanization in China due to their long-standing status and vital roles in supporting the city functions. Hence, Chinese government has actively claimed that urban adaptation to climate change concerns the vital interests of the people, the sustained and healthy development of the city and the building of a well-off society in an all-round way. In order to build a climate-adaptive city, China has given the national guidance on the basis of overall planning and coordination in relevant government departments. In view of the critical problems under climate change conditions that a few cities have faced, the city governments have been exploring and prioritizing effective actions and measures through pilot projects, fully considered the impacts of climate change in urban planning and urban construction management in order to achieve the objective of safe operation and sustainable development.

15 Statistics from Ministry of Civil affairs.

Piloting an Integrated Climate Risk Management approach

3



3.1 Introducing the pilot project

Under the new policy development of climate adaptation, the ACRI+ in China is moving the global practice on applying integrated climate risk management approach and risk transfer solution for climate adaptation and urban resilience in China for the first time. The pilot aims for the Chinese government on municipal level to have access to climate risk transfer solutions as part of their integrated risk management for critical infrastructure. The objective of this pilot is to improve the climate resilience of urban critical infrastructure and to systematically reduce the impact of climate risks on the economic, social and fiscal system, and to protect the livelihood of millions of urban citizens.

Reflecting China's national commitments on climate change, the pilot provides methods and tools to identify the hazard, exposure and vulnerability in vulnerable areas. According to analysis results, the Chinese government is able to apply a practical integrated management approach and risk transfer solution for different intervention levels (urban areas, industrial infrastructure, small-medium enterprises, and individuals).

The pilot project is partnering with public sector and technical experts to jointly design and implement the integrated risk management approach. The pilot will engage major Chinese public departments including city planning, urban construction, finance, disaster risk management, industrial park and critical infrastructure. Due to its innovative character, this project has substantial potential for cooperation with other international development agencies, fostering its global impact, replication and roll-out into other vulnerable areas in China and in other developing countries.

The project selects Lishui as a pilot city to carry out key actions to adapt to climate change in urban infrastructures regarding the increasingly severe extreme weather events such as high temperatures, storms and floods. As flood is one of the most serious natural disasters in the city and causes massive economic losses and even casualties each summer, it is selected as the major focus of this pilot. To achieve this, the project conducts climate risk (flood) analysis, flood risk simulation and assessment, so as to ensure that the cost-effective adaptation actions are identified and applied. Its fundamental purpose is to explore strategy and construction pathways for climate adaptation in a demonstration area and to improve the government's ability to manage climate risks and implement adaptation measures. In this way city governments can build typical climate adaptation pilots, and Lishui's experience can be scaled up within China's PSCCAC and even to the whole country.

Specifically, Economics of Climate Adaptation (ECA) approach applied to this pilot offers a unique way to identify cost-effective climate change adaptation (CCA) measures for a variety of projects and sectors. ECA offers a systematic and transparent approach that fosters trust and initiates in-depth inter-sectoral stakeholder discussions. The methodology can be flexibly applied from the national down to local level to different sectors and different hazards. It also provides key information for program-based approaches, insurance approaches and has potential to support the development of pilot project.

As a key strategic and technical partner of this pilot project, Swiss Re is providing its technical contributions for the implementation of the activities as well as technical assistance on re/insurance related matters during the project implementation period.

Major findings and recommendations from the pilot are:

- The flood risk in Lishui City is mainly caused by the rainstorm or typhoon during the rainy spell in early summer. The main risk source is the river basin flood, and the secondary source is the waterlogging flood in the built-up area of the city.

- The flood risk management of Lishui City should be structurally combined with the flood risk management of the watershed. That would include effective operation on upstream and downstream reservoirs, improvement of dikes, key gates and waterlogging drainage systems. Regulation on watershed land use can also effectively reduce the risk of flood.

- Sponge city construction is an effective means to mitigate urban waterlogging in old urban areas of Lishui City.

- Preparation and Response measures are important non-construction measures to reduce flood risk, including rainstorm and flood forecasting, early warning system, emergency plan, contingency plan;

- Financial means such as catastrophe insurance should be applied to transfer residual risks.

These conclusions are highly relevant to the discussions below in policy and institutional arrangement, capacity, urban planning and constructions. A few more major results of climate risk analysis can be found in → Annex B.

3.2 Integrated climate risk management for urban infrastructure: analysis of gaps, actions and actors

The analysis proceeds through each of the five areas of ICRM (prevention, retention or transfer residual risk, preparedness, response and recovery). The focus of the following analysis is on key infrastructure in urban area, as ACRI+ project is piloting in Lishui, China. It includes all sorts of key infrastructure in cities, covering public buildings, transport, water, energy, communication system and green land, etc. The analysis identifies some of the main gaps that exist with regards to unban infrastructure, and suggests actions that could be taken to address those gaps.

PREVENT

Baseline /topic	Gap	Action
Very limited availability of scientific and historical data for implementing climate risk analysis	No publicly available loss and damage data for urban infrastructure, specifically key infrastructure that supports the city's operation. Nor meteorological data and economic data for a precise modelling on climate scenarios. Those sets of data are a necessary input to risk models that should underpin DRM strategies and instruments.	Call for a platform for sharing and meteorological data and loss/ damage data, supervised by local city government and ministries in charge. Consider the option of acquiring access from other sources; e.g.: private data company.
Different approaches for risk assessments implemented by all various stakeholders	Inconsistent understanding and approaches f or risk assessment and risk management are found amongst different government departments, infrastructure companies and communities.	Standardize and implement Integrated Climate risk assessment practices, which aligns different stakeholders into one consistent management system.
Very limited knowledge and coordination for implementing integrated climate risk management amongst government departments	while major policies and urban planning are set to support climate adaptation in the city, government departments lack sufficient knowledge, capacity and coordination in implementation.	Improve management skills through general awareness raising and capacity building in the field of addressing climate adaptation in the city and put emphasis on integrated climate management and the coordination amongst relevant departments.
Inconsistent understanding on Standards for construction and maintenance of infrastructure from different perspectives	In the case of hydro projects and other key infrastructure projects effected by flood risk, project managers are sharing different opinions with risk management experts, in terms of the economic impacts under different climate scenarios and economic scenarios, and the required construction standards.	Review building standards and mechanisms to ensure enforcement. Organize consultations for risk management experts and stakeholders for infrastructure operation, in order to better understand the associated risks, the prevention measures and the expected impacts.
Adaptation not measured nor integrated in urban planning or infrastructure construction	The pilot city has released a stand-alone City Adaptation Plan. However, the effectiveness of those adaptation measures in that plan are not measured.	Cost-effective adaptation measures and projects should be identified and prioritized in the city's urban planning.

RESIDUAL RISK

Baseline /topic	Gap	Action
High exposure to catastrophic climate risk and limited understanding on managing residual risk	Though the impacts of climate risks are revealed to city government, the residue risks are not yet fully taken into considerations due to limited understanding in risk management and the associated approaches.	Government and private sector (and development partners) to work together to develop risk transfer solutions for key urban infrastructure. Consider options for transferring extreme / catastrophic risk to national and international reinsurance markets via intermediaries.
Insurers hesitate to develop products given various perceived risks and huge payouts	The pilot project provides sufficient results on assessing the flood risks and the associated loss in climate scenarios, which indeed put the insurers into serious consideration on researching and designing the insurance products.	Call for a platform for sharing and studying the risk analysis results with the participation of risk management experts, insurers, reinsurers and city government. Consensus on the conditions and methods of risk analysis are important to draw the correct conclusion on residual risks, which is the base for a reasonable proposal for insurance product.
Holistic risk assessment on climate risk for a rational pricing on insurance solution	The methodology applied in the pilot project is questioned by its reliability and applicability in this project and as always every methodology has its own limitations.	Pilot project and other professional technical team employed by other stakeholders, e.g. the city government or the insurers, should be working together but applying different methodologies for a precise assessment on the risks.
Lack of Insurance mechanism to include public funding	China has been piloting Catastrophe insurance program since 2013. In 2016, the former Insurance Regulatory Commission and the Ministry of Finance jointly issued the Implementation Plan for Establishing the Urban and Rural Residential Earthquake Catastrophe Insurance System. Forty-five property insurance companies initiated the establishment of China's Urban and Rural Resident Earthquake Catastrophe Insurance Community on the basis of the principle of voluntary participation and risk sharing. Subsequently, China's urban and rural residential earthquake catastrophe insurance products were sold in an all-round way, marking the landing of China's urban and rural residential earthquake catastrophe insurance system. However, the pilots are not yet scaled up officially due to the crucial limitation on public fiscal system, that the spending of public funding does not suit into the insurance mechanism	Creation of attention in ministries and regulators on the Lishui pilot project, with a sound arrangement of public funding that supports the insurance mechanism for urban infrastructure.
Lack of understanding and technical capacity among decision makers and government officers	City decision makers feel that they lack the knowledge and information to fully understand the climate risks and the associated impacts; this means they feel unable to fully consider whether an insurance product is viable, and therefore to develop products at all.	Provide technical training packages tailored to needs of City decision makers. Encourage dialogue between insurers and City decision makers.

PREPARE

Baseline /topic	Gap	Action
Make application of the analysis of climate risks	Climate risk analysis for Lishui city has been completed and are available for use by both the public sector. However, this information could be better digested and disseminated to ensure that relevant departments can incorporate the latest projections as part of their decision making processes.	Capacity development for elaborating climate risk results is in need. Continuous investment into climate risk analysis on a yearly basis is in need and the results should be compared then disseminated to relevant departments for revising their planning.
Early warning systems	Although early warning system on meteorological disasters and information distributing channels are established, guidance on using the information is not provided and the coverage of the information distribution should be improved.	Alert messages should be tailored to become less generic and more helpful for relevant departments and the communities. Information provision and/or capacity-building on how to access and respond to early warning systems, including links to contingency plans. An emergency center is in need as the central brain to collect, analyze and disseminate the information to public and government departments in a more tailored and efficient fashion.
Coordinated contingency plans	While the full package of contingency plans in all relevant government departs are in place, the activities of those departments are not coordinated, which means they may interact with each or instruct same community with different instructions.	Apply integrated climate risk management practices, which aligns different stakeholders into one consistent management system.

RESPOND

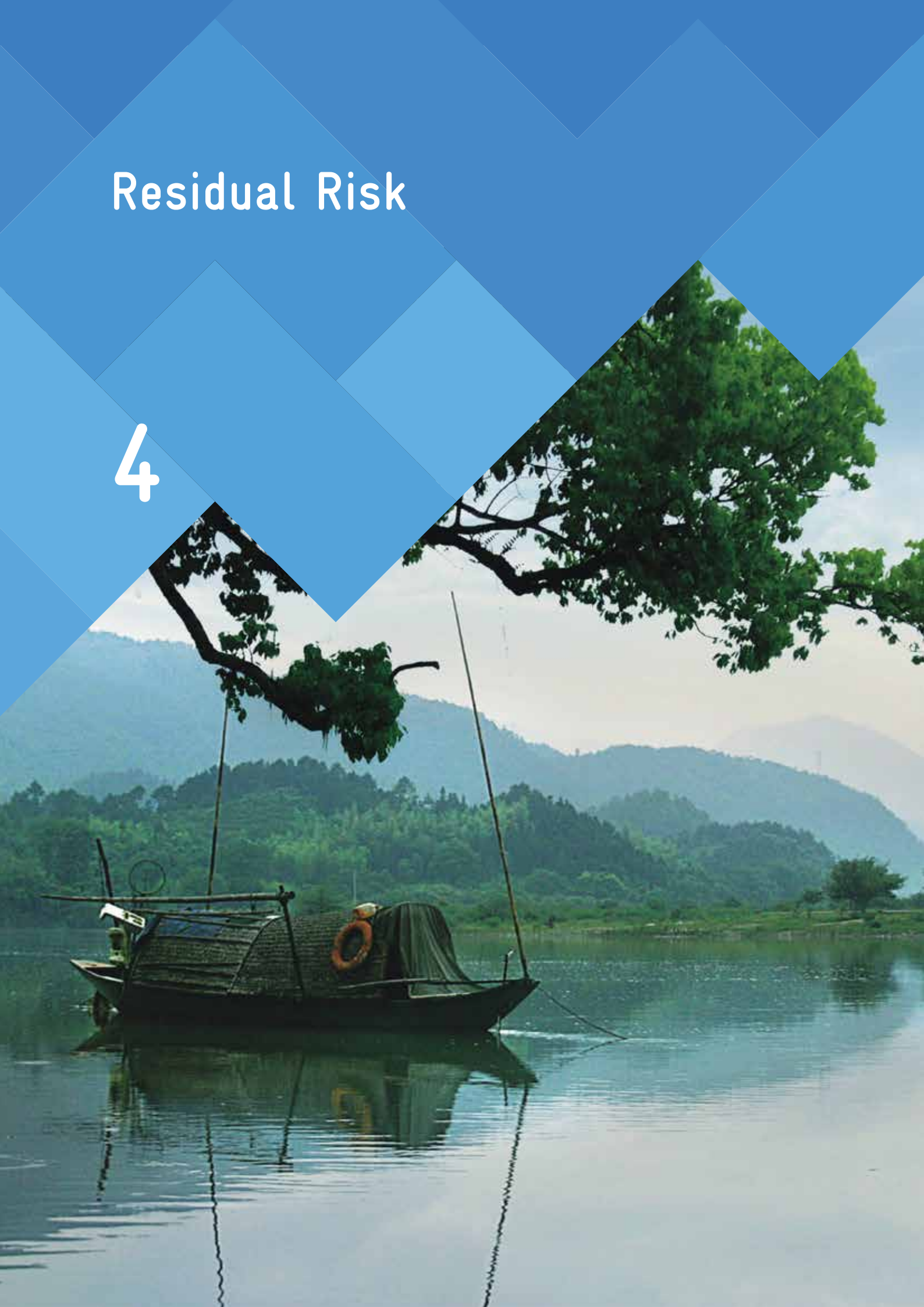
Baseline /topic	Gap	Action
Funds for rapid response	A number of substantial contingency funds is budgeted in place for relief, response and rebuild in general, for any emergency events take place in the city. Furthermore, funds would have to be requested from higher administration in China, the provincial and national level governments for payouts on life and asset loss. Based on the experiences of Lishui city, rapid liquidity and smooth financial impacts provided by insurance payouts are affirmed, which builds a good understanding to scale up the cases.	Strengthen and mainstream with relevant actors the business case for allocating rapid response funds under an insurance umbrella, which integrates public funding as the major contributor.

RECOVER

Baseline /topic	Gap	Action
Affordability	Climate scenarios with an assumption on high-speed socio-economic development reveal that the value of infrastructure assets and construction costs in Lishui city is to be relatively high and this will place a significant impact on the recognition of city government on accepting the insurance premiums.	Call for a platform for sharing and studying the risk analysis results with the participation of risk management experts, insurers, reinsurers and city government. Consensus on the conditions and methods of risk analysis are important to draw the correct conclusion on residual risks, which is the base for a reasonable proposal for insurance product.

Residual Risk

4



4.1 UNDERSTANDING RESIDUAL RISK

Residual risk is the risk that remains after prevention and mitigation activities have been undertaken. There are different ways of managing residual risk. Risk transfer is usually a rational option for managing most types of climate risk, given the potential of climate shocks to be catastrophic and covariate and therefore beyond the manageable risk retention limit for most entities.

Where the risk-bearer chooses to retain their risk, they may pursue a risk financing strategy. This could include 'ex ante' measures, in which finance is raised prior to a disaster actually occurring (i.e. precautionary savings and reserves, or arrangements for contingent credit facilities) or 'ex post' measures (i.e. reallocations of normal spending to cover post-disaster needs, borrowing and loans).

Risk transfer is an alternative to risk retention whereby the risk, or a portion of it, is passed onto a third party. That third party would be responsible for assuming some or all of the costs should a disaster occur. Therefore, risk transfer reduces the financial exposure of the risk-bearing entity, whether that is an individual, a business or a government. Risk transfer can either be direct or indirect.

- **Direct risk transfer** refers to the situation when an at-risk entity (individual, household, business) enters directly into an agreement with a risk-bearing entity (such as an insurance or reinsurance company).
- **Indirect risk transfer** involves an intermediary institution in between the entity whose risk is being transferred and the entity bearing that risk.

4.2 TOOLS FOR RISK TRANSFER SOLUTIONS

Climate risk insurance

Insurance is a form of risk transfer. Insurance against extreme weather events can be defined as a mechanism which provides financial security against loss of assets and livelihoods by ensuring effective post-disaster relief on an individual, local, regional and national level.

Climate Risk Insurance as a disaster risk financing component helps governments, individual producers and private enterprises along the agricultural value chain to manage extreme weather impacts. If embedded into climate risk management plans, insurance can contribute to urban resilience and its critical infrastructures, including the promotion into better production. Therefore, DRM plans should build on risk assessment, the impact assessment and the DRM analysis – Phase 1 Prevention.

Risk decentralization mechanism is the core link of catastrophe insurance system. In accordance with the requirements of deepening reform of the Party Central Committee and the State Council, China is speeding up the establishment of climate and catastrophe insurance system. China Banking and Insurance Regulatory Commission is actively promoting all aspects of work, including catastrophe insurance legislation, insurance pilot projects, Catastrophe Risk Modelling and Uncertainty Quantification.

CASE: Innovative Parametric Insurance in Guangdong

In December 2015, the Guangdong provincial government approved the publication of the „Implementation Plan for the Pilot Work of Catastrophe Insurance in Guangdong Province". In 2016, the pilot work was carried out in 10 cities. The premium was financed by the provincial and municipal governments. The budget of each pilot city was 30 million CNY, and the insured amount was 2.347 billion CNY. Taking Shanwei City as an example, catastrophe insurance takes typhoon and heavy rainfall as its insurance liability. The annual maximum payout limit is 202 million CNY, of which 150 million CNY is typhoon payout limit. The insurance scheme set 5 rating-scales payout to wind and 4 rating-scales for payout to rainfall. In October 2016, Typhoon Hippocampus triggered a payout, which was totaled in 21 million CNY.

Alternative risk transfer: catastrophe bond[16]

Catastrophe bonds transfer part of catastrophe risk from insurance companies to bond investors by issuing bonds whose returns are linked to specified catastrophe losses.

Facing the increasingly serious natural catastrophe losses, the traditional insurance and reinsurance methods have limited payout capacity for catastrophe losses while the risk management gap of reinsurance is growing. Compared with catastrophe losses, capital market retains a large scale of funds. If capital market funds can be introduced into catastrophe insurance, it is undoubtedly of great significance to promote the development of catastrophe insurance. Since catastrophe risk securitization needs to have a highly developed financial market, flexible and effective regulatory mechanism and perfect legal protection, China has only carried out some pilot projects of catastrophe risk securitization in the current stage.

CASE: Successful Issuance of China's First Catastrophe Bond in Overseas Markets

On July 1,2015 China's first catastrophe bond on earthquake risk was successfully issued in overseas markets. The bond was sponsored by China Real Estate Insurance, a wholly-owned subsidiary of China Banking and Insurance Regulatory Committee (CBIRC). The main issuer of the bond is PandaRe, a special purpose vehicle based in Bermuda, which raised $50 million. China Re Group and China Real Estate Insurance reinsured some of the earthquake risks in mainland China to PandaRe by the means of reinsurance transfer. PandaRe then issued catastrophe bonds in overseas capital markets to finance these risks, providing full collateral insurance.

16 China Re, 2015, First Catastrophe Bond Issued Overseas, http://www.cpcr.com.cn/zhzcx/469642/470066/507389/index.html

Alternative risk transfer: policy catastrophe insurance fund

Catastrophe insurance fund is a special fund formulated with the participation of governments at all levels to prevent the risk of excess payout by government or insurance companies caused by natural catastrophe risk. From this point of view, catastrophe insurance fund is a special catastrophe risk loss reserve, different from the general liability reserve and reserve.

In China, the catastrophe insurance fund is generally composed of investments from the government as the main operation body, insurance companies and industry associations. In order to cope with huge natural disasters, it is mainly used to cope with the excess liability of insurance companies. The raising of catastrophe risk fund can be considered through many channels, such as national financial subsidy, tax preference, insurance premium extraction of agricultural insurance companies, financial market and so on. Specially, catastrophe insurance fund is applied politically in China to support agricultural catastrophe risk business, so as to effectively share the catastrophe risk losses of agricultural insurance companies.

CASE: Pilot Project of Agricultural Catastrophe Insurance Fund

Zhejiang Provincial Government has established a policy-oriented reserve system for agricultural insurance catastrophe as from January 1, 2011. By raising the premium rate of planting insurance, the province established the catastrophe risk reserve for policy-oriented agricultural insurance by collecting 25% of that premium for seven planting insurance. The catastrophe risk reserve shall be managed following the principles as "collected on a yearly basis, capped in total amount, managed by special accounts and spent as special funds". When the total amount of payout for the insured agricultural business exceeds 1.3 times of the paid premium, the reserve shall provide the exceeded payout for the part of 1.3-2 times of that premium.

4.3 AVAILABILITY OF CLIMATE RISK INSURANCE FOR URBAN INFRASTRUCTURE

China has a relatively well-developed sound financial industry. The insurance industry accounted for around 5% of total financial assets in 2017. Same year, the annual insurance premium income of insurance companies was 3658.1 billion CNY, an increase of 18.2% over the previous year. In the last 10 years, the average growth rate was about 17%, the total assets of the insurance industry reached 12.36 trillion CNY, and the average growth rate in the last 10 years exceeded 20%. China's insurance industry is expected to become the second largest insurance market in the world. there are quite large number of entities offering insurance in China, though both life and general insurance markets are heavily dominated by a few large state-owned companies.

However, China does not have a comprehensive risk financing strategy that sets out different financing tools in managing climate risks. Furthermore, insurance industry is very hesitated to provide relevant climate-risk products.

Regarding the challenges and opportunities in insurance industry that are relevant to climate risks, the catastrophe business of property insurance is most affected in the short term due to the increasing annual average losses and extreme losses. In the long run, liability insurance, life insurance, health insurance and water insurance will be affected by the significant trend of climate change. However, demand for catastrophe protection and new types of risk transfer products (such as catastrophe bonds and risk swaps) will increase significantly in the future. In addition, there are also many opportunities for new insurance products in new technology areas such as renewable energy, carbon capture and storage (CCS), hydrogen fuel systems and so on[17].

Specifically, the loss caused by flood disaster could be insured in the coverage of enterprise property insurance, family property insurance and construction project insurance liability. That being said, commercial insurance plays an active role in payout for the loss of insured enterprises and families after flood disaster. According to the statistics of the People's Insurance Company of China, 1991, 1996, 1998 and 1999 are flood years.
In these flood years, the payout of the People's Insurance Company of China for flood disasters at that time alone reached 2.6 billion CNY, 3 billion CNY, 2.5 billion CNY and 1.6 billion CNY, respectively.

Until now, there are no specific flooding insurance available in China market. However, existing insurance products that cover flood risks include:

1. **Enterprise Property Insurance**
   Enterprise property comprehensive insurance can be used to deal with natural disasters such as rainstorms, floods, debris flows, landslides and so on. In China, the penetration rate of corporate property insurance is about 4.2%[18].

2. **Household Property Insurance**
   At present, household property insurance can coves the loss of household property caused by floods, fires and storms, such as houses, interior decoration, furniture and household appliances. However, the penetration rate of household property insurance is very low, far less than that of personal insurance in China, due to its unpopularity and lower acceptance compared to other „major products" of property insurance such as automobile insurance.

17 Interview: Munich Re China Representative
18 China Insurance Yearbook 2016

3. Construction Insurance

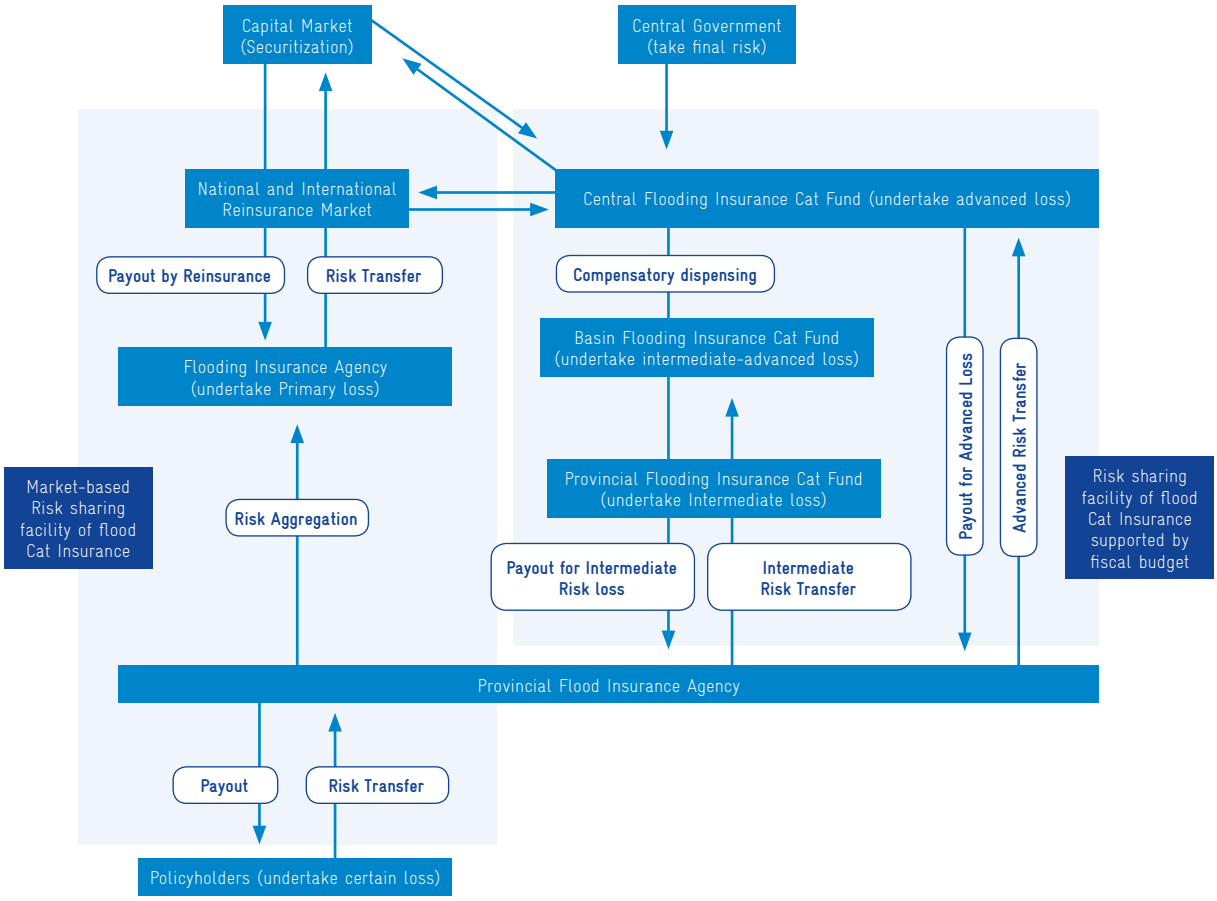
All risks of construction projects are relevant for the owners, investors and contractors of the projects. The risks associated with construction projects are extensive and concentrated, which may lead to material losses caused by natural disasters and accidents, as well as third-party losses caused by accidents, including but not limited to fires, explosive floods, storms, thunderstorms, hurricanes, storms, earthquakes and tsunamis. In China, the vast majority of infrastructure construction projects are legitimately to purchase construction insurance during the construction period and after the completion to cover equipment and facilities losses caused by natural disasters.

4. Agriculture Insurance (crops, livestock, forest)

Crop insurance is based on the loss of the value of harvest or production caused by natural disasters or accidents during the growth of various crops. Normal crop insurance only bears the loss of crop quantity and quality, but not the price fluctuation. Agricultural insurance is strongly supported by the national policy, typically designed with low premium. Data shows that from 1990 to 2006, the average payout rate of agricultural insurance companies is as high as 84.71%.

The application of various flood insurance in China has played an active role in mitigating the loss of flood disasters to a certain extent, but it is undeniable that these practices are still in the exploratory stage. In the view of the huge property losses caused by floods in China every year, the volume of the insured property at risk is minimum. As far as the market is concerned, China's flood risk is relatively concentrated geographically, and the loss after the flood is huge which implicating huge amounts of payout by Insurance companies. However, the profit-seeking motive of commercial insurance determines that insurance companies will not always provide adequate and cheap insurance for all properties. If the potential loss is too huge, the insurer will tend to collect premiums beyond the insured's affordability, impose strict restrictions on insurance conditions, or simply opt out. In view of the affordability of the immature domestic insurance industry, flood insurance should be included in the business scope of policy insurance companies, and flood risk should be partially borne by the country through special insurance funds or special insurance methods of policy insurance institutions. (→ *see Fig 2 below*)

Figure 2: Suggested comprehensive flooding risk financing strategy, People's Insurance Company of China, PICC



CASE: Insurance for sea wall (coastal flood defence system) in Zhejiang Province, 2017[19]

Subject: sea wall (coastal flood defence system)
Premium: beneficiary area 50% ccounty (city, district) 30%, Central/provincial governments 10%
Policy: 2 layers, total limit: 900%;
Summary: only qualified levees eligible to the insurance program; promotion of flood prevention

Wenling City and Beilun District of Ningbo City of Zhejiang Province took the lead in introducing social insurance to insure seawalls through public bidding. Ningbo Branch of China People's Property Insurance Co., Ltd. was chosen as the principal insurer and Ningbo Branch of China Pacific Property Insurance Co. Ltd. as the second insurer. Catastrophe insurance was purchased for 65,000- meter standard seawall and 77,000-meter reinforced seawall, and a total premium of 786,500 CNY was paid. When the insured seawall suffers from irresistible natural disasters such as storms, rainstorms, typhoons, hurricanes, tornadoes and floods, the insurance company will payout for the loss of seawall on 2000 CNY/m and for reinforcement on 500 CNY/m. The maximum payout amount can reach 134 million CNY.

Typhoon and storm tide disasters are the most effective natural disasters along the coast of Zhejiang Province. Sitting on the east coast of Zhejiang Province with a long coastline, Beilun is vulnerable to typhoons and tidal waves, which brings losses to people's lives and property. In the view of this, the government vigorously carries out the construction of high-standard seawall and greatly strengthens the application of non-engineering measures such as seawall insurance, social insurance and risk-sharing scheme of natural disasters.

It is also the first time that seawall insurance projects in Zhejiang Province adopt the rule of "open-tendering" for government procurement. In recent years, the country has deepened the reform of government procurement system and pushed the government to purchase services, including services from commercial insurance companies and taking commercial insurance as a risk-sharing platform.

According to statistics, from 1992 to 1997, there were 487 seawalls insured in Zhejiang Province. The insured amount amounted to 620 million CNY, and the premium was 6.167 million CNY. The total amount of payout was 18.876 million CNY due to three severe typhoons. Standard seawall insurance, although effectively supported the timely repair of seawall, brought in too much risk for the insurers. Huge payout made commercial insurance companies to gradually phase out of the project.

19 Beilun Water Conservancy Bureau, Bulletin of Seawall Insurance Purchase Result, 2017, http://www.ccgp.gov.cn/cggg/dfgg/zbgg/201704/t20170425_8159602.htm

Implementation Plan

5

The following recommendations are derived from the analysis in Chapters 3 and 4, and set a focus on scaling up the potential role of risk transfer in integrated climate risk management.

While they primarily focus on actions that could be taken by the government, they are of relevance to other actors who might play a functional role in the suggested activities or could help to advocate for their implementation.

This "implementation plan" is presented in the format of a table with a general gap area, a more specific gap area, some actors who could be responsible for addressing the gap, and some next steps or 'actions/measures' that could be taken to address that gap.

The implementation plan builds upon the gap analysis shown in Chapter 3, which focuses more generally on achieving ICRM in the pilot city and the gaps and actions needed to achieve that. Quantitative analysis of adaptation measures by applying ECA (results can be found in Annex C) is added up to form a more comprehensive recommendation, which is intended to sort out the actions/measures for the implementers in local government departments to solve specific problems with clear responsibilities. That would then require a more in depth, lengthy, consultation with all relevant stakeholders and would follow-on from this starting point.

Table 2: Implementation Plan (by Gap Area)

Improvement on integrated management, Awareness & Capacity Building			
Specific Gap	Actions/Measures	Period	Actor/s
Very limited availability of scientific and historical data for implementing climate risk analysis	1. Call for a platform for sharing and meteorological data and loss/damage data, supervised by local city government and ministries in charge.	Short-term	Lishui Municipal Bureau of Environment Protection; Lishui Meteorological Bureau; Lishui Municipal Bureau of Civil Affairs
	2. Consider the option of acquiring access from other sources; e.g.: private data company.	Short-term	
Inconsistent understanding on Standards for construction and maintenance of infrastructure from different perspectives	1. Review Standards for construction and maintenance of infrastructure to ensure targets of adaptation measures are achieved.	Short-term	Lishui Municipal Bureau of Environment Protection; Lishui City Office, Lishui Municipal Bureau of Urban Planning, Lishui Municipal Bureau of Water Conservancy, Lishui Municipal Bureau of Land
	2. Organize consultations for risk management experts and stakeholders for infrastructure operation, in order to better understand the associated risks, the prevention measures and the expected impacts.	Short-term	
Insufficient effort in conducting and understanding Climate risk analysis	1. Capacity development for elaborating climate risk results in urban planning and project construction is in need.	Short-term	Lishui Municipal Bureau of Environment Protection; Lishui Municipal Bureau of Urban Planning; Lishui Transportation Bureau, Lishui Electronic Power Company, Lishui Municipal Commission of Economy and Information Technology and other relevant departments.
	2. Continuous investment into climate risk analysis on a yearly basis is in need and the results should be compared then disseminated to relevant departments for revising their planning.	Short-term	
	3. Standardize and implement Integrated Climate risk assessment practices, which aligns different stakeholders into one consistent management system.	Medium-term	

lack of sufficient Coordination amongst relevant government departments in integrated climate risk management	1. Improve management skills through general awareness raising and capacity building in the field of addressing climate adaptation in the city and put emphasis on integrated climate management and the coordination amongst relevant departments.	Medium-term	Lishui Municipal Bureau of Environment Protection; Lishui Municipal Bureau of Civil Affairs, Lishui City Office, Lishui Municipal Bureau of Urban Planning, Lishui Municipal Bureau of Water Conservancy, Lishui Municipal Bureau of Land, Zhejiang Design Institue of Water Conservancy and Hydro-electric power, Lishui Meteorological Bureau, Lishui Transportation Bureau, Lishui Electronic Power Company, Lishui Municipal Commission of Economy and Information Technology and other relevant departments.
	2. Messages distributed from early warning systems should be tailored to become less generic and more helpful for relevant departments and the communities.	Medium-term	
	3. Information provision and/or capacity-building on how to access and respond to early warning systems, including links to contingency plans.	Short-term	
	4. An emergency centre is in need as the central brain to collect, analyse and disseminate the information to public and government departments in a more tailored and efficient fashion.	Long-term	
	5. Apply integrated climate risk management practices contingency plans, which aligns different stakeholders into one consistent management system.	Medium-term	
Lack of under-standing and technical capacity on managing residual risk among decision makers and government officers	1. Provide technical training packages tailored to needs of city decision makers.	Medium -term	Lishui City Office; Lishui Municipal Bureau of Finance, Lishui Municipal Bureau of Environment Protection; Lishui Municipal Bureau of Civil Affairs,
	2. Encourage dialogue between insurers and City decision makers. Encourage government and private sector (and development partners) to work together to develop risk transfer solutions for key urban infrastructure.	Long-term	

Sponge city and Green land construction, grey infrastructure construction			
Specific Gap	Actions/Measures	Period	Actor/s
Adaptation not measured nor integrated in urban planning or infrastructure construction	Apply non-engineering measures: Natural ecological security protection	Long-term	Lishui City Office, Lishui Municipal Bureau of Environment Protection; Lishui Municipal Bureau of Civil Affairs, Lishui Municipal Bureau of Urban Planning, Lishui Municipal Bureau of Water Conservancy, Lishui Municipal Bureau of Land, Lishui Meteorological Bureau, Lishui Transportation Bureau, Lishui Electronic Power Company, Lishui Municipal Commission of Economy and Information Technology and other relevant departments.
	Apply green sponge city measures that include: 1. Eco-drainage system 2. Urban flexible space 3. Vertical Development of New Area 4. Low-Impact Development of Buildings 5. Low-Impact Road Development 6. Construction of Green Space System	Medium-term	
	Conduct grey infrastructure construction that include: 1. Storm water storage 2. New Storm water Pipeline	Short-term	

Finance & Insurance			
Specific Gap	Actions/Measures	Period	Actor/s
Limited Knowledge and access to data of insurers/reinsurers for a rational pricing and product design	The pilot project provides sufficient results on assessing the flood risks and the associated loss in climate scenarios, which indeed put the insurers into serious consideration on researching and designing the insurance products.	Short-term	Lishui City Office; Lishui Municipal Bureau of Finance, Lishui Municipal Bureau of Environment Protection; Lishui Meteorological Bureau
	Pilot project and other professional technical team employed by other stakeholders, e.g. the city government or the insurers, should be working together but applying different methodologies for a precise assessment on the risks.	Short-term	
	Call for a platform for sharing and studying the risk analysis results with the participation of risk management experts, insurers, reinsurers and city government. Consensus on the conditions and methods of risk analysis are important to draw the correct conclusion on residual risks, which is the base for a reasonable proposal for insurance product.	Medium-term	
Affordability of rapid response and recovery	scale up the cases that insurance payouts provide rapid liquidity and smooth financial supports in case of emergency	Long-term	Lishui City Office; Lishui Municipal Bureau of Finance, Lishui Municipal Bureau of Environment Protection;
	Strengthen and mainstream with relevant actors the business case for allocating rapid response funds under an insurance umbrella, which integrates public funding as the major contributor.	Long-term	
	Increase the visibility of Lishui pilot project in ministries and regulators with a sound arrangement of public funding that supports the insurance mechanism for urban infrastructure.	Long-term	

ANNEX A

THE METHODOLOGY OF ECONOMICS OF CLIMATE ADAPTATION (ECA)

The pilot project in Lishui City has been conducted along with the Economics of Climate Adaptation (ECA) methodology.

ECA has been developed by the world leading expertise in climate change and financial solutions, who are Swiss Re, McKinsey and a number of international development agencies. ECA offers a unique way to identify cost-effective climate adaptation measures for a variety of projects and sectors.

According to the ECA guidebook for practitioners, ECA also offers a systematic and transparent approach that fosters and initiates in-depth inter-sectoral stakeholder discussions. The methodology can be flexibly applied from the national down to local level to different sectors and different hazards. It also provides key information for program-based approaches, insurance approaches and has potential to support the development of Urban Climate Adaptation Pilot Cities Program. Specifically, the ECA presents:

- Qualitative data on potential loss and damage brought by climate risks on economy and society;
- Adaptation measures corresponding to climate risks and locations based on cost-effective analysis tool;
- Priority ranking on adaption measures, based on which adaptation strategy and projects are suggested.

Additional information about ECA methodology can be found through:

i ECA Guidebook[20]
ii General Information in ECA[21]
iii Manual for climada (modelling software embedded in ECA)[22]

20 Dr Maxime Souvignet, Economics of Climate Adaptation (ECA) - Guidebook for Practitioners, 2016, https://www.kfw-entwicklungsbank.de/PDF/Download-Center/Materialien/2016_No6_Guidebook_Economics-of-Climate-Adaptation_EN.pdf

21 Dr Maxime Souvignet, Economics of Climate Adaptation (ECA) in Development Cooperation: A Climate Risk Assessment Approach, 2016, https://www.kfw-entwicklungsbank.de/PDF/Download-Center/Materialien/2016_No5_Economics-of-Adaptation_EN.pdf

22 David N. Bresch, MATLAB (R2017a) version of CLIMADA, 2015, https://github.com/davidnbresch/climada

ANNEX B

MAJOR RESULTS OF CLIMATE RISK ANALYSIS BY APPLYING ECA FOR THE PILOT PROJECT IN LISHUI CITY

Disaster risk assessment is an important means to optimize adaptation measures based on the methodology of ECA. To meet the needs on optimization of flood risk adaptation measures and their application, this pilot project in Lishui City introduces the flood risk assessment methods and derives the results in different climate change scenarios.

Climate Scenarios

Two emission scenarios, RCP 2.6 and RCP 8.5, simulated by the General Circulation Model (GCM) model (EC-Earth), are selected to analyse the trend of annual precipitation in the study area from 2006 to 2036. Linear fitting results show that under the two emission scenarios (RCP 2.6 and 8.5), the precipitation in the study area shows a fast increasing trend in precipitation fluctuation. Compared with RCP 2.6, RCP 8.5 shows a more significant increasing trend. The growth rate under the former emission scenario is about 8 mm/year, and that under the latter emission scenario is about 3 mm/year. It is concluded that the increase of precipitation is notable, which may lead to the increase in the frequency and intensity of floods .

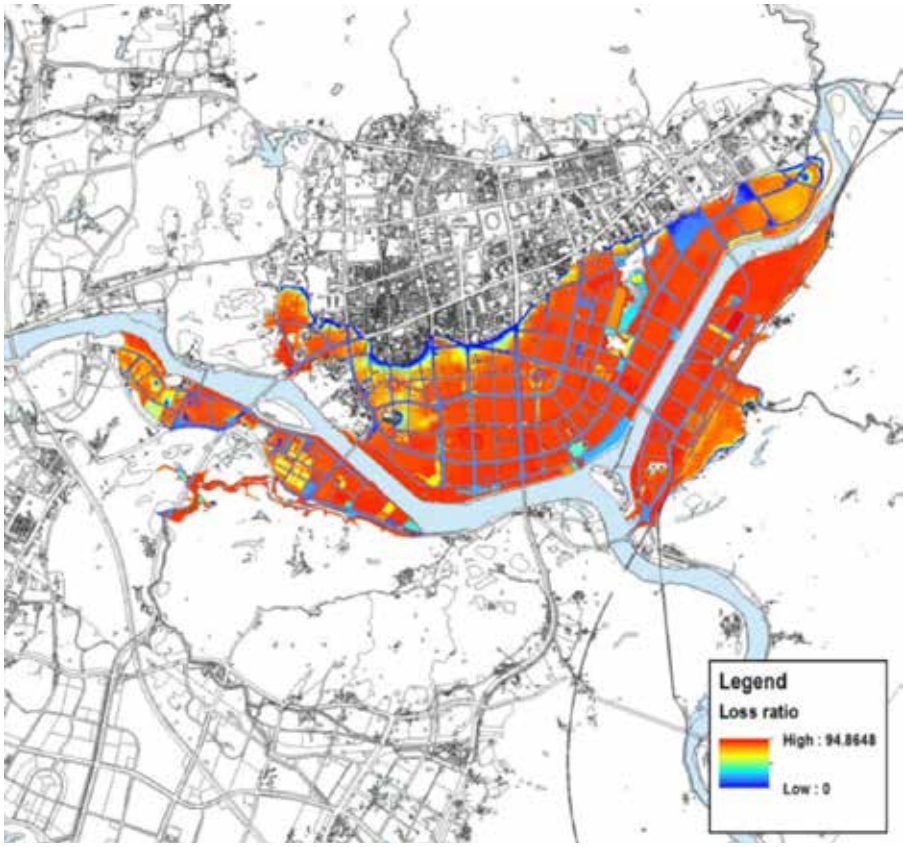
Flood Risk Analysis

In the process of rapid urban development in Lishui City, there is obvious expansion of urban water system. In addition, it is prominent to use reservoirs so as to increase the area of urban water system and improve the urban environment. The remote sensing data of water system shows that the width of major water stream in Lishui urban area has increased significantly since 2005. Many reservoirs built upstream and downstream can play the key role in flood peak reduction and flood regulation if they are properly operated. Otherwise, they may become amplifiers of flood disasters.

Although the expansion of the main urban area of Lishui City is limited by geographical conditions after 2005, the speed of urban spatial expansion has been accelerated after the opening of the new South City. According to Lishui's 2030 plan, the city aims to control the urban construction land within 87.5 square kilometres with a permanent population of 700,000 people in the central city. In 2030, residential land will increase by 113%, industrial land by 38.77%, public facilities land by 54.30%, logistics storage and green land by 519.34% and 321.23% respectively.

To conclude, the expansion of water system and change of land use pattern will greatly affect the scope and risk of floods.

Figure 3: RCP 2.6 Climate Scenario: Loss Rate Distribution in case of a 100-year heavy rain under flood-resistant design on a 100-year flood in Lishui City



Direct and indirect economic impacts accordingto vulnerability curves of accounted key infrastructure

The vulnerability curves of 50 categories of assets are produced in the pilot project, which provides a basis for calculating the loss rate under different flood scenarios. The total direct economiclosses under each scenario combination are formed by adding up the direct economic losses of all flood-affected assets. *(→ Table 1)* As an example, Figure 3 shows the direct economic loss ratio under one certain scenario combination of a 100-year heavy rain under flood-resistant design on a 100-year flood.

With the increasing of social and economic integration, the Interdependence among various industrial sectors is growing significantly. Climate disasters not only cause serious direct economic losses, but also indirect economic losses to the social and economic system transmitted through industrial chains. In addition to huge direct economic losses to Lishui City, the „8.20" flood occurred on August 20, 2014 also resulted in a large amount of disaster relief investment, and industrial and commercial shutdown, agricultural production reduction, disruption of transportation, and the impacts on related industries. Therefore, it is necessary to take indirect economic losses into account when calculating the losses caused by flood disasters. To compare the numbers, the Total Economic Impacts in the scenario of RCP 2.6 and flood-resistant design on a 50-year flood counts 0.39 billion CNY when GDP of Lishui City in 2017 was 129.82 billion CNY.

Table 1: Comparison of Flood Risk Impacts under Different Scenarios in Lishui City (in 10,000 CNY)

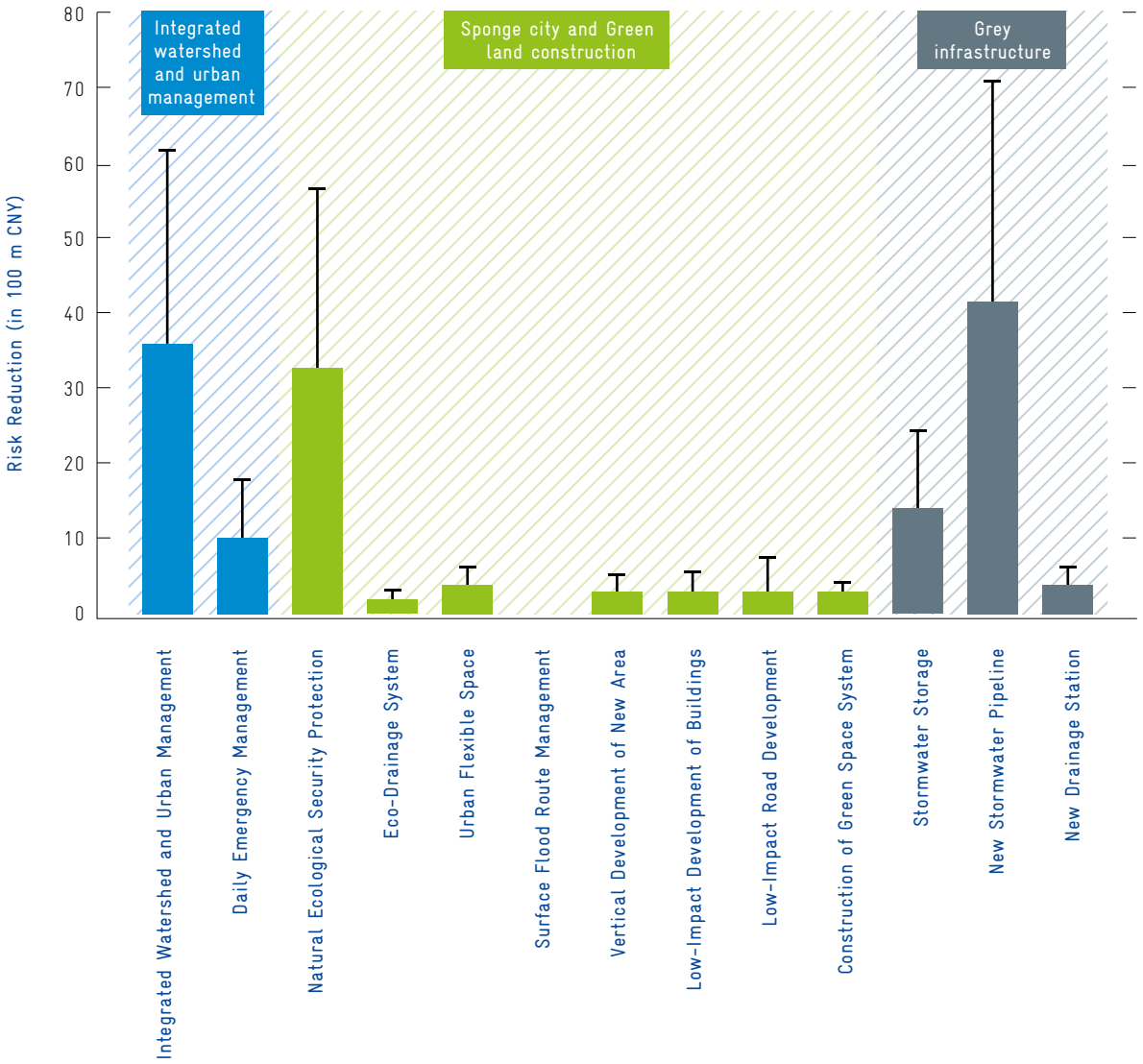
Scenarios	In RCP 2.6			In RCP 8.5		
	flood-resistant design on a 50-year flood	flood-resistant design on a 100-year flood	flood-resistant design on a 200-year flood	flood-resistant design on a 50-year flood	flood-resistant design on a 100-year flood	flood-resistant design on a 200-year flood
Direct Economic Impacts	31217.06	10436.52	3885.26	45305.80	32336.36	19591.74
Indirect Economic Impacts	7938.03	2615.29	956.48	11512.07	8189.55	4969.19
Total Economic Impacts	39155.10	13051.81	4841.74	56817.87	40525.90	24560.93

Cost-effective analysis on adaptation measures

The analysis of various adaptation measures for Lishui City to address flood risk show the same trend under various flood simulation conditions. Grey infrastructure, Sponge city and Green land construction, integrated watershed and urban management measures show bigger benefits amongst all the measures that have been analysed. Given the fact that non-engineering measures and management measures cost less than constructions, adaptation measures ranked by their cost-effectiveness are presented in the figure 4 below as: non-engineering measures (such as natural ecological security protection), management measures (such as integrated watershed and urban management), sponge city measures and grey infrastructure construction.

However, the effectiveness of sponge city and green land construction on flood mitigation is not as significant as that on reducing urban waterlogging and water pollution. When identifying sponge city measures for adaptation purpose, only low-maintenance cost measures with higher cost-effectiveness are prioritized. The best plan is always to apply a combination of these categories of measures to manage flood risk in the pilot area.

Figure 4: Cost-effective analysis on adaptation measures in the pilot of Lishui City



ANNEX C

RATIONAL AND SOLUTION OF CLIMATE RISK TRANSFER FOR LISHUI CITY (PRESENTED BY SWISS RE)

Rational of Lishui financial risk index insurance

The natural disasters that normally place significant impacts in Lishui are heavy rainfall, typhoon and debris flow. Under the circumstance of climate change and social development, natural disasters have been increasingly blocking the sustainable economic development and livelihood enhancement in Lishui.

Whenever major natural disasters occur in the city, resulting in pollutant leaking and physical damage on key infrastructure, they cause huge pollution in well-developed water system and the adjacent ecological protection areas, and direct losses in public assets. It will conclusively pose a huge impact on the ecological tourism industry of Lishui City, and unpredictable indirect losses on the overall economic development.

In the case of serious absence and misplacement of insurance in the financial management systems of residents, enterprises and governments, these hazards pose a great threat to the assets and liabilities of residents, enterprises and governments. With the increase of disaster intensity, the boundaries of responsibility amongst them are gradually blurred until they disappear. Therefore, all kinds of government budget funds related to disasters become the last or only source of funds in the case of severe disasters.

The government's contingent financial responsibility for natural disasters mainly includes three aspects: disaster relief, post-disaster reconstruction and post-disaster fiscal revenue reduction. Without an insurance scheme, these responsibilities are far beyond the capability of government's disaster-related budgetary funds, and the transfer payments traditionally relied on the central authorities are insufficient to cope with major disaster events. In view of this, the Financial Risk Index Insurance plays the role of fiscal policy tool to place insurance as contingent capital so as to hedge the government's disaster-related contingent financial liabilities by using the limited budgetary funds to obtain the highly incremental disaster-related funds. While fulfilling the responsibilities of disaster relief and post-disaster reconstruction, insurance scheme should ensure the rigidity and balance of financial budget and improve the liquidity of government assets.

Climate risk transfer solution: Lishui financial risk index insurance scheme (rainfall index)

During the insurance period, when heavy rainfall disasters occur, the financial responsibility of the people's government of Lishui City is incurred in the insured area for fulfilling public responsibilities such as emergency response, disaster relief, rehabilitation and reconstruction of post-disaster public facilities, and post-disaster social relief. When the disaster degree reaches the disaster threshold stipulated in the insurance contract, the insurer shall be liable for payout in accordance with the agreement.

According to the correlation analysis of the maximum rainfall recurrence period and disaster losses in Lishui city, the disaster factors table is established. Taking into account the disaster occurrence amount of each district and county, and the number of population, property scale and financial responsibility affected, the weight table of insurance parameters in each district and county is established. When heavy rainfall events occur, the disaster index is obtained by multiplying the disaster factors corresponding to the maximum rainfall of each district and county by the corresponding weight of insurance parameters. In the administrative region of Lishui City, based on the city as a unit of payout, the disaster index of heavy rainfall events is calculated according to the weight and rainfall of the city's ground observation stations. When it reaches the agreed threshold, the pre-scheduled payout is initiated.

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About ACRI+

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The Munich Climate Insurance Initiative (MCII) was launched in April 2005 in response to the growing realization that insurance-related solutions can play a role in adaptation to climate change, as advocated in the Framework Conventionand the Kyoto Protocol. This initiative brings together insurers, experts on climate change and adaptation, NGOs and policy researchers who intend on finding solutions to the risks posed by climate change. MCII provides a forum and gathering point for insurance-related expertise on climate change impact issues. MCII is hosted at UNU-EHS in Bonn, Germany.

http://www.climate-insurance.org/projects/advancing-climate-risk-insurance-acri

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