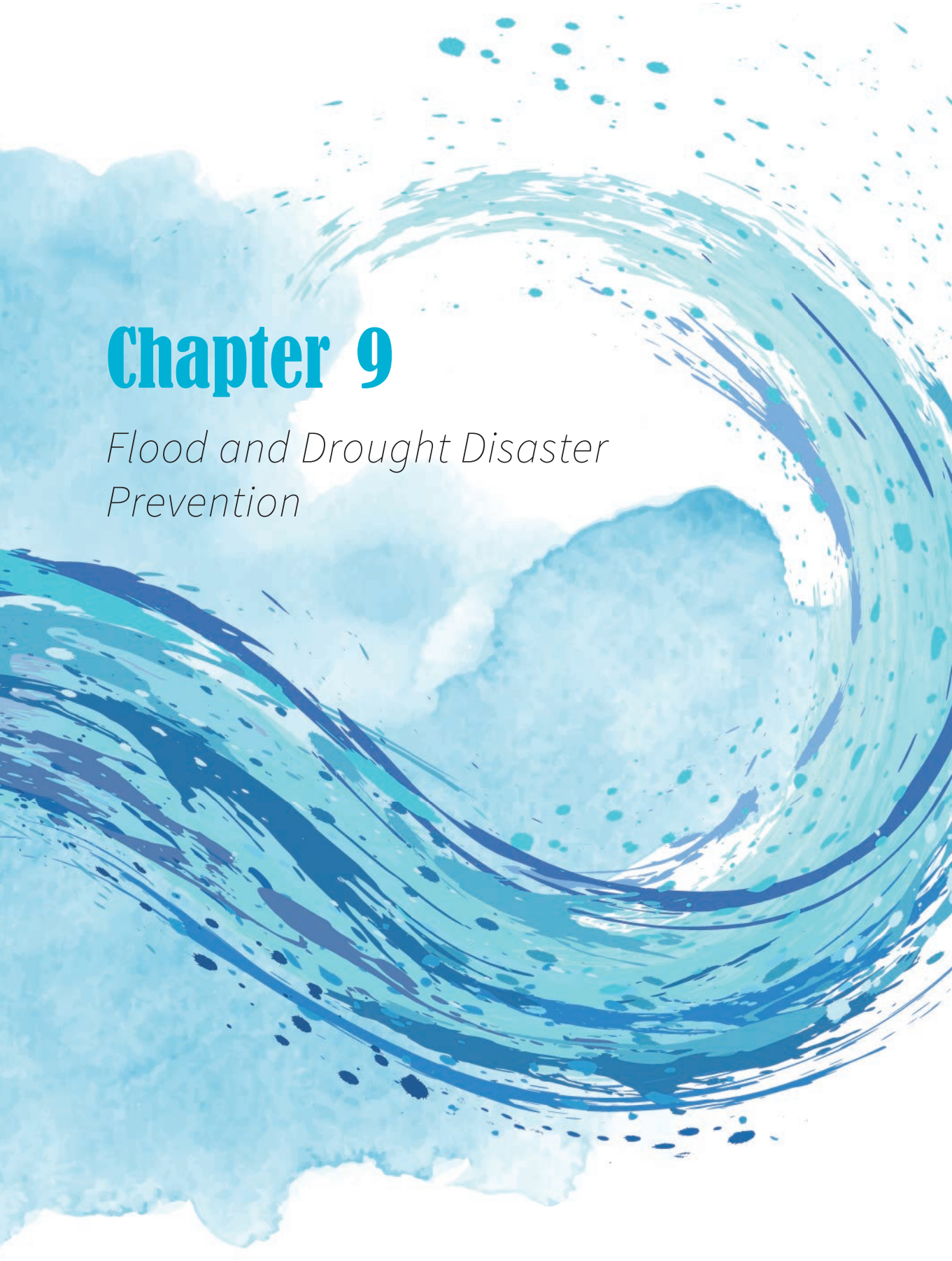

Chapter 9

Flood and Drought Disaster Prevention

1 Overview

1.1 Main Types of Flood Disasters in China

1.1.1 Basin-wide Floods

The regions seriously threatened by floods in China are around the middle and lower reaches of the Yangtze River, Yellow River, Huaihe River, Haihe River, Pearl River, Songhuajiang River, Liaohe River, including those rivers that flow into the sea alone and Taihu Lake, where there is 1/2 of the national population, 1/3 of the national arable land and 3/4 of the gross industrial and agricultural output of China. Since 1949, more than 60 major basin-wide floods have hit China.

1.1.2 Flash-floods

The Flash-flood Hazard Abatement area in China covers 3.86 million km^2, affecting a total population of around 300 million.The area in China directly threatened by flash-floods extends to 480,000 km^2 with a population of more than 76 million. Jointly affected by numerous factors, such as special geographical conditions, extreme disastrous weather events, and economic and social activities, China is subject to frequent flash floods caused by sudden regional torrential rains, which leads

Mouth of Mudslide Valley in Zhouqu Disaster-hit Area in Gansu Province

to casualties and property losses.The death toll of flash-floods usually accounts for 70% of the total casualties caused by flood disasters.

1.2 Drought

1.2.1 Agricultural Drought

Since 1950, the average drought-affected area per annum in China is 19.77 million hm^2, whereas average annual grain loss stands at 15.74 million metric tons or even goes up to 60 million metric tons in extremely dry years. In 1997, when a catastrophic drought hit the Yellow River Basin, the Lijin section in the lower reaches of the Yellow River dried off 13 times for a total of 226 days, and the total length of dried-off river extended over 700 km. In 2000 and 2001, the whole country was caught in consecutive catastrophic droughts. In 2006 Chongqing Municipality and Sichuan Province suffered a 100-year-return drought. In 2009 numerous severe droughts hit the northern part of China. In 2010 another catastrophic drought occurred in southwest China.The year 2020 witnessed the worst hydro-meteorological drought ever recorded in the region of Yangtze River.

1.2.2 Water Shortage in Cities

More than 400 cities in China are short of water, of which over 100 cities suffer severe water shortage. Since 2000, due to consecutive droughts in the Haihe River Basin, Tianjin Municipality was frequently short on water supply. During 2000, the severe drought in Yantai and Weihai in Shandong Province meant available water per capita per month was capped at 1 metric ton in these cities. From the winter of 2004 onward, saltwater intrusion in the estuary of the Pearl River has threatened the safety of water supply in various cities on the Pearl River Delta, including Zhuhai and Macau, etc. Moreover, water pollution has led to frequent urban water supply crises. The drinking water supply for nearly one million inhabitants was suspended in cities, including Neijiang, because of the serious pollution of Tuo River in 2004. Jilin and Harbin were both caught in a water supply crisis when the Songhuajiang River was polluted in 2005. Likewise, the cyanobacteria bloom in Taihu Lake in 2007 led to a water supply crisis in Wuxi.During the second half of 2021 and spring 2022, many cities in Guangdong Province and Fujian Province suffered from a shortage in water supply, which was due to long-term drought

and salinization of the Pearl River that lasted three straight seasons from autumn, winter to spring.

1.3 Prevention and Management Institution of Flood and Drought Disaster and Relevant Laws and Regulations

China has established the State Flood Control and Drought Defense Headquarters, which is responsible for organizing the work of flood control and drought defense throughout the country under the leadership of the State Council. Its general commander is a leader of the State Council who is in charge of the State Flood Control and Drought Defense Headquarters and its members include relevant ministries of the central government as well as the People's Liberation Army (PLA) and the Chinese Armed Police Force (CAPF). The minister of water resources serves as deputy commander-in-chief.

Basin flood control and drought relief headquarters are set up for major river and lake basins (the Yangtze River, Yellow River, Huaihe River, Haihe River, Songhuajiang River, Pearl River and Taihu Lake), and the coordination leading group for flood control and drought relief is established for the Liaohe River basin. It is responsible for flood control and drought relief work within the jurisdiction. Local people's governments at or above the county level with flood control and drought relief tasks have set up offices to organize and direct relevant work under the leadership of the higher flood control and drought relief agencies and the people's governments at the corresponding levels. The Ministry of Water Resources is mainly responsible for monitoring and pre-warning of flood and drought, water project scheduling and

Linhuaigang Flood Control Works in Anhui Province

technical support for flood prevention and fighting.

China has successively promulgated the *Water Law*, the *Flood Control law*, the *Flood Control Regulations*, the *Drought Control Regulation* and the *Interim Measures for Compensation in Flood Storage and Detention Areas*. All provinces, autonomous regions and municipalities have correspondingly promulgated and implemented the supplementary regulations and rules for flood control and drought relief. In accordance with relevant laws and regulations, various emergency plans for flood control and drought relief, flood prevention schemes for major rivers and their major tributaries and flood dispatching schemes have been formulated. Most of the nearly 100,000 reservoirs and hydropower stations around the country have formulated emergency plans for flood control and scheduling plans for rescue. Preparatory operation plans have been made for all the 98 national flood storage and detention areas, and flash-flood preparatory plans for 2,076 counties, townships and villages with the task of flash-flood prevention and defense.

2 Major Achievements and Challenges

2.1 Major Achievements

Currently, main sections of major rivers in China are by and large capable of withstanding the most catastrophic flood since 1949. With the combined use of dykes, reservoirs as well as flood storage and detention areas, both

the Jinjiang section of Yangtze River and the main sections of Huaihe River that are most prone to flood disasters could survive 100-year-return floods; the sections on the middle and lower reaches of the Yellow River are capable of preventing 1000-year-return floods; the rivers in the northern part of the Haihe River basin can defend floods similar to the 1939 one, while the main sections of rivers in the southern part could combat 1963-type floods; and the main sections of Songhuajiang River, Liaohe River, Pearl River and Taihu Lake are basically capable of guarding against the most catastrophic flood since 1949. The dykes along the key coastal areas that used to sustain 5~10-year-return typhoons are now able to defend 50-year-return typhoons. Medium and small rivers are capable of withstanding ordinary floods. When medium drought years appear in some areas, industrial and agricultural production and ecology will not be greatly affected, which can basically ensure the safety of the urban and rural water supply.

China has not only enhanced the construction of a flood and drought prevention system, but also adopted various non-engineering measures across the country. 121,000 hydrologic stations of various types have been built, shortening the time of information collection nationwide to 15 minutes with the accuracy rate of flood forecasting exceeding 90% and 70% in critical periods of major rivers in the South and the North respectively. Flash-flood monitoring and pre-warning platforms have been built in 2,076 counties tasked with prevention and control in all the 29 provinces, autonomous regions, municipalities and Xinjiang Production and Construction Corps across China.

According to the research results of the Chinese Academy of Engineering, now China's flood control capability has been upgraded to a safer level, and its flood and drought prevention capability has reached an international medium level, which is relatively high in the ranking among developing countries. Thanks to the gradual improvement of engineering and non-engineering systems and the extensive participation of the whole society, flood and drought prevention in China has achieved enormous social benefits and economic returns.In the recent decade, annual losses from floods accounts for 0.31% of GDP, down from 0.57% a decade ago.

2.1.1 Assurance of Lake and River Safety

Recently, China has established well-designed monitoring and forecasting tools, and a flood-control engineering system, which are significant in

scientific analysis of precipitation, water flow, flood, project progress. Additionally, these tools and systems have been used for precise decisions for water projects such as water transfer, flood diversion, sluices and flood detention basin. These assurances played a key role in coping with many major flooding, safeguarding safety and minimizing the losses from floods.

Table of Floods Successfully Controlled in China in Recent Years

Year	River/River Basin	Scale/ Severity of Floods
1998	Yangtze River	Basin-wide extraordinary flood
	Songhuajiang River	Basin-wide extraordinary flood
1999	Taihu River	Extraordinary flood
2003	Huaihe River	Basin-wide extraordinary flood
	Hanjiang River, Jialingjiang River, Weihe River	Serious autumn flood
2005	Xihe River（Pearl River basin）	⩾100-year-return extraordinary flood
	Liaohe River Bain	The most extraordinary flood in 20 years
	Hanjiang River, Jialingjiang River, Weihe River	Serious autumn flood
2007	Huaihe River basin	Basin-wide extraordinary flood
2011	Hanjiang River, Jialingjiang River, Weihe River	Serious autumn flood
2013	Lower reach of Heilongjiang River	⩾100-year-return extraordinary flood
	Songhuajiang River basin	The most extraordinary basin-wide flood since 1998
	Upper reach of Hun River (Liaohe River basin)	⩾50-year-return extraordinary flood
2016	Taihu Lake Basin	Basin-wide extremely catastrophic flood recorded as the second highest water level in history
	Yangtze River basin	The most extraordinary basin-wide flood since 1998
2017	Yangtze River basin	Regional extraordinary flood
2020	Yangtze River basin	Basin-wide extraordinary flood
	Huaihe River basin	Basin-wide flood
	Taihu Lake Basin	Basin-wide extraordinary flood, recorded as the 3rd highest water level since 1954
2021	The middle and lower reaches of the Yellow River	The most serious autumn flood since 1949
	Zhangweihe River (South Haihe basin)	Continuous flood season in summer and autumn, rare in history
	Songhuajiang River basin	Basin-wide flood
	Upper reach of Heilongjiang River	Catastrophic flood
2022	Beihe River（Pearl River basin）	The most extraordinary flood since 1915
	Liaohe River basins	The most extraordinary flood since 1995

2.1.2 Assurance of Water Supply Safety

Since 2000, irrigation of drought-affected land extends to an area of 21.74 million hm^2 per annum on average, which reduces grain loss by 34.84 million metric tons, and enables 17.55 million people and 12.17 million livestock to have temporary access to drinking water. On multiple occasions, the Chinese government diverted water from the Yellow River to the City of Tianjin, and replenished fresh water to suppress salt water intrusion in the Pearl River basin, which has ensured the safety of water supply and ecosystems in Tianjin and cites on the Pearl River Delta including Guangzhou, Zhuhai, Zhongshan and Macau Special Administrative Region.In 2022, regions along the Yantze River were hit by the most severe hydro-meteorological drought since 1961. To ensure water supply for the urgent needs of citizens, along with irrigation of crop plants with an area of 12.2 million hectares, with scientific analysis of the Three Gorges Dam, we transferred 6.2 billion cubic meters of water to the lower reaches of the Yantze River from groups of water conservancy projects at upper reach of the Yantze River, Dongting Lake and Boyang Lake. To tackle the intrusion of salt tides at the estuary of the Yantze River, China strengthened water supply of this area from the Three Gorges Dam. In addition, the project of water diversion from Qiantangjiang River to Taihu Lake was carried out that enabled Taihu Lake to connect with the river network and water conservancy projects. These measures have successfully safeguarded the water supply of Shanghai.

2.1.3 Assurance of Life Safety

With the enhanced management of society, and improvement of the flood control system, the death toll caused by flood disasters has decreased continuously year by year. In the 1950s, the number of deaths caused by flood hazards in China was 8,976 per annum while the corresponding figures in the 1980s and 1990s stood at 4,338 and 3,744 respectively. For the first 10 years of the 21st century, the death toll has reduced to 1,582. Between 2011-2020, the total number of death and missing reduced to 600, and 187 in 2021. Since 2010, China has vigorously implemented the construction of flash-flood prevention and control projects. It has basically established a flash-flood disaster monitoring and pre-warning system and a mass monitoring and prevention system, which have minimized casualties. The average annual death toll from flash-floods in the first ten

years of the 21st century was 1,179. From 2011 to 2022, the average annual death toll and missing from flash-floods dropped to 327. The number further reduced to 119 in 2022, hitting a record low.

2.2 Challenges

Presently, China encounters some problems and deficiencies in flood control and drought defense, including a lack of strategic water conservancy projects on some major rivers, shortage of flood control standards for some major tributaries, safety concerns of dams during the flood season, and difficulty in preventing and controlling floods in medium and small rivers, as well as mountain areas. The nation also encounters intensifying problems such as an under-developed allocation contingency plan for water conservancy projects, while the modern allocation platform is yet to be completed. On the other hand, hydrologic monitoring can't fully cover all the flood-control-functioning rivers. China still suffers from a weak capability of forecasting sudden regional heavy rainstorms and an unsystematic drought monitoring station network and evaluation tools. Some major issues related to disaster prevention and control need serious consideration in rural and urban areas, such as illegal appropriation of flood diversion rivers, floodplains and flood basins. Besides, the public awareness of flood control, drought defense, risk prevention and emergency response is still yet to improve.

3 Strategies and Measures for Future Development

3.1 Strategies for Future Development

In 2016, President Xi Jinping proposed major principles of disaster prevention, control and relief. That is, we should put disaster prevention to the fore and employ an integrated approach of regular disaster control with emergent disaster relief. Meanwhile, we should strive to shift our

focus from disaster relief to disaster prevention, shift our preparation for single disaster control to multiple disaster control, and shift our target from reducing disaster losses to reducing disaster risks. These principles offer a framework for the work of flood prevention and drought defense in the new era. Based on the guiding principles of *putting people and safety first, precaution first*, the MWR prioritizes flood and drought prevention. In this regard, we will focus on the scientific control of water conservancy projects and refine the administration of the industry for disaster defense. Meanwhile, our strategies lay emphasis on disaster monitoring and forecasting, disaster relief technology and water conservancy projects control, especially projects for drought defense and urgent water sources. We will strive to handle the difficulties of mountain torrent defense and reservoir safety during flood season. To that end, it is necessary to conduct comprehensive examination and rectification of potential risks, revision and rehearsal of contingency plans, construction of the Watershed-Area Joint Disaster Control System of the Water Conservancy Projects, together with reservoir water level monitoring and supervision during flood season.

3.2 Main Measures for the Future Development

3.2.1 Secure Flood Prevention and Water Supply

We will closely monitor precipitation, flood and drought development and intensify consultation and investigation so as to release timely pre-warning and offer guidance for the scientific disaster-control of water conservancy projects at the watershed or local levels. It is also our duty to provide technological support for disaster relief, secure the life and property safety of the public, as well as the water supply in urban and rural areas.

3.2.2 Advance Capacity of Monitoring, Forecasting and Pre-warning

We will strive to advance the capacity of river flood forecasting,optimize flood forecasting models to enable earlier forecast, accuracy and prompt pre-caution for the frontline of flood control and drought defense. We will simulate dynamic flood routing and water transfer of water conservancy projects, iterate flood control plans, and prepare and assign inspectors, professionals and rescue teams to key regions.

3.2.3 Improve the Disaster Control Capability of Water Conservancy Projects

We will revise the regular and emergent water-transfer control schemes for major rivers, lakes and major water conservancy projects during flood or drought seasons. It is necessary to improve joint control of water conservancy projects, so as to make full use of the water conservancy network. To that end, we will conduct investigations on the multi-functional and coordinated joint control of the projects, apart from the main target of flood control. Furthermore, we will advance the construction of watershed-area joint disaster control system of the water conservancy projects, carry out programs of determination of drought warning water level in rivers, lakes, and water conservancy projects.

3.2.4 Intensify Supervision on the Control and Use of Water Conservancy Projects

In an attempt to regulate reservoir control and use, and eliminate illegitimate operations above the maximum water level during flood season, we will stipulate *Regulations on Supervision of Water Levels during Flood Season*, and *Regulations on Inspections of the Disaster Control and Use of Water Conservancy Projects*. These measures will be accompanied with intensified supervision and accountability inspections for flood control and drought defense, so as to guarantee that the projects are under control in a legitimate, legal and scientific manner. We will implement *Regulations on Water Transfer of Large and Medium-sized Reservoirs During Flood Season*, which ensures specific requirements and water transfer for large and medium-sized reservoirs during flood season, and makes a comprehensive play of reservoirs in flood control.

3.2.5 Facilitate Public Awareness of Disaster Defense

We will work on the evaluation of floods, and move on to the compilation and application of flood-risk charts. Also, we will carry out massive educational campaigns about flood and drought prevention and drought defense, so as to increase public awareness of disaster prevention. We will attach equal importance to the study and application of modern equipment and disaster relief technologies.

The Dyke along the Qiantangjiang River

4 International Cooperation and Exchanges

China attaches great importance to international exchanges and cooperation in the fields of flood control, drought relief and disaster reduction. In recent years, five consecutive Sino-Swiss seminars on Flood Control and Disaster Reduction have been jointly held by China and Switzerland. China also hosted a technical workshop on the project of urban flood risk management sponsored by the World Bank, two training courses of the World Bank, and the Fifth Training Course on Regional Flood Risk Management. In addition, China has taken an active role in international exchanges, seminars and meetings. In October 2011, at the invitation of the Thai Government, China dispatched a team of flood control experts to Thailand for the provision of consulting services on flood control, disaster rescue and relief work. In June 2012, China sent another team of 23 experts to Thailand who advised on flood control and submitted the *Consulting Report on Flood Control in the Chao Phraya River Basin in Thailand*. In 2013, China and Russia cooperated to combat the flood in the Heilongjiang River basin. In 2014, the Ministry of Water

Resources of China and the Emergency Department of the Russian Federation signed the MOU on flood control and hosted the first meeting of the Sino-Russian Working Group on Flood Control Cooperation. In 2015, at the request of the Myanmar government, China sent a team of experts to Myanmar for the provision of consulting services on emergency response and flood control techniques.The experts advised the Myanmar government on the emergency restoration of water-damaged projects as well as flood control and disaster mitigation planning. In 2016, China urgently dispatched cascade power station of Lancang River to increase water release to ease severe drought plaguing in Vietnam. In 2018, the Yarlung Zangbo River was threatened by two dammed lakes. The Indian was informed of the situation without delay.In addition, China also actively carries out joint international research projects. In cooperation with the World Bank, Asian Development Bank and International Council for Science, China has completed multiple projects such as research on major technical problems in flood control and disaster relief, regional consulting meeting on poverty and floods, research on flood management strategy, and research on drought management strategy in China, etc. In 2022, China sent an expert panel of water conservation to Pakistan to offer consultation and suggestions for flood control, disaster relief, and post-disaster re-building.