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China Flood and Drought Disaster Prevention Bulletin

2021

中华人民共和国水利部

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2021年，我国部分地区遭遇极端强降雨，发生严重洪涝灾害，局部地区出现持续旱情。习近平总书记7月21日就防汛救灾工作作出重要指示，7月30日主持中央政治局会议，强调要抓细抓实各项防汛救灾措施，为做好水旱灾害防御工作提供了根本遵循。李克强总理多次主持召开国务院常务会议和专题会议并赴河南考察，就防汛救灾和灾后恢复重建作出部署。胡春华副总理、王勇国务委员等国务院领导同志多次安排部署，提出明确要求。水利部坚决贯彻习近平总书记重要指示批示精神，按照李克强总理等领导同志要求和国家防汛抗旱总指挥部（以下简称国家防总）部署，抓细抓实各项防御措施，全力以赴打赢抗击严重洪旱灾害这场硬仗。

注：

（1）本公报数据未包括香港特别行政区、澳门特别行政区和台湾地区统计数据，新疆生产建设兵团统计数据计入新疆维吾尔自治区统计数据；

（2）本公报所采用的计量单位部分沿用水利统计惯用单位，未进行换算；

（3）本公报数据来源于水利部、应急管理部，降水量数据依据水利部信息中心业务系统报汛数据统计，未注明来源的数据均来源于水利部，指标解释分别参阅《水旱灾害防御统计调查制度（试行）（2021）》《自然灾害情况统计调查制度（2020）》。

In 2021, China suffered from extreme and/or heavy rainfalls, severe floods, and persistent droughts in some regions and localities. The Chinese President XI Jinping instructed on flood control and disaster relief on July 21 and emphasized the need to concretize flood control and disaster relief measures on a July 30 meeting of the Political Bureau of the CPC Central Committee he presided over, thereby providing a fundamental guide for flood and drought disaster prevention. Premier LI Keqiang presided over several executive meetings and ad-hoc meetings of the State Council on relevant topics and visited Henan Province to make arrangements for flood control, disaster relief and post-disaster recovery and reconstruction. Vice Premier HU Chunhua, State Councilor WANG Yong, and other leading officials of the State Council made arrangements and put forward clear requirements on multiple occasions. The Ministry of Water Resources (hereinafter MWR) thoroughly implemented the central commands and deployments made by President Xi Jinping, Premier Li Keqiang and other leadership officials, as well as the State Flood Control and Drought Relief Headquarters (hereinafter SFDH). With focuses laid on putting in place solid preventive measures, all-out and forceful fights against the severe flood and drought disasters were staged in 2021.

Note:

(1) The data in this Bulletin does not include statistics of the Hong Kong Special Administrative Region (SAR), the Macao Special Administrative Region (SAR) and Taiwan, and the statistics of the Xinjiang Production and Construction Corps is included in the statistics of the Xinjiang Uygur Autonomous Region;

(2) Parts of the measurement units used in this Bulletin conform to what are customarily used in water conservancy and are not converted;

(3) The data in this Bulletin are from the Ministry of Water Resources (MWR) and the Ministry of Emergency Management (MEM), the data on precipitation are drawn upon the flood data reported on the service platform of MWR Water Resources Information Center, the data that do not indicate the source are all from the MWR, and interpretations on the indicators can be found in *Statistical Investigation System for Flood and Drought Disaster Prevention (Trial)(2021)* and *Statistical Investigation System for Natural Disasters (2020)*, respectively.

1 雨情、水情

RAINFALL AND WATER REGIME

1.1 雨情

2021 年，全国共出现 42 次强降雨过程，全国平均降水量 664 毫米，较常年（625 毫米）偏多 6%，列 1961 年有完整序列资料以来第 6 位；海河流域大部、黄河流域东部和中南部、松辽流域西部南部、淮河流域北部等较常年偏多 3 ~ 7 成，黄河流域西北部、珠江流域中部东部等较常年偏少 2 ~ 5 成。2021 年 5—9 月，全国平均降水量 489 毫米，较常年同期偏多 8%；海河流域东部南部、黄河流域东部和中南部、松辽流域西部南部、淮河流域东部北部、长江支流汉江流域北部等较常年同期偏多 4 ~ 9 成，黄河流域西北部、珠江流域大部等较常年同期偏少 2 ~ 5 成。2021 年全国雨情总体有 3 个特点。

降水空间分布不均，呈“北多南少”格局。2021 年，东北西部南部、华北大部、黄淮大部、西北东南部等地年平均降水量较常年偏多 3 成至 1 倍，华南东部和西南部及云南西北部等地较常年偏少 3 ~ 6 成；北京、天津、河北、河南、陕西、山西等北方省份年平均降水量均为 1961 年有完整序列资料以来最多。

夏秋降雨偏多明显，秋雨持续时间长。从全国逐月降水量来看，7—11 月降水量较常年分别偏多 3%、14%、28%、44%、18%，其余月份以偏少为主，1 月、12 月分别偏少 54% 和 33%。秋季阴雨天气自 8 月下旬开始，较常年明显偏早，至 10 月上旬结束，长江上游嘉陵江、汉江上游、黄河中下游、海河漳卫河系、淮河沙颍河上游等累计降水量较常年同期偏多 1.5 ~ 3 倍，均列 1961 年有完整序列资料以来同期第 1 位。

1.1 Rainfall

In 2021, 42 heavy rainfall processes occurred in China. The national average annual precipitation was 664 mm, 6% more than normal (625 mm) and ranking the sixth since complete sequence data was available in 1961. The most of the Haihe River basin, the eastern and central-southern parts of the Yellow River basin, the western and southern parts of the Songhua-Liaohe River basin, and the northern part of the Huaihe River basin received 30%-70% more rainfall than normal, while the northwestern part of the Yellow River Basin and the central and eastern parts of the Pearl River basin received 20%-50% less rainfall than normal. From May to September 2021, the national average precipitation was 489 mm, 8% more than normal over the same period; precipitation in the eastern and southern parts of the Haihe River basin, the eastern and central-southern parts of the Yellow River basin, the western and southern parts of the Songhua-Liaohe River basin, the eastern and northern part of the Huaihe River basin, and the northern part of the Hanjiang River, a tributary of the Yangtze River, was 40%-90% more than normal, while precipitation in the northwestern part of the Yellow River basin and the most of the Pearl River basin was 20%-50% less than normal. Rainfall in 2021 generally took on the following three characteristics:

The spatial distribution of precipitation was uneven, showing a pattern of “more in the north and less in the south”. In 2021, the annual average precipitation in the western and southern part of Northeast China, most of North China, most of area between the Yellow River and the Huaihe River, and the southeastern part of Northwest China was 30%-100% more than normal, while precipitation in the eastern and southwestern parts of South China and the northwestern part of Yunnan Province was 30%-60% less than normal. Average annual precipitation in the northern provinces/municipalities of Beijing, Tianjin, Hebei, Henan, Shaanxi, and Shanxi topped the records since 1961, when complete sequence data became available.

Summer and autumn were notably wetter than normal, and the autumn rainy season lasted long. Judging from the monthly precipitation nationwide, precipitation from July to November was 3%, 14%, 28%, 44%, and 18% more than their respective normals. The other months were largely drier than normal, with January and December receiving 54% and 33% less precipitation than normal. Rainy weather in autumn started in late August, significantly earlier than normal, and ended in early October. The accumulated precipitation in Jialing River (a tributary to the upper reach of the Yangtze), the upper reach of the Hanjiang River, the middle and lower reaches of the Yellow River, the Zhanghe-Weihe River System of the Haihe River Basin, and the upper reach of the Shaying tributary of the Huaihe River were 1.5 to 3 times more than normal over the same period, all topping their records since complete sequence data were available in 1961.

北方降水过程集中，局地暴雨频发多发。6—9 月，全国发生 26 次强降雨过程，其中涉及北方 16 次，占比 62%。局地暴雨频发多发的特征明显，河南、河北、湖北、新疆等省（自治区）局部降水量打破历史极值。河南省 7 月 17—23 日降雨过程为 2021 年最强降雨过程，全省有 21 个降雨监测站日降水量突破有气象记录以来历史极值，7 月 20 日 16—17 时郑州站降水量 201.9 毫米，超过我国大陆极值（198.5 毫米，1975 年 8 月 5 日河南林庄站）；8 月 11—12 日，湖北襄阳、随州 18 小时降水量 200 ~ 495 毫米，宜城 24 小时降水量 305.9 毫米，突破当地有气象记录以来历史极值。

1.2 水情

1.2.1 江河径流量

据水利部信息中心统计，2021 年，全国主要江河径流量较常年总体偏多，其中长江偏多 1 成，黄河中下游偏多 2 ~ 4 成，淮河及沂河偏多 3 ~ 5 成，海河流域滦河、北三河系、漳卫河系偏多 7 成至 1.6 倍，松花江偏多近 9 成。长江流域鄱阳湖水系赣江、洞庭湖水系湘江偏少 1 ~ 3 成，海河流域拒马河、滹沱河偏少 2 ~ 9 成，珠江流域西江、东江、北江偏少 3 ~ 6 成。

注：松花江、辽河、海河、黄河流域径流量统计时段划分：汛前（1—5 月）、汛期（6—9 月）、汛后（10—12 月）；淮河、长江、珠江及钱塘江、闽江流域径流量统计时段划分：汛前（1—4 月）、汛期（5—9 月）、汛后（10—12 月）；太湖暂不做径流量统计。

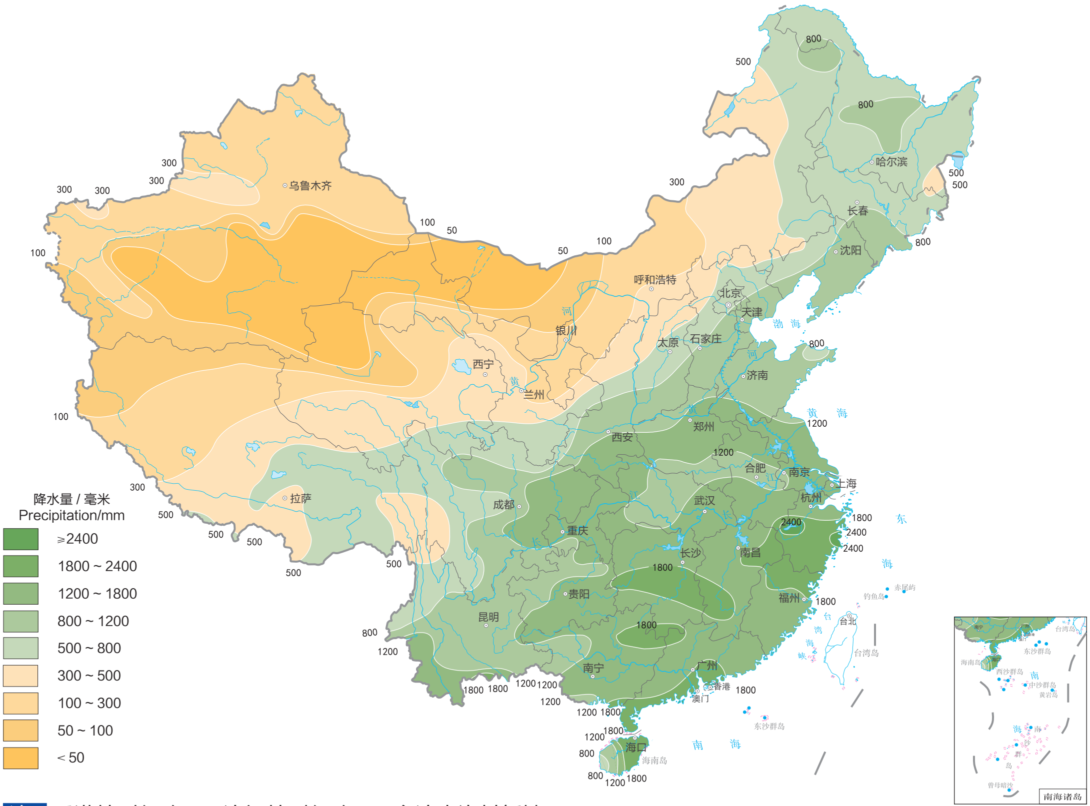
Rainfall processes skewed toward the north, with local extreme rainstorms occurring frequently. From June to September, of the 26 heavy rainfall processes that occurred across the country, 16 happened in the north, accounting for 62%. In addition, the pattern of frequent localized rainstorms was obvious, with the local precipitation in Henan, Hebei, Hubei, and Xinjiang provinces/autonomous regions breaking historical highs. The rainfall process during July 17-23 in Henan Province was the strongest rainfall process in 2021. Daily rainfall at 21 rainfall monitoring stations in the province exceeded the historical extremes since there were meteorological records. The rainfall at Zhengzhou Station was 201.9 mm during 16:00-17:00 on July 20, breaking the maximum hourly rainfall record in mainland China (198.5 mm, Linzhuang Station in Henan Province, on August 5, 1975); During August 11-12, Xiangyang city and Suizhou city in Hubei Province had an 18-hour rainfall of 200-495 mm and Yicheng had a 24-hour rainfall of 305.9 mm, all making new historical highs since there were local meteorological records.

1.2 Water Regime

1.2.1 River discharge

According to statistics from the MWR Water Resources Information Center, discharges in China's major rivers in 2021 were largely more than normal. In particular, discharge in the Yangtze River was 10% more, in the middle and lower reaches of the Yellow River 20%-40% more, and in the Huaihe and the Yihe Rivers 30%-50% more. The Luanhe River, the Beisan River System, and Zhanghe-Weihe River System in the Haihe basin had 70%-160% more discharge than normal, and the Songhua River had nearly 90% more. Discharges in the Ganjiang River, which drains to the Poyang Lake System, and the Xiangjiang River, which drains to the Dongting Lake System, both in the Yangtze River basin, were 10%-30% less; discharges in the Juma River and the Hutuo River in the Haihe basin were 20%-90% less; and discharges in the Xijiang River, the Dongjiang River and the Beijiang River in the Pearl basin were 30%-60% less than normal.

Note: For statistics of river discharges in the Songhua, the Liaohe, the Haihe, and the Yellow River basins: pre-flood period (January-May), flood period (June-September), post-flood period (October-December); for statistics of river discharges in the Huaihe, the Yangtze, the Pearl, the Qiantang, and the Minjiang River basin: pre-flood period (January-April), flood period (May-September), post-flood period (October-December); No statistics of discharges in the Taihu Lake are prepared.

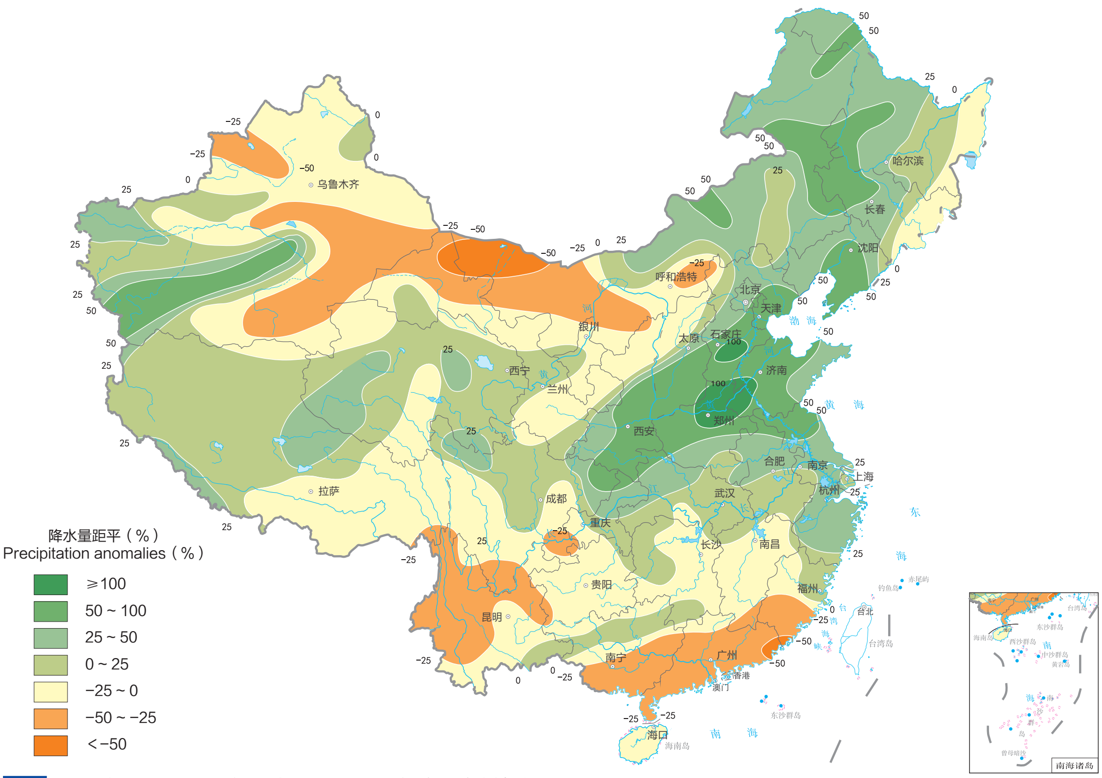


注： 香港特别行政区、澳门特别行政区、台湾省资料暂缺。

Note: Data of HongKong SAR, Macao SAR and Taiwan are currently unavailable.

图 1–1　2021 年全国降水量等值线图

Figure 1–1　Isogram of national precipitation in 2021

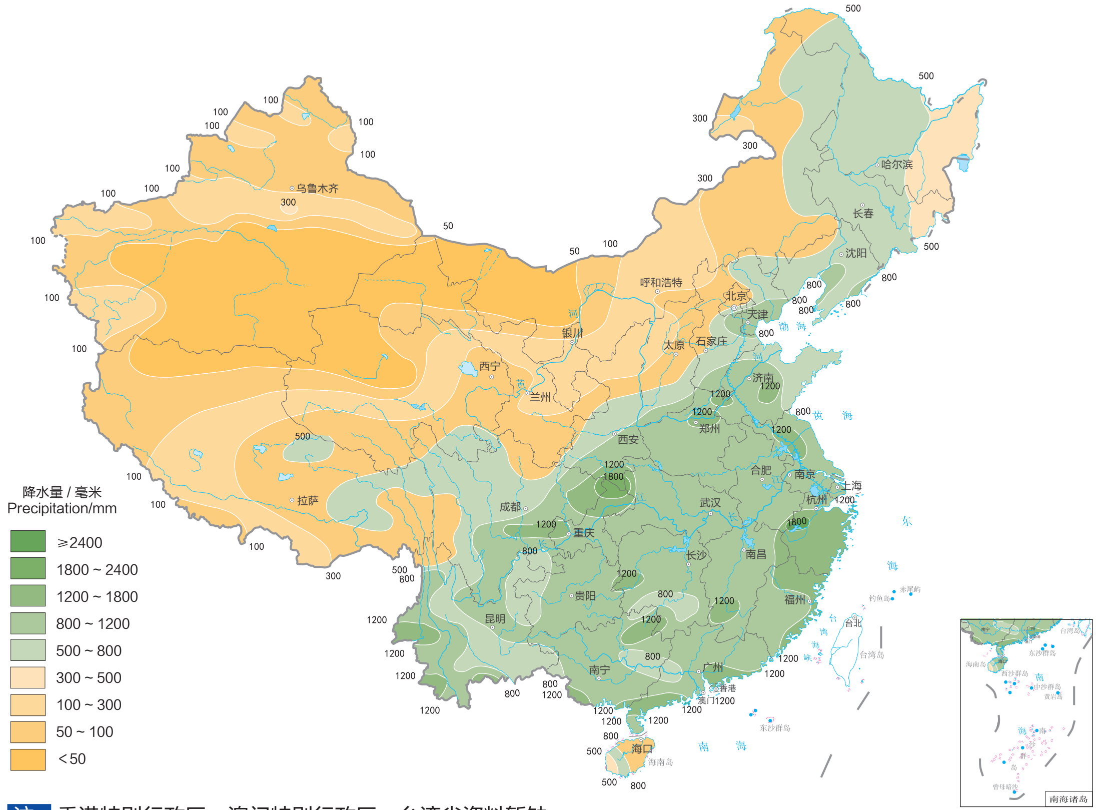


注： 香港特别行政区、澳门特别行政区、台湾省资料暂缺。

Note: Data of HongKong SAR, Macao SAR and Taiwan are currently unavailable.

图 1–2　2021 年全国降水量距平图

Figure 1–2　National precipitation anomalies in 2021

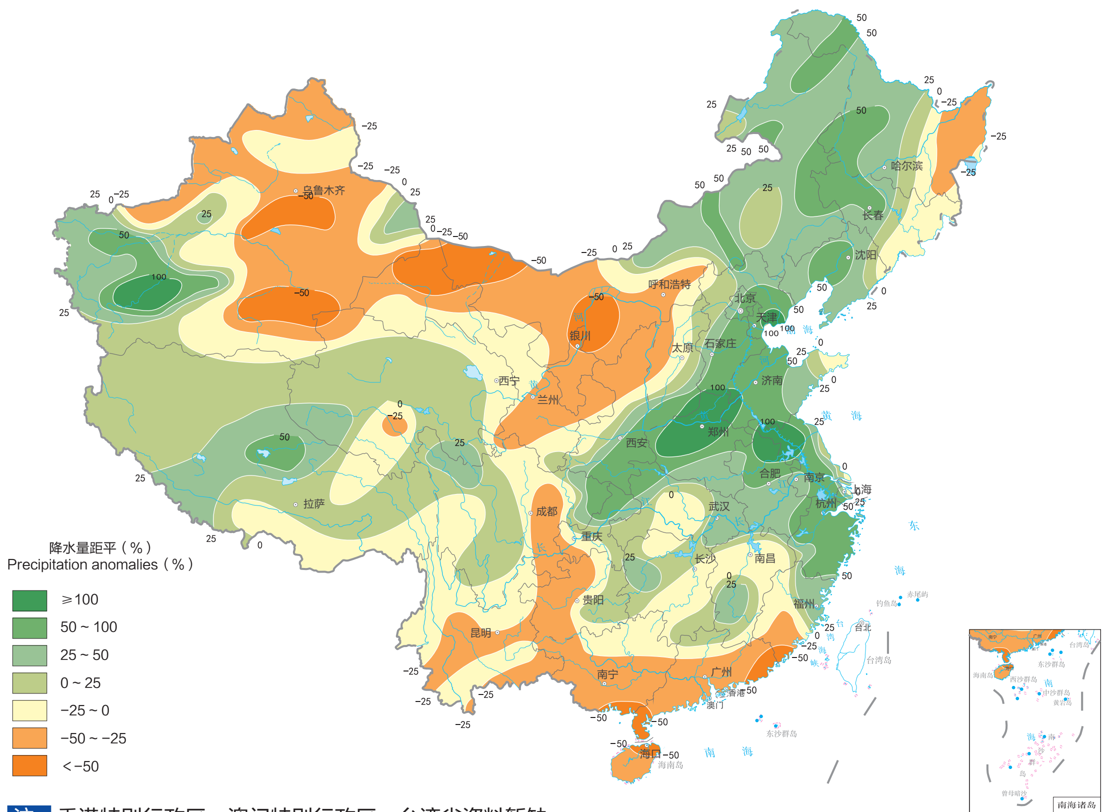


注： 香港特别行政区、澳门特别行政区、台湾省资料暂缺。

Note: Data of HongKong SAR, Macao SAR and Taiwan are currently unavailable.

图 1–3　2021 年 5—9 月全国降水量等值线图

Figure 1–3　Isogram of precipitation from May to September 2021



注： 香港特别行政区、澳门特别行政区、台湾省资料暂缺。

Note: Data of HongKong SAR, Macao SAR and Taiwan are currently unavailable.

图 1–4　2021 年 5—9 月全国降水量距平图

Figure 1–4　Precipitation anomalies from May to September 2021

汛前，长江上中游偏多 1 ~ 2 成，黄河偏多 3 ~ 6 成，淮河及沂河偏多 3 成至 1.2 倍，珠江流域西江偏多近 1 成，松花江及辽河偏多 4 ~ 5 成；长江流域鄱阳湖水系赣江、洞庭湖水系湘江偏少 3 ~ 6 成，海河流域拒马河、漳河、滹沱河、滦河偏少 4 ~ 9 成，珠江流域东江、北江偏少 4 ~ 7 成。

汛期，长江中下游偏多 1 成，黄河下游偏多近 2 成，淮河及沂河偏多 2 ~ 3 成，海河流域滦河、北三河系、漳卫河系偏多 7 成至 1.8 倍，松花江偏多 1 倍；长江流域鄱阳湖水系偏少 2 成，黄河上中游偏少 2 ~ 4 成，海河流域拒马河、滹沱河偏少 2 ~ 9 成，珠江流域西江、东江、北江偏少 4 ~ 8 成，辽河偏少 2 成。

汛后，长江及洞庭湖水系湘江偏多 2 ~ 3 成，黄河中下游偏多 7 成至 1.1 倍，沂河偏多 1.8 倍，海河流域拒马河、漳河、滹沱河、卫运河、白河、潮河、滦河偏多 7 成至 6.2 倍，松花江及辽河偏多 9 成至 2.3 倍；长江流域鄱阳湖水系赣江偏少 3 成，淮河偏少 1 成，珠江流域西江、东江、北江偏少 2 ~ 6 成。

1.2.2 水库蓄水

据水利部信息中心统计，6 月 1 日，全国纳入日常统计范围的 6920 座水库蓄水量 3799.1 亿立方米，较 1 月 1 日减少 19%，较常年同期偏多 13%。其中，709 座大型水库蓄水量 3338.0 亿立方米，较 1 月 1 日减少 21%，较常年同期偏多 13%；2980 座中型水库蓄水量 394.6 亿立方米，较 1 月 1 日减少 2%，较常年同期偏多 11%。

10 月 1 日，全国纳入日常统计范围的 6920 座水库蓄水量 4653.8 亿立方米，较 6 月 1 日增加 22%，较常年同期偏多 9%。其中，709 座大型水库蓄水量 4208.1 亿立方米，较 6 月 1 日增加 26%，较常年同期偏多 10%；2980 座中型水库蓄水量 406.2 亿立方米，较 6 月 1 日增加 3%，较常年同期偏多 6%。

年末（2022 年 1 月 1 日统计），全国纳入日常统计范围的 6920 座水库蓄水量 4644.0 亿立方米，较 1 月 1 日减少 1%，与 10 月 1 日基本持平，较常年同期偏多 13%。其中，709 座大型水库蓄水量 4202.8 亿立方米，与 1 月 1 日、10 月 1 日均基本持平，较常年同期偏多 13%；2980 座中型水库蓄水量 403.2 亿立方米，与 1 月 1 日、10 月 1 日均基本持平，较常年同期偏多 13%。

Before the flood season, the discharges in the upper and middle reaches of the Yangtze were 10%-20% more, the Yellow River 30%-60% more, the Huaihe and the Yihe 30%-120% more, the Xijiang River in the Pearl basin nearly 10% more, and the Songhua and the Liaohe 40%-50% more. Discharges in the Ganjiang River, which drains to the Poyang Lake System, and the Xiangjiang River, which drains to the Dongting Lake System, both in the Yangtze River basin, were 30%-60% less, the Juma, the Zhanghe, the Hutuo and the Luanhe in the Haihe basin 40%-90% less, and the Dongjiang and the Beijiang in the Pearl basin 40%-70% less.

During the flood season, discharges in the middle and lower reaches of the Yangtze were 10% more, the lower reach of the Yellow River 20% more, the Huaihe and the Yihe 20%-30% more, the Luanhe River, Beisan River System and Zhanghe-Weihe River System in the Haihe basin 70%-180% more, and the Songhua 100% more. Discharges in the Poyang Lake System in the Yangtze basin were 20% less, the upper and middle reaches of the Yellow River 20%-40% less, and the Juma and the Hutuo in the Haihe basin 20%-90% less. Discharges in the Xijiang, the Dongjiang and the Beijiang in the Pearl basin were 40%-80% less, and the Liaohe 20% less.

After the flood season, discharges in the Yangtze River and the Xiangjiang River, the latter of which drains to the Dongting Lake System, were 20%-30% more, the middle and lower reaches of the Yellow River 70%-110% more, the Yihe 180% more, the Juma, the Zhanghe, the Hutuo, the Wei Canal, the Baihe, the Chaohe and the Luanhe in the Haihe basin 70%-620% more, and the Songhua and the Liaohe 90%-230% more. Discharge in the Ganjiang, which drains to the Poyang Lake System in the Yangtze basin, was 30% less, the Huaihe 10% less, and the Xijiang, the Dongjiang and the Beijiang in the Pearl basin 20%-60% less.

1.2.2 Reservoir storage

According to statistics from the MWR Water Resources Information Center, on June 1, the 6,920 reservoirs that report daily statistics in China had a total storage of 379.91 billion m^3, 19% less than that on January 1 and 13% higher than normal over the same period. Among them, the 709 large reservoirs had a total storage of 333.8 billion m^3, 21% less than that on January 1 and 13% higher than normal over the same period; the 2,980 medium-sized reservoirs had a total storage of 39.46 billion m^3, 2% less that that on January 1 and 11%

higher than normal over the same period.

On October 1, the total storage of the 6,920 reservoirs that report daily statistics was 465.38 billion m^3, 22% more than that on June 1 and 9% more than normal over the same period. Among them, the 709 large reservoirs had a total storage of 420.81 billion m^3, 26% more than that on June 1 and 10% more than normal over the same period; the 2,980 medium-sized reservoirs had a total storage of 40.62 billion m^3, 3% more than that on June 1 and 6% more than normal over the same period.

At the end of the year (data as of January 1, 2022), the total storage of the 6,920 reservoirs that report daily statistics was 464.4 billion m^3, 1% less than that on January 1, almost the same as that on October 1, and 13% higher than normal over the same period. Among them, the 709 large reservoirs had a total storage of 420.28 billion m^3, almost the same as those on January 1 and on October 1, and 13% higher than normal over the same period; the 2,980 medium-sized reservoirs had a total storage of 40.32 billion m^3, almost the same as those on January 1 and on October 1, and 13% higher than normal over the same period.

表 1–1　2021 年全国 6920 座水库蓄水情况

Table 1–1　Water storage of 6,920 reservoirs nationwide in China in 2021

时间 Date	6920 座水库蓄水量 / 亿立方米 Storage in 6,920 reservoirs/100 million m^3			
	709 座大型水库 709 large reservoirs	2980 座中型水库 2,980 medium–sized reservoirs	3231 座小型水库 3,231 small reservoirs	合计 Total
1 月 1 日 January 1	4237.0	403.4	50.7	4691.1
6 月 1 日 June 1	3338.0	394.6	66.5	3799.1
10 月 1 日 October 1	4208.1	406.2	39.5	4653.8
年末 Year–end	4202.8	403.2	38.0	4644.0

注：年末数据指 2022 年 1 月 1 日统计数据。

Note: Year–end data as of January 1, 2022.

2 洪涝灾害防御

FLOOD DISASTER PREVENTION

2.1　汛情

2021 年，全国共有 571 条河流发生超警戒洪水，其中 148 条河流发生超保证洪水、43 条河流发生超历史实测记录洪水。长江流域（片）有 235 条河流发生超警戒洪水，其中渠江、嘉陵江支流白溪浩河等 61 条河流发生超保证洪水，汉江支流池河、白河等 7 条河流发生超历史实测记录洪水；黄河流域（片）有 41 条河流发生超警戒洪水，其中伊洛河、新疆塔里木河等 11 条河流发生超保证洪水，渭河、洛河等 5 条河流部分测站发生超历史实测记录洪水；淮河流域（片）有 40 条河流发生超警戒洪水，其中 3 条河流发生超保证洪水，沙颍河支流贾鲁河、骆马湖水系中运河、洪泽湖水系濉河 3 条河流发生超历史实测记录洪水；海河流域（片）有 17 条河流发生超警戒洪水，其中 6 条河流发生超保证洪水，卫河、共产主义渠等 7 条河流发生超历史实测记录洪水；珠江流域（片）有 85 条河流发生超警戒洪水，南盘江支流泸江发生超保证洪水；松辽流域（片）有 45 条河流发生超警戒洪水，其中嫩江支流甘河、额尔古纳河支流激流河等 19 条河流发生超保证洪水，呼玛河、科洛河等 8 条河流发生超历史实测记录洪水；太湖流域（片）有 108 条河流发生超警戒洪水，其中黄浦江、苕溪等 47 条河流发生超保证洪水，姚江、浦阳江等 13 条河流发生超历史实测记录洪水。

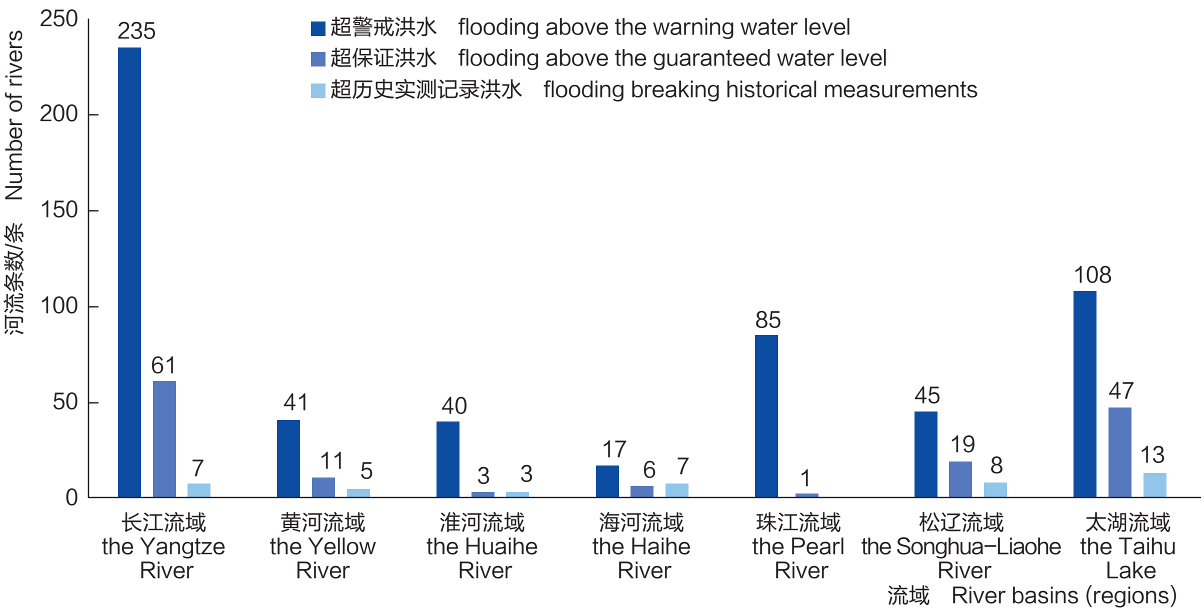


图 2-1　2021 年各流域（片）发生超警戒、超保证、超历史实测记录洪水河流条数统计

Figure 2-1　Number of rivers experiencing floods above the warning water level, above the guaranteed water level, and breaking historical measurements in the major river basins in 2021

注：全国汛情及各流域（片）数据来源于水利部信息中心。

Note: Data on floods nationwide and by different water basins/regions are from the Water Resources Information Center, MWR.

2.1 Floods

In 2021, 571 rivers swelled above the warning water level, 148 rivers experienced flooding above the guaranteed water level, and 43 rivers experienced flooding breaking historical measurements. In the Yangtze River basin (region), 235 rivers had floods above the warning water level. In particular, 61 rivers including the Qujiang River and the Baixihao tributary of the Jialing River had floods above the guaranteed water level, and 7 rivers including the Chihe tributary and the Baihe tributary of the Hanjiang River had floods breaking historical measurements. In the Yellow River basin, 41 rivers had floods above the warning water level. In particular, 11 rivers such as the Yiluo River and the Tarim River in Xinjiang had floods above the guaranteed water level, and flooding recorded at some stations along five rivers, including the Weihe River and Luohe River, broke historical measurements. In the Huaihe River basin, 40 rivers had floods above the warning water level. In particular, 3 rivers had floods above the guaranteed water level, and the Jialu tributary of the Shaying River, the Middle Canal in the Luoma Lake System, and the Suihe River in the Hongze Lake System had floods breaking historical measurements. In the Haihe River basin, 17 rivers had floods above the warning water level. In particular, 6 rivers had floods above the guaranteed water level, and floods breaking historical measurements occurred in 7 rivers, including the Weihe River and the Communist Canal. In the Pearl River basin, 85 rivers had floods above the warning water level, and the Lujiang tributary of the Nanpan River had floods above the guaranteed water level. In the Songhua-Liaohe River basin, 45 rivers had floods above the warning water level. In particular, 19 rivers, including the Ganhe tributary of the Nenjiang River and the Jiliu tributary of the Argun River had floods above the guaranteed water level, and 8 rivers, including the Huma River and the Keluo River had floods breaking historical measurements. In the Taihu Lake basin, 108 rivers had floods above the warning water level. In particular, 47 rivers such as the Huangpu River and the Tiaoxi River had floods above the guaranteed water level, and 13 rivers such as the Yaojiang River and the Puyang River had floods breaking historical measurements.

2021 年全国主要江河湖泊共发生 12 次编号洪水。

长江流域：9 月 6 日 14 时，三峡水库入库流量 54000 立方米每秒，形成长江 2021 年第 1 号洪水。

黄河流域：9 月 27 日 15 时，黄河潼关站流量 5020 立方米每秒，形成黄河 2021 年第 1 号洪水；9 月 27 日 21 时，黄河花园口站流量 4020 立方米每秒，形成黄河 2021 年第 2 号洪水；10 月 5 日 23 时，黄河潼关站流量 5090 立方米每秒，形成黄河 2021 年第 3 号洪水。

海河流域：7 月 13 日 14 时，滦河潘家口水库入库流量 2390 立方米每秒，形成滦河 2021 年第 1 号洪水；7 月 22 日 6 时，漳河岳城水库入库流量 2640 立方米每秒，形成漳卫河 2021 年第 1 号洪水；10 月 7 日 11 时，漳河岳城水库入库流量 2010 立方米每秒，形成漳卫河 2021 年第 2 号洪水。

松辽流域：6 月 21 日 14 时，嫩江尼尔基水库入库流量 4160 立方米每秒，形成嫩江 2021 年第 1 号洪水；7 月 18 日 8 时，尼尔基水库入库流量 4110 立方米每秒，形成嫩江 2021 年第 2 号洪水；7 月 31 日 14 时，尼尔基水库入库流量 3560 立方米每秒，形成嫩江 2021 年第 3 号洪水；8 月 21 日 2 时，松花江干流

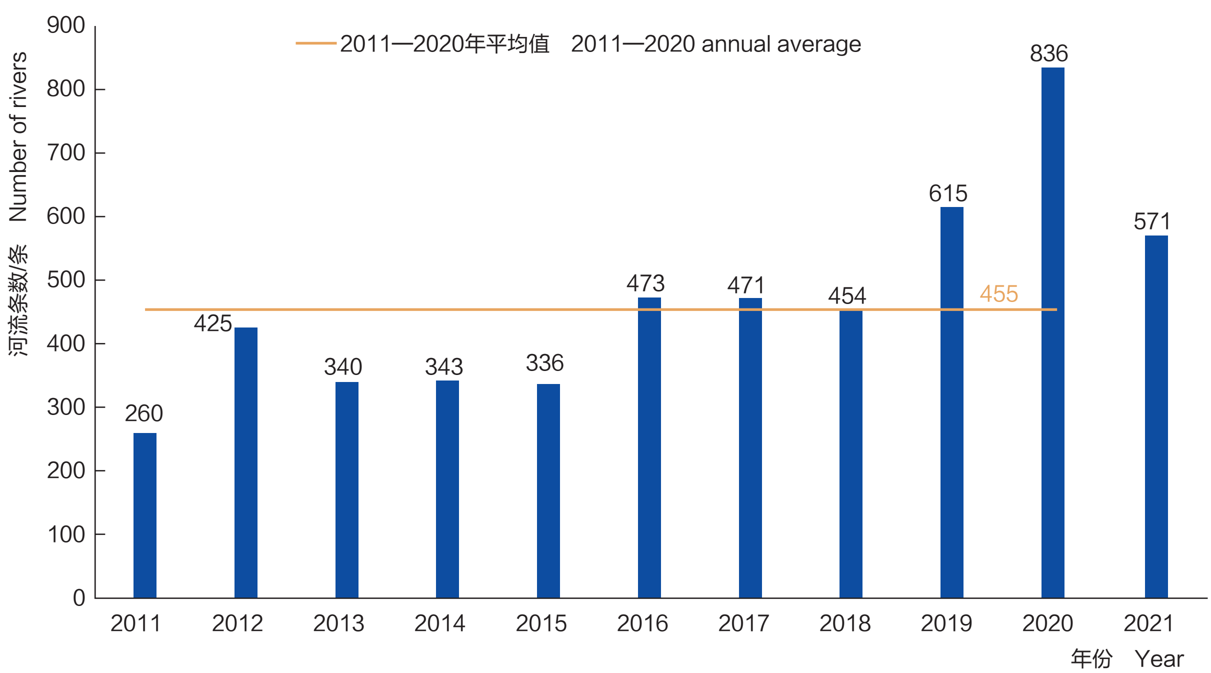


图 2-2　2011—2021 年全国发生超警戒洪水河流条数统计

Figure 2-2　Number of rivers experiencing floods above the warning water level in China 2011—2021

In 2021, there were 12 numbered floods in major rivers and lakes across the country.

Yangtze River basin: At 14:00 on September 6, the inflow to the Three Gorges Reservoir was 54,000 m^3/s, forming the 2021 No.1 flood in the Yangtze River.

Yellow River basin: At 15:00 on September 27, the flow at Tongguan Station on the Yellow River was 5,020 m^3/s, forming the 2021 No.1 flood in the Yellow River. At 21:00 on September 27, the flow at Huayuankou Station on the Yellow River was 4,020 m^3/s, forming the 2021 No. 2 flood in the Yellow River. At 23:00 on October 5, the flow at Tongguan Station on the Yellow River was 5,090 m^3/s, forming the 2021 No. 3 flood in the Yellow River.

Haihe River basin: At 14:00 on July 13, the inflow to Panjiakou Reservoir on Luanhe River was 2,390 m^3/s, forming the 2021 No.1 flood in the Luanhe River. At 6:00 on July 22, the inflow to Yuecheng Reservoir on Zhanghe River was 2,640 m^3/s, forming the 2021 No.1 flood in the Zhanghe-Weihe River. At 11:00 on October 7, the inflow to Yuecheng Reservoir on Zhanghe River was 2,010 m^3/s, forming the 2021 No.2 flood in the Zhanghe-Weihe River.

Songhua-Liaohe River basin: At 14:00 on June 21, the inflow to Nierji Reservoir on Nenjiang River was 4,160 m^3/s, forming the 2021 No.1 flood in Nenjiang River. At 8:00 on July 18, the inflow to Nierji Reservoir was 4,110 m^3/s, forming the 2021 No.2 flood in Nenjiang River. At 14:00 on July 31, the inflow to Nierji Reservoir was 3,560 m^3/s, forming the 2021 No.3 flood in Nenjiang River. At 2:00 on August 21, the water level at Harbin Station on

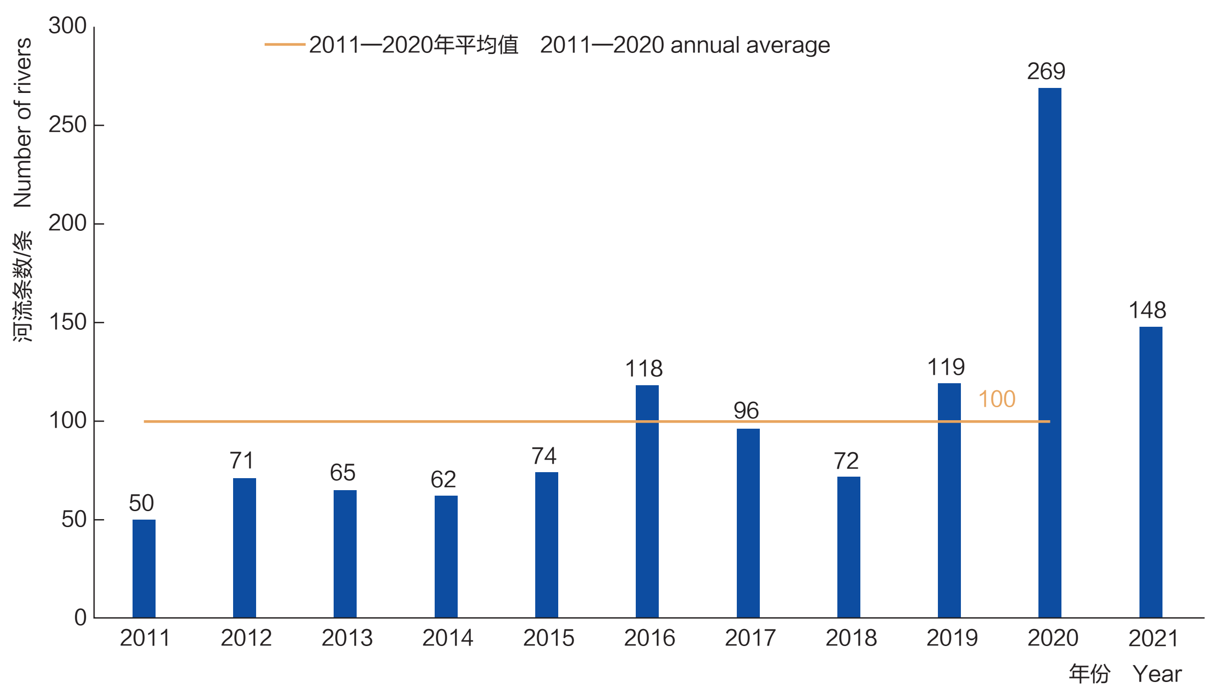


图 2-3 2011—2021 年全国发生超保证洪水河流条数统计

Figure 2-3 Number of rivers experiencing floods above the guaranteed water level in China 2011—2021

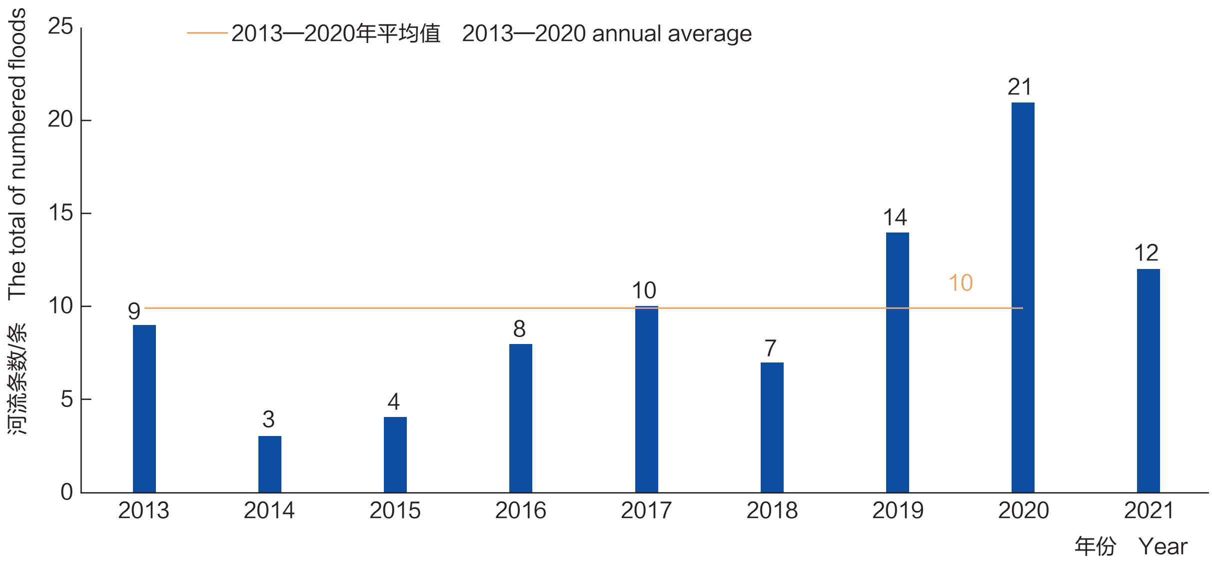


图 2-4　2013—2021 年全国主要江河湖泊发生编号洪水次数统计

Figure 2-4　Statistics of numbered floods in major rivers and lakes in China 2013—2021

哈尔滨站水位 118.30 米，与警戒水位持平，形成松花江干流 2021 年第 1 号洪水。

太湖流域：7 月 27 日 23 时，太湖水位超过警戒水位（3.80 米），形成太湖 2021 年第 1 号洪水。

2021 年，全国汛情总体有 3 个特点。

北方河流洪水量级大、超警戒持续时间长。2021 年主要江河湖泊 12 次编号洪水中有 10 次发生在北方河流，其中黄河 3 次，海河流域漳卫河 2 次、滦河 1 次，松花江流域嫩江 3 次、松花江 1 次。黄河流域、淮河流域、海河流域、松花江流域的 23 条河流发生超历史实测记录洪水，黑龙江上游发生特大洪水，海河流域卫河上游发生特大洪水，松花江发生流域性较大洪水。东北地区 6 月即发生汛情，黑龙江、嫩江、松花江干流超警戒时间分别长达 104 天、53 天和 50 天。

洪水范围广、区域性洪水时空集中。发生超警戒洪水的 571 条河流分布在除西藏、青海、宁夏外的 28 省（自治区、直辖市）。7 月 17—23 日，海河流域漳卫河、子牙河，黄河中游伊洛河、沁河，淮河支流沙颍河等流域遭遇特大暴雨袭击；海河流域卫河、共产主义渠，黄河流域洛河，淮河流域贾鲁河等 8 条河流发生超历史实测记录洪水。

秋汛并发重发，历史罕见。从 8 月下旬起，全国连续发生多次强降雨过程，秋季阴雨持续 47 天，主雨区除覆盖汉江、嘉陵江、渭河等传统华西秋雨区外，罕见扩大至黄河支流汾河、伊洛河、沁河、大汶河和海河漳卫河等流域。黄河中下游发生 1949 年以来最大秋季洪水，支流汾河、北洛河、伊洛河分别

the main-stem Songhua River reached the warning water level at 118.30 m, forming the 2021 No. 1 flood in the main-stem Songhua River.

Taihu Lake basin: At 23: 00 on July 27, the Taihu Lake rose beyond the warning water level (3.80 m), forming the 2021 No.1 flood in the Taihu Lake.

In 2021, floods in China generally took on the following three characteristics:

Rivers in the north had large floods that hovered above the warning water level for long periods. In 2021, 10 of the 12 numbered floods in major rivers and lakes occurred in the northern waters, including three in the Yellow River, two in the Zhanghe-Weihe River and one in the Luanhe River (both in the Haihe River basin), and three in the Nenjiang River and one in the Songhua River (both in the Songhua-Liaohe River basin). All together 23 rivers in the Yellow River basin, Huaihe River basin, Haihe River basin, and Songhua River basin experienced floods breaking historical measurements. Very large floods occurred in the upper reach of the Heilong River and the upper reach of the Weihe River in the Haihe River basin, and large floods basin-wide occurred in the Songhua River. Flooding occurred in Northeast China as early as in June, and flooding above the warning water level in the main-stems of the Heilong, the Nenjiang and the Songhua lasted for 104 days, 53 days and 50 days, respectively.

Flooding was extensive and certain river systems were battered with regional flooding repetitively in a short period of time. The 571 rivers with flooding above the warning water level flow along 28 provinces/autonomous regions/municipalities (exclusive of Tibet, Qinghai and Ningxia). During July 17-23, the Zhanghe-Weihe River and Ziya River in the Haihe basin, the Yiluo River and Qinhe River in the middle reach of the Yellow River, and the Shaying tributary of the Huaihe River were hit by extreme rainstorms. Eight rivers, including Weihe River and Communist Canal in the Haihe basin, Luohe River in the Yellow River basin, and Jialu River in the Huaihe basin, withstood record-breaking floodwater.

Severe autumn floods occurred concurrently, which was rare in history. Since late August, a stream of heavy rainfall processes occurred across China. The autumn rainy season lasted for 47 days. In addition to the traditional autumn rain areas in West China, including the Hanjiang River, Jialing River and Weihe River, the main rain area quite unusually expanded

发生 1964 年、1999 年、1982 年以来最大洪水。汉江发生重现期超 20 年大洪水，丹江口水库连续发生 7 次入库洪峰流量超过 10000 立方米每秒的较大洪水过程，累计入库水量列建库以来历史同期第 1 位；支流白河发生超历史实测记录特大洪水。海河流域漳卫河系发生历史罕见秋汛，漳河、卫河分别发生 1952 年、1951 年有实测资料以来同期最大洪水。

2.2 主要洪水过程

主要江河发生 7 次影响较大的洪水过程（按时间顺序）。

2.2.1 7 月中下旬嫩江第 2 号洪水

7 月 12—19 日，嫩江流域降中到大雨，局地暴雨到大暴雨，流域面雨量 74.3 毫米，其中尼尔基水库以上流域 106.5 毫米、嫩江中游 103.8 毫米、嫩江下游 32.1 毫米。特别是 7 月 17—18 日，嫩江上中游局地降暴雨到大暴雨，主雨区位于嫩江干流尼尔基水库和支流诺敏河，局部面雨量超过 100 毫米。受强降雨影响，7 月 18 日 8 时尼尔基水库入库流量 4110 立方米每秒，为嫩江 2021 年第 2 号洪水，14 时入库洪峰流量 4520 立方米每秒，重现期超 5 年；嫩江 10 条支流发生超警戒洪水，诺敏河支流西瓦尔图河上的永安水库（小（1）型）、新发水库（中型）发生溃坝，诺敏河古城子（二）站发生重现期超 50 年的特大洪水。

嫩江第 2 号洪水期间，齐齐哈尔市齐梅公路路面淹没（7 月 20 日）
The inundated Qiqihar-Meilisi Highway in Qiqihar City during the No. 2 flood in the Nenjiang River (July 20)

to some tributaries of the Yellow River, including Fenhe River, Yiluo River, Qinhe River and Dawen River, as well as the Zhanghe-Weihe River in the Haihe River basin. The middle and lower reaches of the Yellow River experienced the largest autumn flood since 1949, and its three tributaries–the Fenhe, the Beiluo and the Yiluo–experienced the largest floods since 1964, 1999, and 1982, respectively. The Hanjiang River experienced flooding that exceeded a 20-year flood. The Danjiangkou Reservoir withstood 7 consecutive large flooding processes with a peak flow exceeding 10,000 m^3/s; the cumulative inflow over the same period made new record since the reservoir was constructed. The Baihe, a tributary of the Hanjiang, had flooding breaking historical measurements. The Zhanghe-Weihe River System in the Haihe River basin had a rare autumn flood, with the Zhanghe and the Weihe experiencing their largest floods over the same period since measured data were available in 1952 and 1951, respectively.

2.2 Major Flood Processes

Below is the account (in chronological order) of the seven big flood processes in major rivers.

2.2.1 No. 2 flood in the Nenjiang during the mid-to-late July

During July 12-19, moderate to heavy rain fell across the Nenjiang River Basin, and some areas were hit by rainstorms or even extreme rainstorms. The average rainfall over the whole basin was 74.3 mm, over the basin upstream the Nierji Reservoir 106.5 mm, in the middle reach of the Nenjiang 103.8 mm, and in the lower reach of the Nenjiang 32.1 mm. Especially during July 17-18, the upper and middle reaches of the Nenjiang were lashed with localized rainstorms and/or extreme rainstorms, the main rain area hovered over the Nierji Reservoir on the Nenjiang main-stem and the Nuomin tributary, and the average rainfall over some parts of the basin exceeded 100 mm. Affected by heavy rainfall, Nierji Reservoir received a flow of 4,110 m^3/s at 8:00 on July 18, marking the 2021 No. 2 flood in Nenjiang River. The flood peak discharge was 4,520 m^3/s at 14:00, with a return period exceeding 5 years. Ten tributaries of the Nenjiang River experienced floods above the warning water level, the Yong'an Reservoir (small (1) type) and Xinfa Reservoir (medium type) on the Xivaltu River, a tributary to the Nuomin River, suffered dam breaks, and extreme floods with a return period of more than 50 years occurred at Guchengzi (II) Station on the Nuomin River.

2.2.2 7 月中下旬河南、河北等地特大暴雨洪水

7 月 17—23 日，受西太平洋副热带高压异常偏北、夏季风偏强以及低涡及低空急流影响，河南、河北等地降大到暴雨，其中河南郑州、新乡、鹤壁、安阳、焦作和河北邯郸、邢台、石家庄、保定等地降大暴雨到特大暴雨。淮河流域贾鲁河降水量 327 毫米，其中中牟站以上 496 毫米、扶沟闸站以上 361 毫米。郑州市累计降水量 400 毫米以上笼罩面积为 5590 平方公里，600 毫米以上笼罩面积 2068 平方公里，降雨折合水量近 40 亿立方米，为郑州市有气象观测记录以来范围最广、强度最大的暴雨过程。郑州市最大日降水量为郑州站 624.1 毫米（7 月 20 日），接近年平均降水量（640.8 毫米），为建站以来最大值（189.4 毫米，1978 年 7 月 2 日）的 3.3 倍；最大 1 小时降水量为郑州站 201.9 毫米（7 月 20 日 16—17 时），突破我国大陆气象观测记录历史极值（198.5 毫米，1975 年 8 月 5 日河南林庄站）。海河流域漳卫河系 227 毫米、子牙河系 114 毫米、大清河系 90 毫米、北三河系 35 毫米，过程累计最大点降水量河南新乡辉县龙水梯站 1159 毫米。

受强降雨影响，淮河流域洪汝河支流洪河、沙颍河及其支流贾鲁河、涡河支流惠济河等河流发生超警戒洪水，其中贾鲁河中牟站 7 月 21 日洪峰水位

漳卫河发生 2021 年第 1 号洪水（岳城水库上游观台水文站 7 月 22 日）
The 2021 No.1 flood in the Zhanghe-Weihe River (July 22, Guantai Hydrologic Station, upstream of the Yuecheng Reservoir)

2.2.2 Extreme rainstorms and floods in Henan and Hebei provinces during the mid-to-late July.

During July 17-23, affected by the unusually northern-bound subtropical high in the western Pacific, the stronger-than-average summer monsoon, the low vortex and the low-altitude jet stream, Henan and Hebei provinces were battered with heavy rain to rainstorms. Cities in Henan Province, including Zhengzhou, Xinxiang, Hebi, Anyang and Jiaozuo, and cities in Hebei Province, including Handan, Xingtai, Shijiazhuang and Baoding, withstood heavy to extreme rainstorms. Precipitation in the Jialu watershed (in the Huaihe River basin) was 327 mm, and was 496 mm upstream the Zhongmu Station and 361 mm upstream the Fugouzha Station. The area in Zhengzhou with cumulative precipitation of more than 400 mm reached 5,590 km^2, and that with more than 600 mm of cumulative precipitation was 2,068 km^2. The downpours brought an equivalent of 4 billion m^3 of water, making the most extensive and the strongest rainstorm process in Zhengzhou in its meteorological records. The maximum one-day precipitation in Zhengzhou was 624.1 mm (July 20) at Zhengzhou Station, close to the annual average precipitation (640.8 mm) and 3.3 times the maximum (189.4 mm, July 2, 1978) since the establishment of the station. The maximum one-hour precipitation was 201.9 mm (16:00-17:00 on July 20) at Zhengzhou Station, breaking the historical extreme value (198.5 mm, Linzhuang Station in Henan Province on August 5, 1975) in meteorological observation records in mainland China. In the Haihe River Basin, precipitation in the Zhanghe-Weihe River System was 227 mm, Ziya River System 114 mm, Daqing River System 90 mm, and Beisan River System 35 mm. The cumulative maximum station-based precipitation in the process was 1,159 mm at Longshuiti Station, Hui County, Xinxiang City, Henan Province.

Affected by heavy rainfall, floods above the warning water level occurred in rivers such as the Honghe River, a tributary of the Hongru River, the Shaying River and its tributary Jialu River, and Huiji River, a tributary to the Wohe River. Among them, the flood peak level at Zhongmu Station on Jialu River was 79.40 m on July 21, 1.71 m above the historical highest (77.69 m, November 4, 1960), and the flood peak discharge was 608 m^3/s, 2.6 times of the historical maximum peak discharge (232 m^3/s, 5:20 on August 2, 2019). A numbered flood occurred in the Zhanghe-Weihe River in the Haihe River Basin. The maximum flood peak inflow to the Yuecheng Reservoir on Zhanghe

79.40 米，超历史最高水位（77.69 米，1960 年 11 月 4 日）1.71 米，洪峰流量 608 立方米每秒，为历史最大洪峰流量（232 立方米每秒，2019 年 8 月 2 日 5 时 20 分）的 2.6 倍。海河流域漳卫河发生编号洪水，漳河岳城水库 7 月 22 日 9 时最大入库洪峰流量 4860 立方米每秒；卫河支流共产主义渠、大沙河、淇河、安阳河以及子牙河系滏阳河支流留垒河等河流发生超警戒洪水，最大超警戒水位幅度 0.30 ~ 3.93 米，其中卫河、共产主义渠、大沙河、淇河、安阳河 5 条河流发生超保证洪水，卫河、共产主义渠、大沙河、安阳河、留垒河等发生超历史实测记录洪水。

2.2.3 7 月下旬太湖第 1 号洪水

受 2106 号台风“烟花”影响，太湖流域 7 月 23—27 日 5 天累计降水量 224.5 毫米，仅次于 6214 号台风“艾美”的降水量，列有实测记录以来第 2 位。台风“烟花”登陆时恰逢天文大潮，在风、雨、潮、洪“四碰头”影响下，

River was 4,860 m^3/s at 9:00 on July 22; the Communist Canal, Dasha River, Qihe River and Anyang River, all tributaries to the Weihe River, and the Liulei River, a tributary to the Fuyang River in the Ziya River System had floods above the warning water level, with the maximum level 0.30-3.93 m higher than the warning water level. The Weihe River, Communist Canal, Dasha River, Qihe River, and Anyang River had floods above the guaranteed water level, while the Weihe River, Communist Canal, Dasha River, Anyang River and Liulei River had floods breaking historical measurements.

2.2.3 No.1 flood in the Taihu Lake in late July

Affected by Typhoon "In-Fa" (No. 2106), the cumulative precipitation in the Taihu Lake basin during the five days of July 23-27 was 224.5 mm, second only to the precipitation brought by Typhoon "Amy" (No. 6214) and ranked second in all historical measurements. Typhoon "In-Fa" landed at the time of an astronomical tide. Under the influence of wind, rain, tide and

太湖第 1 号洪水期间，上海青浦区朱家角古镇发生内涝（7 月 28 日）
During the No.1 flood in Taihu Lake, water logging occurred in Zhujiajiao Ancient Town, Qingpu District, Shanghai (July 28)

太湖水位 7 月 27 日 23 时超过警戒水位（3.80 米），为太湖 2021 年第 1 号洪水。8 月 3 日太湖水位涨至最高 4.21 米，7 月 23 日至 8 月 3 日累计涨幅 0.74 米，列有实测记录以来台风暴雨引起太湖水位涨幅的第 2 位。台风影响期间，太湖流域河网的河道、闸坝、潮位站水（潮）位单日最多超警戒站点 93 个，占设有警戒水位站点总数的 89%；超保证水（潮）位站点 49 个，占设有保证水位站点总数的 49%；33 站水（潮）位创有实测记录以来新高。台风过后，太湖流域遭遇类似“倒黄梅”的盛夏连阴雨过程，水位还未降至警戒水位又迅速回涨至 4.17 米，持续超警戒长达 40 天。

2.2.4 长江上游及汉江秋季洪水

8 月 21 日至 10 月 10 日，长江上游发生多次强降雨过程，降水量较常年同期偏多 3 成，其中嘉陵江流域面雨量 491 毫米，较常年同期偏多 1.4 倍，总降水量列 1961 年有完整序列资料以来同期第 1 位。受降雨影响，嘉陵江流域形成 2 次编号洪水；三峡水库共发生 5 次流量超过 40000 立方米每秒的入库洪水，其中 9 月 6 日 14 时入库流量 54000 立方米每秒，为长江 2021 年第 1 号洪水。

同期，汉江流域发生 9 次强降雨过程，降雨过程基本无间歇，雨区主要集中在汉江上游，尤其是汉江支流白河以上区域累计降水量 536 毫米，较常年同期偏多 1.7 倍，总降水量列 1961 年有完整序列资料以来同期第 1 位。其中，石

丹江口水库水位达到 170 米（10 月 10 日）
The Danjiangkou Reservoir rose to 170 m level (October 10)

flood, the water level in Taihu Lake exceeded the warning water level (3.80 m) at 23:00 on July 27 and formed the 2021 No. 1 Flood of Taihu Lake. The water level rose to a maximum of 4.21 m on August 3, and the cumulative level increase from July 23 to August 3 was 0.74 m, ranking second in the water level increase of Taihu Lake caused by typhoon and rainstorm in all historical measurements. Under the typhoon's impact, the water (tide) level at the rivers, gate dams, and tide level stations in the Taihu Lake basin river network exceeded the warning level by a maximum of 93 stations in a single day, accounting for 89% of all the stations designated with warning water levels; 49 stations recorded floodwater exceeding the guaranteed water (tide) level, accounting for 49% of all the stations designated with guaranteed water levels; the water (tide) level at 33 stations reached a new high in measured records. After the typhoon was gone, the Taihu Lake basin encountered a quasi-Meiyu continuous rainy process in the midsummer. Instead of dropping to the warning level, the water level quickly rose to 4.17 m and stayed above the warning level for 40 days.

2.2.4 Autumn floods in the upper reach of the Yangtze River and the Hanjiang River

From August 21 to October 10, multiple heavy rainfall processes occurred in the upper reach of the Yangtze River. The precipitation was 30% more than that of the same period in normal years. Among them, the average rainfall over the Jialing River basin was 491 mm, 1.4 times more than normal. The total precipitation ranked first over the same period since complete sequence data was available in 1961. Affected by rainfall, 2 numbered floods formed in the Jialing River basin; the Three Gorges Reservoir had 5 flood processes passing through, each with a discharge of more than 40,000 m^3/s. Among them, the inflow reached 54,000 m^3/s at 14:00 on September 6, marking the No. 1 flood of Yangtze River in 2021.

During the same period, 9 heavy rainfall processes occurred in the Hanjiang River basin, and the rainfall processes hit largely from back to back. The rain areas mainly hovered over the upper reach of the Hanjiang River. In particular, the area upstream of the Baihe tributary had a cumulative precipitation reaching 536 mm, 1.7 times of its normal. The total precipitation ranked first over the same period since complete sequence data was available in 1961. Among them, the cumulative precipitation in the basin upstream of

泉以上流域累计降水量 628.2 毫米、石泉—白河区间流域累计降水量 591.7 毫米，累计降水量超过 300 毫米的笼罩面积 10 万平方公里，超过 500 毫米的笼罩面积 6 万平方公里。9 月 24 日，汉江中游支流白河鸭河口水库以上区域日面雨量达 166 毫米，唐白河杨西庄站日降水量达 454 毫米，李青站和上官站最大 1 小时降水量 80.5 毫米（9 月 24 日 22—23 时）。受降雨影响，汉江发生重现期超 20 年大洪水，汉江干流丹江口水库连续发生 7 次入库洪峰流量超过 10000 立方米每秒的较大洪水过程（5 次超过 15000 立方米每秒、3 次超过 20000 立方米每秒，9 月 29 日发生 2011 年以来最大入库洪峰流量 24900 立方米每秒），累计入库洪量 344.7 亿立方米；鸭河口水库出现超历史记录的入库洪峰，9 月 25 日入库洪峰流量 18200 立方米每秒（历史最大入库流量 11700 立方米每秒，1975 年 8 月）。

2.2.5 黄河秋季洪水

9月 22—28 日，黄河中下游大部分地区降中到大雨、局部暴雨，主雨区位于泾渭洛河、山陕区间南部、汾河及黄河三门峡至花园口区间（以下简称三花

Shiquan station was 628.2 mm, the cumulative precipitation in the basin between Shiquan station and Baihe station was 591.7 mm, the area with cumulative precipitation of more than 300 mm stretched for 100,000 km^2, and the area with more than 500 mm cumulative precipitation reached 60,000 km^2. On September 24, the single-day average rainfall over the Baihe basin upstream of the Yahekou Reservoir in the middle reach of the Hanjiang River reached 166 mm, the daily precipitation at the Yangxizhuang Station on the Tangbai River reached 454 mm, and the maximum one-hour precipitation at the Liqing Station and Shangguan Station was 80.5 mm (22:00-23:00 on September 24). Affected by rainfall, the Hanjiang River experienced major floods with a return period of more than 20 years. The Danjiangkou Reservoir on the main-stem Hanjiang River experienced 7 consecutive major flood processes with a flood peak flow exceeding 10,000 m^3/s: five exceeded 15,000 m^3/s, three exceeded 20,000 m^3/s, and the largest post-2011 flood peak flow of 24,900 m^3/s occurred on September 29; the cumulative flood volume reached 34.47 billion m^3. Yahekou Reservoir has a record-breaking flood peak flow (18,200 m^3/s) on September 25, surpassing the historical maximum of 11,700 m^3/s on August 1975.

2.2.5 Autumn Floods in the Yellow River

During September 22-28, vast areas of the middle and lower reaches of the Yellow River received moderate to heavy rainfall and localized rainstorms.

黄河第 2 号洪水通过河南兰考东坝头控导工程（9 月 28 日）
The No.2 flood of the Yellow River passed the Dongbatou Control and Diversion Project in Lankao, Henan Province (September 28)

区间），且强降雨在泾渭河和三花区间等地反复发生，累计降水量超过 100 毫米的笼罩面积 14 万平方公里，7 天累计最大点降水量渭河八里坪站 309 毫米，其中 9 月 24 日降水量最大，三花区间及渭河下游当日面雨量均达 40 毫米以上。受降雨影响，黄河中游渭河、伊洛河、沁河等出现较大洪水过程。渭河咸阳站 9 月 27 日 5 时 54 分洪峰流量 6050 立方米每秒，为 1935 年有实测资料以来同期最大流量，华县站 9 月 28 日 16 时 30 分洪峰流量 4860 立方米每秒，为 2011 年以来最大流量。黄河潼关站 9 月 27 日 15 时 48 分流量 5020 立方米每秒，形成黄河 2021 年第 1 号洪水，29 日 23 时洪峰流量 7480 立方米每秒，为 1988 年以来最大流量。沁河润城站 9 月 26 日 12 时洪峰流量 1520 立方米每秒，为 1993 年以来最大流量，下游武陟站 27 日 15 时 24 分洪峰流量 2000 立方米每秒，为 1950 年以来同期最大流量。受伊洛河、沁河洪水影响，黄河花园口站 9 月 27 日 21 时流量 4020 立方米每秒，形成黄河 2021 年第 2 号洪水，9 月 29 日 0 时洪峰流量 4800 立方米每秒。

受 10 月 2—6 日降雨影响，黄河山陕区间南部、渭河、北洛河、汾河普遍涨水，多站出现 10 月历史同期最大洪水，北洛河狱头站 10 月 7 日 7 时洪峰流

岳城水库启用溢洪道泄洪（10 月 10 日）
Spillways of Yuecheng Reservoir opened to release floodwater (October 10)

The main rain area was located in the Jinghe-Weihe-Luohe River System, the southern Shanxi-Shaanxi section, the Fenhe River and the section of the Yellow River between Sanmenxia and Huayuankou (hereinafter the SanHua section), with heavy rainfall frequenting the Jinghe-Weihe River System and the SanHua section. The area with its accumulated precipitation exceeding 100 mm was 140,000 km^2. The cumulative maximum station-based precipitation in 7 days was 309 mm at Baliping Station on Weihe River, and the most voluminous precipitation occurred on September 24 with the average rainfall over the SanHua section and over the lower reach of the Weihe River both beating 40 mm. Affected by rainfall, major floods occurred in the Weihe River, Yiluo River, and Qinhe River in the middle reach of the Yellow River. The Xianyang Station on Weihe River had a peak flow of 6,050 m^3/s at 5:54 on September 27, ranking top over the same period since measured data were available in 1935; the Huaxian Station had a peak flow of 4,860 m^3/s at 16:30 on September 28, ranking top since 2011. At 15:48 on September 27, the Tongguan Station on the Yellow River had a flow of 5,020 m^3/s, forming the 2021 No. 1 flood of the Yellow River; at 23:00 on September 29, the peak flow was 7,480 m^3/s, ranking top since 1988. The Runcheng Station on Qinhe River had its post-1993 largest flow of 1,520 m^3/s at 12:00 on September 26, while the downstream Wuzhi Station had its post-1950 largest same-period flow of 2,000 m^3/s at 15:24 on September 27. Affected by the floods of the Yiluo River and Qinhe River, the Huayuankou Station on the Yellow River had a flow of 4,020 m^3/s at 21:00 on September 27, forming the 2021 No. 2 flood of the Yellow River; the peak flood flow registered 4,800 m^3/s at 0:00 on September 29.

Affected by the rainfall during October 2-6, the Shanxi-Shaanxi section of the Yellow River, the Weihe River, the Beiluo River and the Fenhe River swelled extensively. Many stations experienced the largest flood over the same period in October. The peak flow at Zhuangtou Station on the Beiluo River was 1,580 m^3/s at 7:00 on October 7, the largest flow since 1999. The peak flow at Hejin Station on the Fenhe River was 985 m^3/s at 8:24 on October 9, the largest flow since 1964. After the confluence of the incoming water from all sections, the Tongguan Station on the Yellow River had a flow of 5,090 m^3/s at 23:00 on October 5, forming the 2021 No. 3 flood of the Yellow River. The peak flow was 8,360 m^3/s at 7:36 on October 7, the largest since 1979.

量 1580 立方米每秒，为 1999 年以来最大流量，汾河河津站 10 月 9 日 8 时 24 分洪峰流量 985 立方米每秒，为 1964 年以来最大流量。各区间来水汇合后，黄河潼关站 10 月 5 日 23 时流量 5090 立方米每秒，形成黄河 2021 年第 3 号洪水，10 月 7 日 7 时 36 分洪峰流量 8360 立方米每秒，为 1979 年以来最大流量。

2.2.6 漳卫河系秋季洪水

9 月 23 日至 10 月 6 日，海河流域出现 3 次强降雨过程（9 月 23—26 日、10 月 2—3 日、10 月 4—6 日），全流域面平均降水量 103 毫米，较常年同期多 3 倍，漳卫河系、子牙河系、徒骇马颊河系和大清河系面平均降水量分别为 167 毫米、164 毫米、149 毫米、113 毫米，较常年同期分别偏多 6.2 倍、6.3 倍、4.5 倍、4.1 倍，其中 9 月 23—26 日，流域大部分地区大到暴雨（40 ~ 70 毫米），局部大暴雨（120 ~ 180 毫米），漳卫河系、子牙河系下游、徒骇马颊河系上游、大清河系下游面平均降水量超过 100 毫米。受强降雨影响，海河流域漳卫河系发生历史罕见秋汛，10 月 7 日 11 时，漳河岳城水库入库流量 2010 立方米每秒，形成漳卫河 2021 年第 2 号洪水，7 日 12 时入库洪峰流量达到 2150 立方米每秒。卫河（及支流共产主义渠）、漳河、漳卫新河、徒骇河发生超警戒洪水，共产主义渠合河站超警戒历时 23 天、最高超过警戒水位 1.09 米，刘庄站超警戒历时 15 天、最高超过警戒水位 1.03 米；卫河淇门站超警戒历时 17 天、最高超过警戒水位 1.50 米；漳河蔡小庄站超警戒历时 6 天、最高超过警戒水位 0.19 米；漳卫新河辛集闸超警戒历时 17 天、最高超过警戒水位 0.38 米。岳城、盘石头、关河、后湾、漳泽 5 座大型水库水位创历史新高。岳城水库最高水位 152.30 米，超历史最高水位（149.08 米，1971 年 9 月 4 日）3.22 米；盘石头水库最高水位 260.08 米，超历史最高水位（257.91 米，2021 年 7 月 24 日）2.17 米；关河水库最高水位 994.03 米，超历史最高水位（992.93 米，1962 年 7 月 15 日）1.10 米；后湾水库最高水位 921.56 米，超历史最高水位（920.10 米，1993 年 8 月 6 日）1.46 米；漳泽水库最高水位 903.31 米，超历史最高水位（903.26 米，2008 年 3 月 5 日）0.05 米。

2.2.6 Autumn floods in the Zhanghe-Weihe River System

From September 23 to October 6, there were three heavy rainfall processes in the Haihe River basin (September 23-26, October 2-3, and October 4-6). The average rainfall over the whole basin was 103 mm, three times more than the multi-year average over the same period. The average rainfall over the Zhanghe-Weihe River System, the Ziya River System, the Tuhai-Majia River System, and the Daqing River System was 167 mm (6.2 times the same-period historical average), 164 mm (6.3 times the same-period historical average), 149 mm (4.5 times the same-period historical average) and 113 mm (4.1 times the same-period historical average), respectively. During September 23-26, most areas of the basin experienced heavy rains to rainstorms (40-70 mm) and localized heavy rainstorms (120-180 mm). The average precipitation over the Zhanghe-Weihe River System, the lower reach of the Ziya River System, the upper reach of the Tuhai-Majia River System, and the lower reach of the Daqing River System all exceeded 100 mm. Affected by heavy rainfall, the Zhanghe-Weihe River System in the Haihe River basin experienced a rare autumn flood. At 11:00 on October 7, the inflow to Yuecheng Reservoir on Zhanghe River was 2,010 m^3/s, forming the 2021 No.2 flood of Zhanghe-Weihe River, and by 12:00 the peak inflow reached 2,150 m^3/s. Floods above the warning water level occurred in the Weihe River (and its tributary, the Communist Canal), Zhanghe River, Zhangwei New River, and Tuhai River. On the Communist Canal, the Hehe Station had floods above the warning water level for 23 days with its maximum level exceeding the warning water level by 1.09 m; the Liuzhuang Station had floods above the warning water level for 15 days with its maximum level exceeding the warning water level by 1.03 m. On the Weihe River, the Qimen Station had floods above the warning water level for 17 days with its maximum level exceeding the warning water level by 1.50 m. On the Zhanghe River, the Caixiaozhuang Station had floods above the warning water level for 6 days with its maximum water level exceeding the warning water level by 0.19 m. On the Zhangwei New River, the Xinji Gate had floods above the warning water level for 17 days with its maximum level exceeding the warning water level by 0.38 m. The water levels in five large reservoirs of Yuecheng, Panshitou, Guanhe, Houwan and Zhangze reached record highs. The highest water level in Yuecheng Reservoir was 152.30 m, 3.22 m above the historical highest (149.08 m, September 4, 1971); the highest water level in Panshitou Reservoir was 260.08 m, 2.17 m above the historical highest (257.91 m, July 24, 2021); the highest water level in Guanhe Reservoir was 994.03 m, 1.10 m above the historical highest (992.93 m, July 15, 1962); the highest water level in Houwan Reservoir was 921.56 m, 1.46 m above the historical highest (920.10 m, August 6, 1993); and the highest water level in Zhangze Reservoir was 903.31 m, 0.05 m above the historical highest (903.26 m, March 5, 2008).

2.3 洪涝灾情

2.3.1 基本情况

2021 年，全国 30 省（自治区、直辖市）发生不同程度洪涝灾害。因洪涝共有 5901.01 万人次受灾，比前 10 年的平均值下降 28.1%；590 人死亡失踪，比前 10 年的平均值下降 1.7%；15.20 万间房屋倒塌，比前 10 年的平均值下降 50.5%；农作物受灾面积 4760.43 千公顷，比前 10 年的平均值下降 38.3%，其中绝收面积 872.35 千公顷；直接经济损失 2458.92 亿元，占当年 GDP 的 0.22%，比前 10 年直接经济损失占当年 GDP 的百分比的平均值下降 31.25%。河南、陕西、四川、山西 4 省因洪涝直接经济损失 1907.80 亿元，占全国的 77.6%，其中河南省死亡失踪 404 人，占全国因洪涝死亡失踪人口的 68.5%，因洪涝直接经济损失占全国的 52.9%。

2.3 Disasters and Losses

2.3.1 Summary

In 2021, flood disasters of varying degrees were borne by 30 provinces/autonomous regions/municipalities across China. A total of 59.0101 million person-times were affected by floods, down by 28.1% from the preceding decadal average; 590 people died or went missing, down by 1.7% from the preceding decadal average; 152,000 dwellings collapsed, down by 50.5% from the preceding decadal average; the affected cropland area was 4,760,430 hectares, down by 38.3% from the preceding decadal average; the failed cropland area was 872,350 hectares; the direct economic loss was 245.892 billion RMB, accounting for 0.22% of the annual GDP and 31.25% lower than the average of direct economic loss as a percentage of GDP in the previous 10 years. The four provinces of Henan, Shaanxi, Sichuan, and Shanxi suffered direct economic losses of 190.78 billion RMB due to floods, accounting for 77.6% of the total national loss. Among them, Henan Province had a toll of 404 deaths and missing persons, accounting for 68.5% of the national total, and claimed 52.9% of the national total direct economic losses.

表 2-1 2021 年因洪涝受灾人口、死亡人口、失踪人口及直接经济损失统计表

Table 2-1 Population affected, deaths, missing persons, and direct economic losses by floods

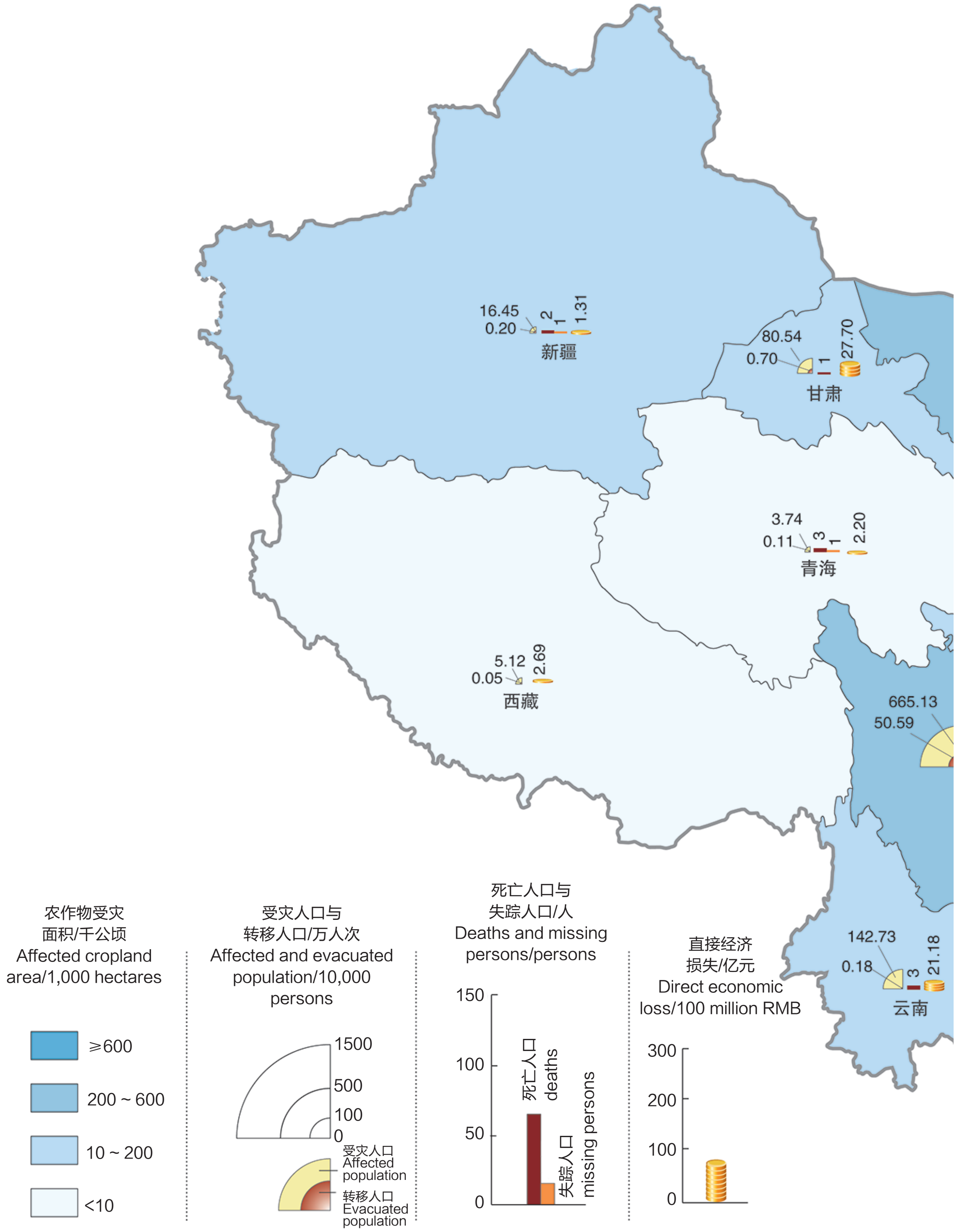
地区 Province	受灾人口 / 万人次 Affected population/ 10,000 person-times	死亡人口 / 人 Deaths/person	失踪人口 / 人 Missing persons/ person	直接经济损失 / 亿元 Direct economic loss/100 million RMB
全国 Nationwide	5901.01	512	78	2458.92
北京 Beijing	6.53	2		11.73
天津 Tianjin	3.22	1		0.59
河北 Hebei	233.59	5		91.35
山西 Shanxi	288.47	47	8	152.90
内蒙古 Inner Mongolia	86.75	14		28.99
辽宁 Liaoning	39.44			12.40
吉林 Jilin	34.81			4.36
黑龙江 Heilongjiang	49.85			43.43
上海 Shanghai				
江苏 Jiangsu	0.24			0.06
浙江 Zhejiang	18.45	3		12.95
安徽 Anhui	82.91	2		12.55
福建 Fujian	22.31			28.49
江西 Jiangxi	248.41			24.11
山东 Shandong	37.27			1.32
河南 Henan	2033.26	361	43	1300.56
湖北 Hubei	515.33	31	3	80.85
湖南 Hunan	455.68	3		71.19
广东 Guangdong	7.85	1		8.32
广西 Guangxi	90.99			14.10
海南 Hainan	1.47			0.59
重庆 Chongqing	124.57	5		28.06
四川 Sichuan	665.13	9	8	217.26
贵州 Guizhou	132.36	1		19.88
云南 Yunnan	142.73	3		21.18
西藏 Tibet	5.12			2.69
陕西 Shaanxi	470.30	18	14	237.08
甘肃 Gansu	80.54	1		27.70
青海 Qinghai	3.74	3	1	2.20
宁夏 Ningxia	3.24			0.72
新疆 Xinjiang	16.45	2	1	1.31

注：数据来源于应急管理部，空白表示无灾情。

Note: The data come from the Ministry of Emergency Management, and spaces in blank denote no such losses by floods.

图 2-5　2021 年全国洪涝灾害分布图

Figure 2-5　A break-down of flood disasters in China in 2021



注：数据来源于应急管理部，香港特别行政区、澳门特别行政区、台湾省资料暂缺。

Note: Data are from the Ministry of Emergency Management. Data of the Hongkong SAR, Macao SAR, and Taiwan are currently unavailable.

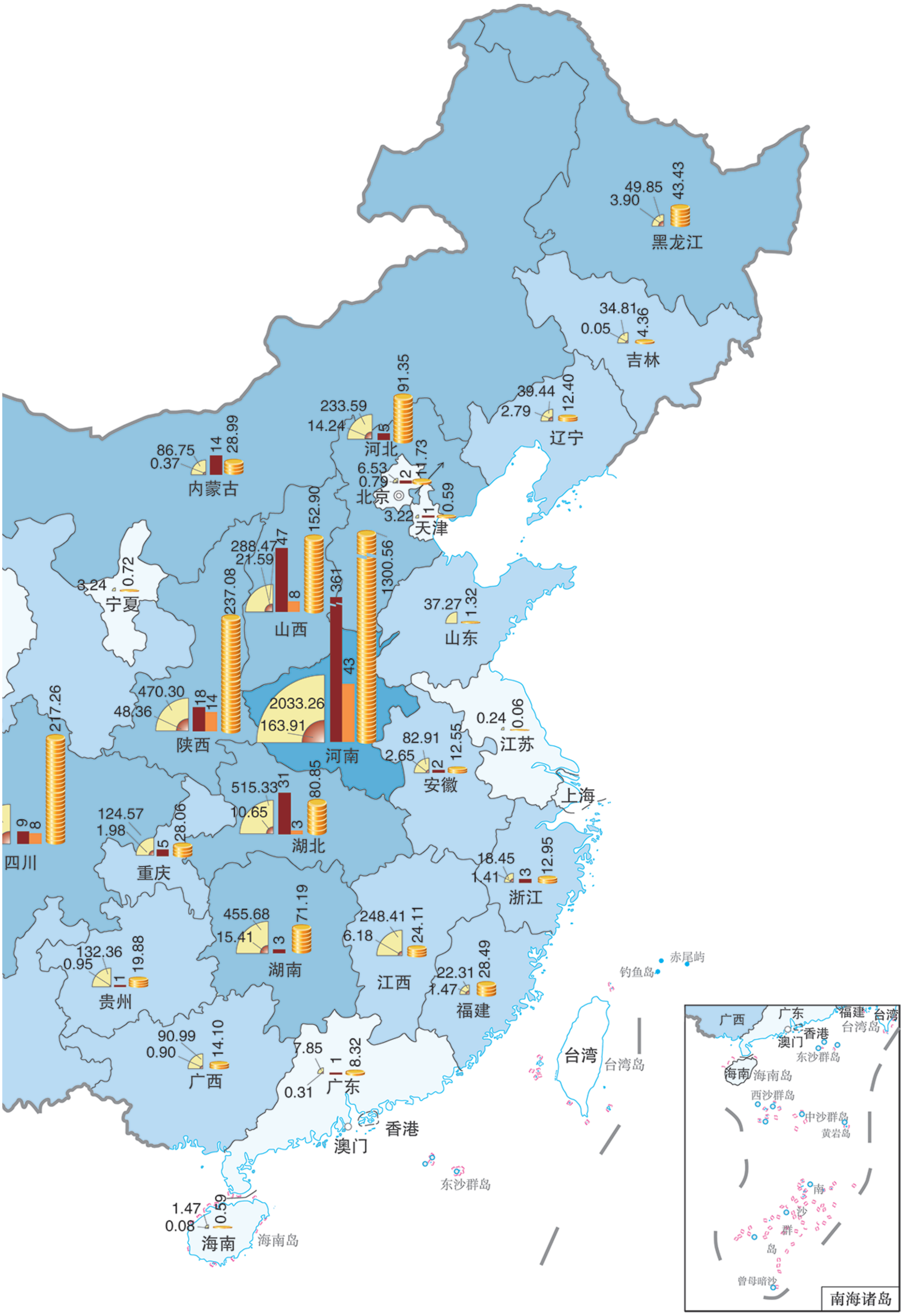
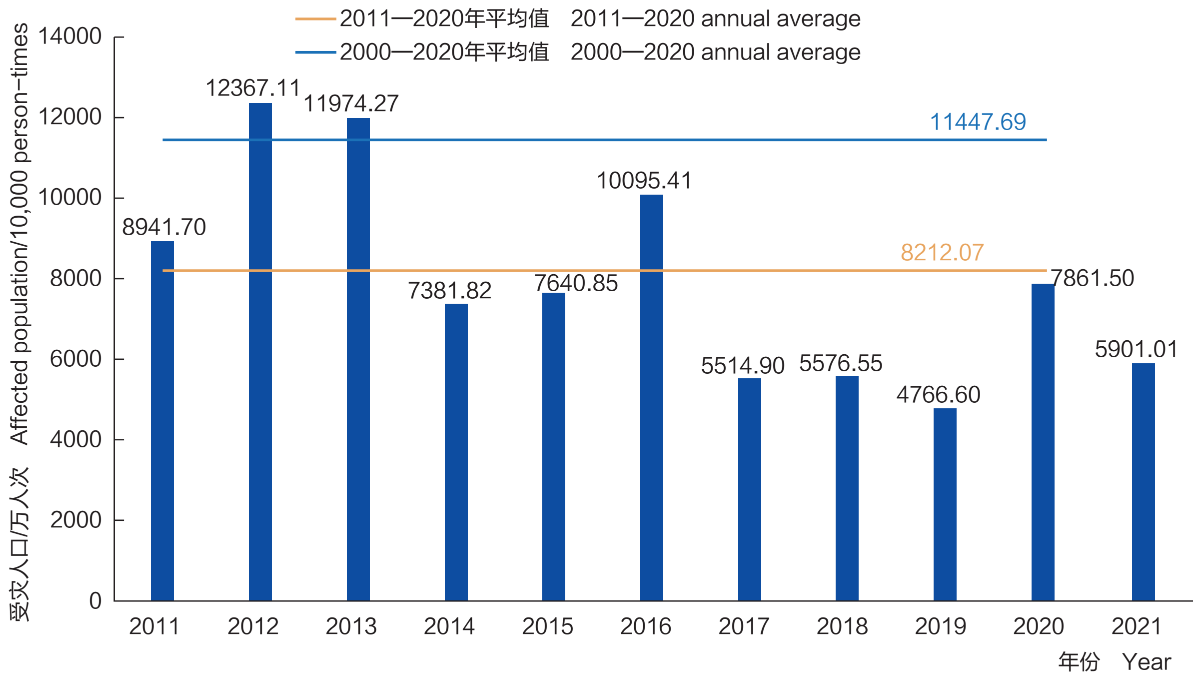

49.85
3.90
43.43
黑龙江
34.81
0.05
4.36
吉林
39.44
2.79
12.40
辽宁
233.59
14.24
91.35
河北
6.53
0.79
北京
3.22
0.59
天津
86.75
0.37
14
28.99
内蒙古
3.24
0.72
宁夏
288.47
21.59
47
8
152.90
山西
237.08
361
43
1300.56
37.27
1.32
山东
470.30
48.36
18
14
陕西
2033.26
163.91
河南
0.24
0.06
江苏
82.91
2.65
2
12.55
安徽
上海
217.26
9
8
四川
124.57
1.98
5
28.06
重庆
515.33
10.65
31
3
80.85
湖北
18.45
1.41
3
12.95
浙江
455.68
15.41
3
71.19
湖南
248.41
6.18
24.11
江西
132.36
0.95
1
19.88
贵州
22.31
1.47
28.49
福建
赤尾屿
钓鱼岛
台湾
台湾岛
90.99
0.90
14.10
广西
7.85
0.31
1
8.32
广东
香港
澳门
东沙群岛
1.47
0.08
0.59
海南
海南岛
广西
广东
福建
台湾
台湾岛
香港
澳门
东沙群岛
海南
海南岛
西沙群岛
中沙群岛
黄岩岛
南
沙
群
岛
曾母暗沙
南海诸岛

表 2-2　2021 年因洪涝农作物受灾面积、农作物绝收面积、倒塌房屋统计表
Table 2-2　Cropland affected and failed and collapsed dwellings by floods

地区 Province	农作物受灾面积 / 千公顷 Affected cropland area/ 1,000 hectares	农作物绝收面积 / 千公顷 Failed cropland area/ 1,000 hectares	倒塌房屋 / 万间 Collapsed dwellings/ 10,000 rooms
全国 Nationwide	4760.43	872.35	15.20
北京 Beijing	3.80	0.20	
天津 Tianjin	2.31	0.51	
河北 Hebei	210.77	51.36	0.10
山西 Shanxi	331.32	50.38	4.88
内蒙古 Inner Mongolia	520.19	54.31	0.03
辽宁 Liaoning	52.53	4.58	0.01
吉林 Jilin	135.00	4.35	0.02
黑龙江 Heilongjiang	408.09	145.04	0.02
上海 Shanghai			
江苏 Jiangsu	2.34		
浙江 Zhejiang	13.25	1.42	0.10
安徽 Anhui	98.44	7.55	0.01
福建 Fujian	23.08	3.62	0.04
江西 Jiangxi	173.77	9.54	0.03
山东 Shandong	27.59	0.19	
河南 Henan	1268.50	315.24	4.49
湖北 Hubei	371.96	55.21	0.31
湖南 Hunan	272.36	36.66	0.55
广东 Guangdong	8.93	0.74	0.02
广西 Guangxi	30.04	3.05	0.07
海南 Hainan	1.01	0.19	
重庆 Chongqing	52.81	11.90	0.48
四川 Sichuan	243.97	39.33	0.87
贵州 Guizhou	81.22	12.73	0.03
云南 Yunnan	88.22	13.37	0.02
西藏 Tibet	1.51	0.34	0.02
陕西 Shaanxi	268.23	46.58	2.33
甘肃 Gansu	40.18	3.57	0.76
青海 Qinghai	3.59	0.19	0.01
宁夏 Ningxia	5.80	0.09	
新疆 Xinjiang	19.62	0.11	

注：数据来源于应急管理部，空白表示无灾情。

Note: The data come from the Ministry of Emergency Management, and spaces in blank denote no such losses or damages.

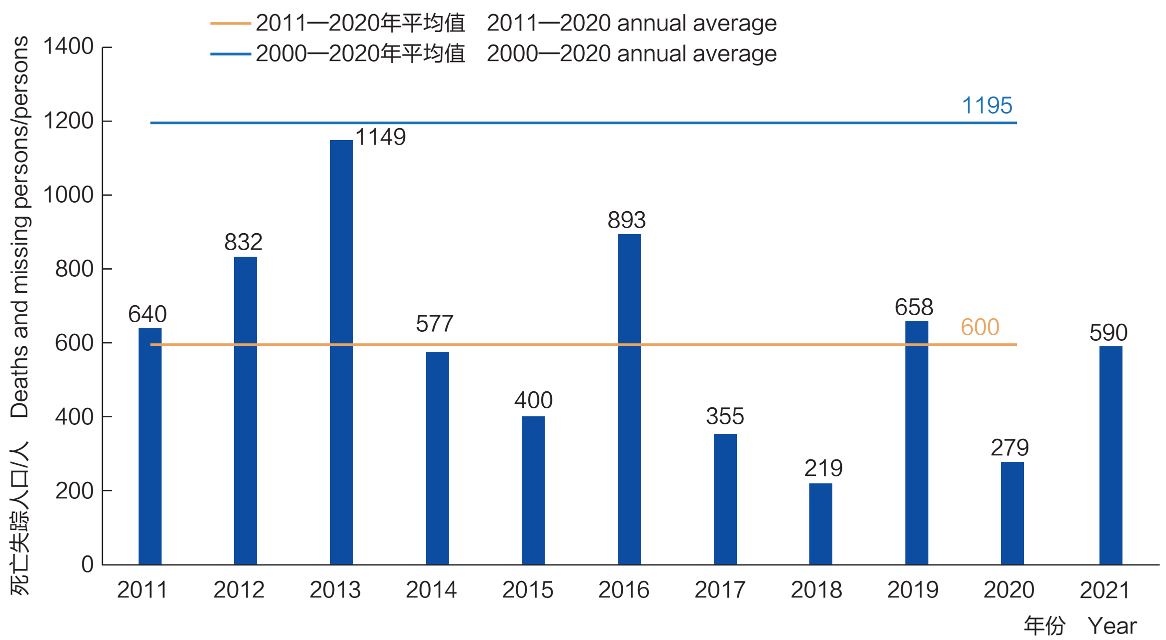


注：2019—2021 年数据来源于应急管理部。

Note: Data for 2019—2021 are from the Ministry of Emergency Management.

图 2-6　2011—2021 年全国因洪涝受灾人口统计

Figure 2-6　Population affected by floods during 2011—2021

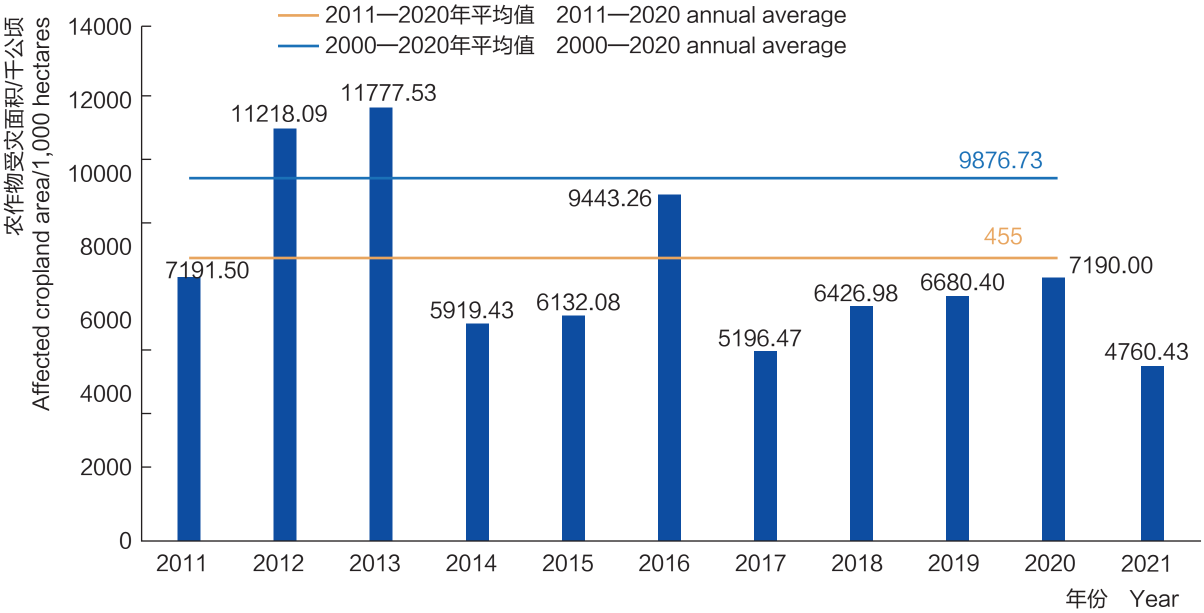


注：2019—2021 年数据来源于应急管理部。

Note: Data for 2019—2021 are from the Ministry of Emergency Management.

图 2-7　2011—2021 年全国因洪涝死亡失踪人口统计

Figure 2-7　Deaths and missing persons attributed to floods during 2011—2021

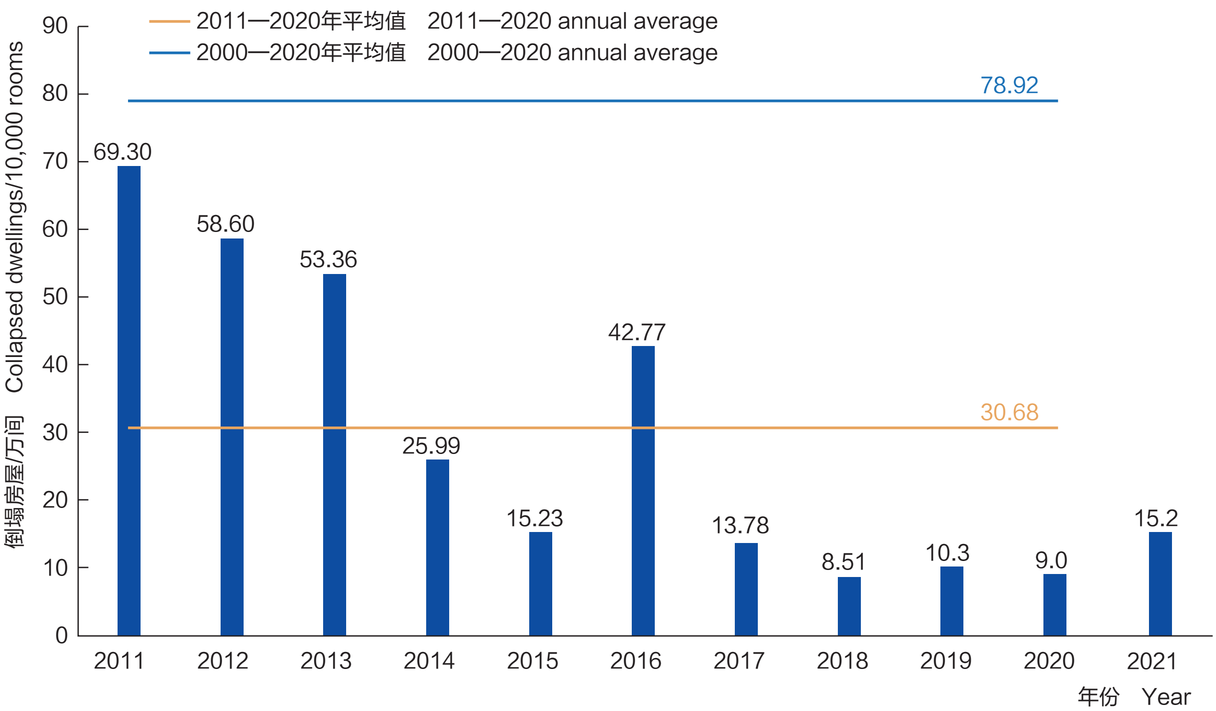


注： 2019—2021 年数据来源于应急管理部。

Note: Data for 2019—2021 are from the Ministry of Emergency Management.

图 2-8　2011—2021 年全国因洪涝农作物受灾面积统计

Figure 2-8　Cropland area affected by floods during 2011—2021

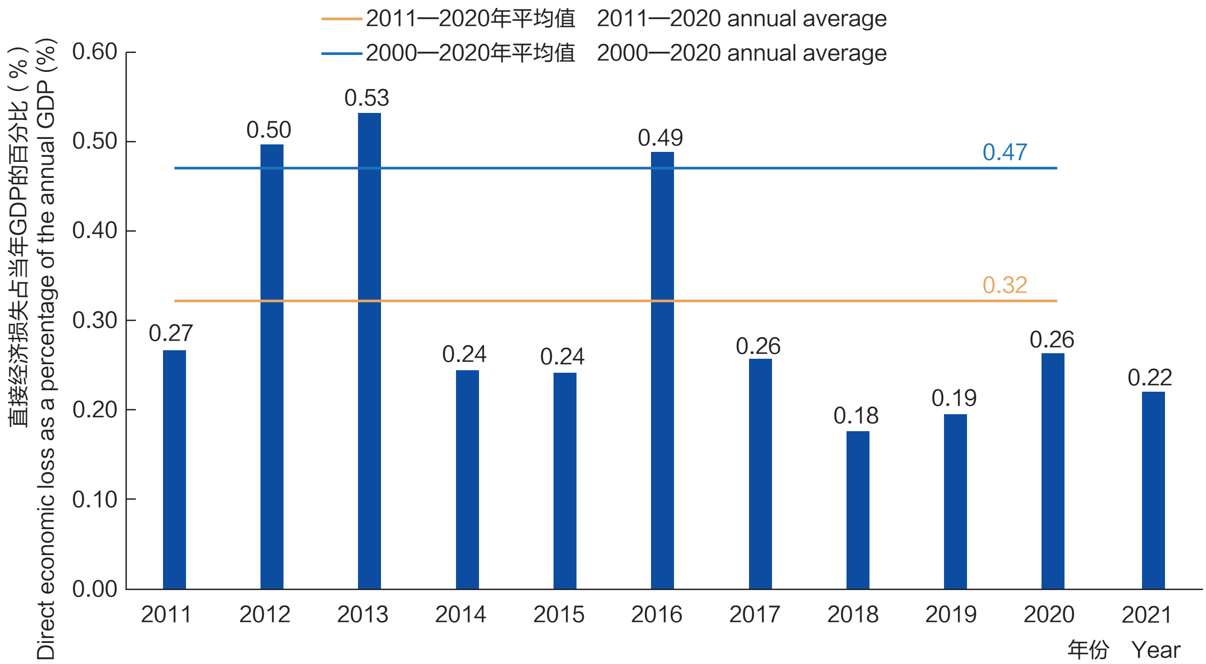


注： 2019—2021 年数据来源于应急管理部。

Note: Data for 2019—2021 are from the Ministry of Emergency Management.

图 2-9　2011—2021 年全国因洪涝倒塌房屋统计

Figure 2-9　Collapsed dwellings attributed to floods during 2011—2021

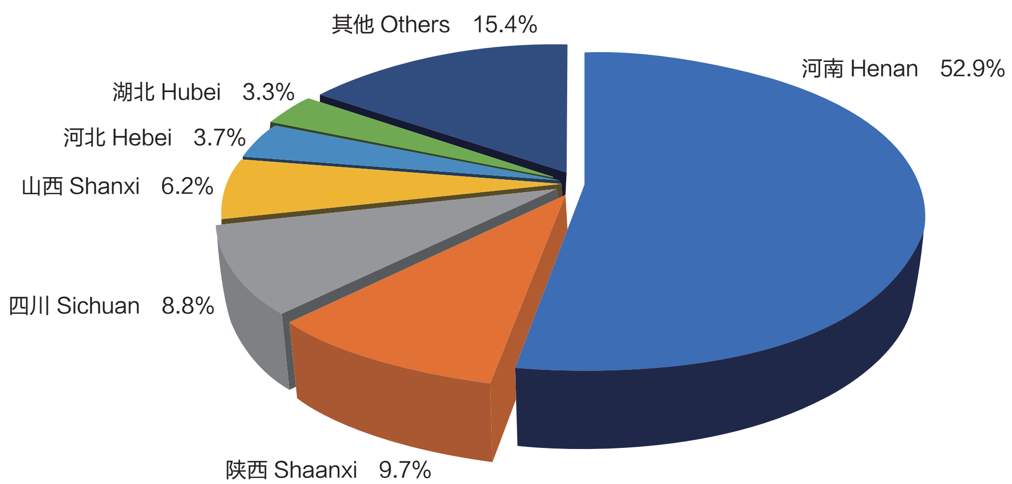


注： 2019—2021 年数据来源于应急管理部。

Note: Data for 2019—2021 are from the Ministry of Emergency Management.

图 2–10 2011—2021 年全国因洪涝直接经济损失占当年 GDP 的百分比

Figure 2–10 National direct economic losses attributed to floods as a percentage of GDP during 2011—2021



注： 数据来源于应急管理部。

Note: Data are from the Ministry of Emergency Management.

图 2–11 2021 年全国因洪涝直接经济损失分布

Figure 2–11 A regional break–down of direct economic losses attributed to floods in 2021

2.3.2 水利工程设施灾损情况

2021 年，全国因洪涝损坏大中型水库 149 座、小型水库 1481 座，其中垮坝 3 座，（内蒙古呼伦贝尔市莫力达瓦旗永安水库（小（1）型）、新发水库（中型），湖北黄冈市罗田县飞钟山水库（小（2）型）），损坏堤防 40960 处 11199.86 公里，其中 124 处 8.50 公里堤防决口，损坏护岸 37722 处、水闸 3784 座、塘坝 25671 座、灌溉设施 52121 处、水文测站 1731 个、机电井 11347 眼、机电泵站 2642 座、水电站 402 座；水利设施直接经济损失 481.29 亿元。

2.3.2 Losses and damages to water projects and facilities

In 2021, 149 large and medium-sized reservoirs and 1,481 small reservoirs were damaged by floods in China. Among them, three collapsed: the Yong'an Reservoir (small (1) type) and the Xinfa Reservoir (medium type) are both in Morin Dawa Banner, Hulunbuir City, Inner Mongolia, and the Feizhongshan Reservoir (small (2) type) is in Luotian County, Huanggang City, Hubei Province. A total of 40,960 dikes ranging 11,199.86 km were damaged, including 8.50 km of breach at 124 embankments. Damages were also caused to 37,722 bank revetments, 3,784 sluices, 25,671 small pond reservoirs, 52,121 irrigation facilities, 1,731 hydrologic stations, 11,347 electromechanical wells, 2,642 electromechanical pumping stations and 402 hydropower stations. The total direct economic loss from water projects and facilities billed 48.129 billion RMB.

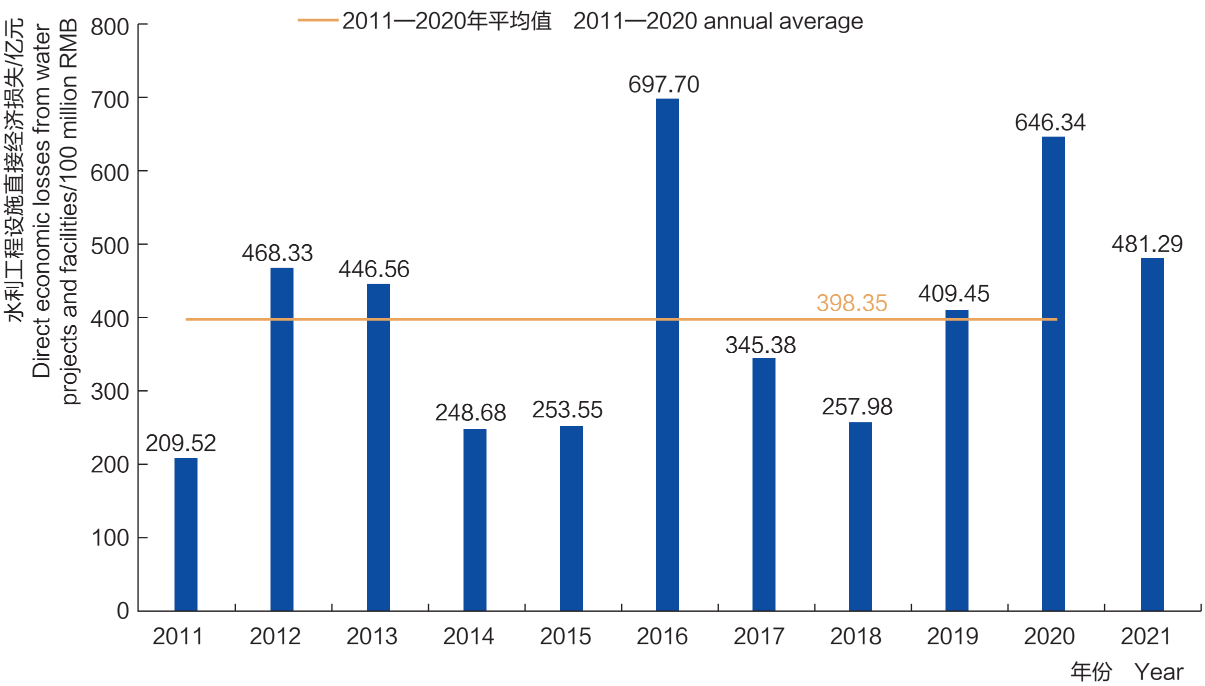


图 2-12 2011—2021 年全国水利工程设施直接经济损失统计
Figure 2-12 Direct economic losses from water projects and facilities in China during 2011—2021

表 2-3　2021 年水利工程设施灾损统计表
Table 2-3　Losses and damages to water projects and facilities in 2021

地区 Directly under the administration of	损坏水库 / 座 Damaged reservoirs/ number		损坏堤防 Damaged dikes		损坏护岸 / 处 Damaged revetments/ number	损坏水闸 / 座 Damaged sluices/ number	损坏塘坝 / 座 Damaged small pond reservoirs/ number	损坏水文测站 / 个 Damaged hydrologic stations/ number	损坏水电站 / 座 Damaged hydropower stations/ number	水利设施直接经济损失 / 亿元 Direct economic loss from water projects and facilities/100 million RMB
	大中型 Large, medium	小型 Small	处数 / 处 Number of sites	长度 / 公里 Length/km						
全国 Nationwide	149	1481	40960	11199.86	37722	3784	25671	1731	402	481.29
北京 Beijing			519	86.10	1022	9		18		7.74
天津 Tianjin			33	519.98		1	2	21		0.21
河北 Hebei	13	47	3715	439.51	3174	195	175	121	16	23.3
山西 Shanxi	35	219	1893	887.26	558	108	562	198	64	49.29
内蒙古 Inner Mongolia	1	2	4464	68.51	261	26	10			7.84
辽宁 Liaoning		4	698	356.00	895	7	32	1	2	6.23
吉林 Jilin		2	82	43.24	1955			2		1.76
黑龙江 Heilongjiang		6	158	113.37	72	39		7		7.13
上海 Shanghai			5	0.72	7	6				0.02
江苏 Jiangsu	2	3	32	10.97	40	65	1	1	1	1.36
浙江 Zhejiang			2420	290.44	2004	195	310	112	38	15.93
安徽 Anhui	3	29	692	186.33	2719	160	1103	125	1	7.18
福建 Fujian		8	248	41.46	1439	110	250	5	36	8.57
江西 Jiangxi		4	607	47.04	2709	289	808	30	19	7.62
山东 Shandong		2	25	12.62	136	74	8	2		0.80
河南 Henan	55	360	6496	4132.24	5577	1141	946	59	32	164.10
湖北 Hubei	5	132	1543	473.06	2806	452	8935	97	16	22.46
湖南 Hunan	1	25	2338	142.11	4201	367	1236	43	25	12.06
广东 Guangdong	9	7	172	26.18	114	43	63	16	11	2.19
广西 Guangxi		22	1127	95.85	482	254	63	51	4	7.72
海南 Hainan	3	8	17	4.49	39	14	20	43		1.40
重庆 Chongqing	1	75	840	93.61	943	25	1718	128	74	11.42
四川 Sichuan	8	328	1604	299.09	1155	87	8950	336	14	33.79
贵州 Guizhou	1	6	153	36.34	123		6	25	6	1.81

续表 Continued

地区 Directly under the administration of	损坏水库 / 座 Damaged reservoirs/ number		损坏堤防 Damaged dikes		损坏护岸 / 处 Damaged revetments/ number	损坏水闸 / 座 Damaged sluices/ number	损坏塘坝 / 座 Damaged small pond reservoirs/ number	损坏水文测站 / 个 Damaged hydrologic stations/ number	损坏水电站 / 座 Damaged hydropower stations/ number	水利设施直接经济损失 / 亿元 Direct economic loss from water projects and facilities/100 million RMB
	大中型 Large, medium	小型 Small	处数 / 处 Number of sites	长度 / 公里 Length/km						
云南 Yunnan	1	4	708	48.18	255	13	23		11	4.03
西藏 Tibet			208	44.31	43	3	7			0.94
陕西 Shaanxi	4	132	9225	2504.49	590	83	414	97	28	61.23
甘肃 Gansu	3	11	335	147.19	48		1	4		2.97
青海 Qinghai			57	14.63	13	5	4		4	1.03
宁夏 Ningxia	3	45	13	4.74	26		24			0.38
新疆 Xinjiang			15	5.41	16	6		34		0.78
长江水利委员会直属 Changjiang Water Resources Commission					3			51		0.21
黄河水利委员会直属 Yellow River Conservancy Commission			474	2.96	4240			23		5.79
淮河水利委员会直属 Huaihe River Commission			9	21.73	7	2		6		0.53
海河水利委员会直属 Haihe River Water Conservancy Commission	1		35	0.12	42			6		0.99
珠江水利委员会直属 Pearl River Water Resources Commission								11		0.08
松辽水利委员会直属 Songliao Water Resources Commission					4			4		0.35
太湖流域管理局直属 Taihu Basin Authority				0.08		1		48		0.05

注：空白表示无灾情。
Note: Spaces in blank denote no such losses or damages.

2021 年，全国因洪涝造成堤防、护岸、水库、水文站等水利设施损毁主要集中在河南、陕西、山西、四川等省。河南省尤其严重，水利工程设施直接经济损失占全国的 34.1%。

In 2021, losses and damages to water projects and facilities such as dikes, revetments, reservoirs, and hydrologic stations attributed to floods were mainly borne by provinces like Henan, Shaanxi, Shanxi, and Sichuan. Henan Province was the largest victim, with its direct economic losses from water projects and facilities claiming 34.1% of the national total.

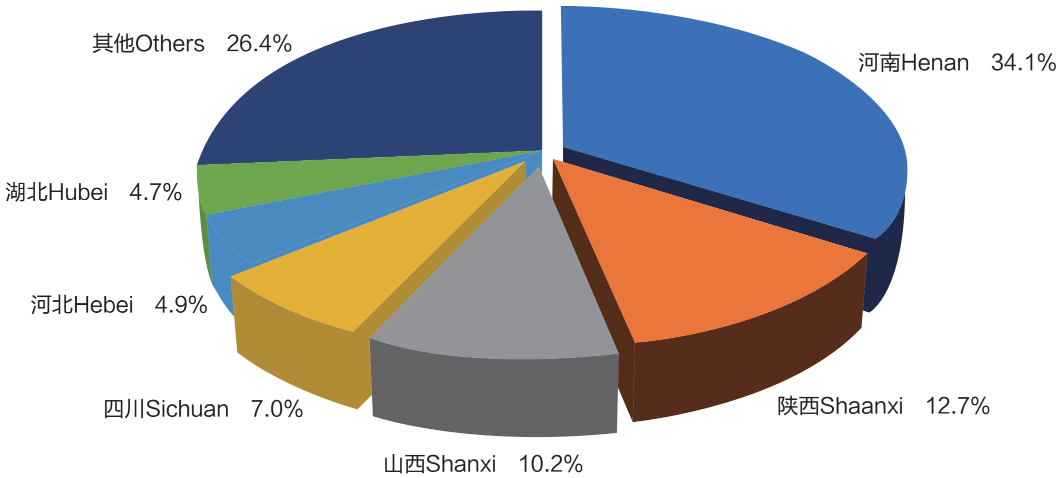


图 2-13 2021 年全国水利工程设施直接经济损失分布

Figure 2-13 A provincial break-down of direct economic losses from water projects and facilities in China in 2021

2.4 防御工作

水利部把防汛作为重大政治责任和头等大事来抓，坚持人民至上、生命至上，坚持防住为王、“预”字当先、“实”字托底，锚定“人员不伤亡、水库不垮坝、重要堤防不决口、重要基础设施不受冲击”的目标，落实预报、预警、预演、预案“四预”措施，贯通雨情、水情、险情、灾情“四情”防御，组织各级水利部门，会同有关部门和地方，超前部署、科学防控、统筹调度，着力防范和化解洪涝灾害重大风险，全力守住防御底线。

2.4.1 部署准备

汛前，水利部召开水旱灾害防御、水库安全度汛、山洪灾害防御等工作视频会议，提早部署防范水旱灾害重大风险，召开专题会议部署重点流域、重点地区防洪保安工作；向社会公布 710 座大型水库大坝安全责任人名单，全面落实 91235 座小型水库行政、技术和巡查“三个责任人”；印发《大中型水库汛期调度运用规定（试行）》，规范大中型水库汛期调度运用；派出 7 个检查组赴七大江河流域督导备汛工作。针对发现的问题，督促地方及时整改，消除度汛安全隐患。坚持流域“一盘棋”思想，组织七大流域召开会议，开展防洪调度演练，充分发挥流域管理机构组织、指导、协调、监督作用。督促指导地方修复水毁防洪工程设施 1.47 万处，及时恢复防洪减灾功能。

2.4 Prevention and Control

MWR treats flood control as a major political responsibility and top priority, insists on the supremacy of the people and life, insists on prevention as the most important orientation, puts preparedness first based on concrete measures, targets “no casualties, no collapsed dams, no breach of important embankments, and no shocks to important infrastructure”, implements the four preemptive pillars of disaster prevention (forecasting, early warning, exercising and contingency planning), puts equal alerts on rainfall, water regime, hazards, and disasters, and organizes water departments, relevant authorities,and local governments at all levels to make advance deployment, scientific prevention and control, and coordinated dispatch. An all-out preventive fight was staged to defuse any major risks of flood disasters.

2.4.1 Flood preparedness

Before the flood season, MWR held video conferences on flood and drought disaster prevention, reservoir safety in flood season, and flash flood disaster prevention to make preparations against major risks of flood and drought disasters, and held ad-hoc meetings to deploy flood control and security work in key river basins and key areas. The Ministry released a public list of responsible persons for the safety of the 710 large dammed reservoirs, and implemented the mechanism of “three responsible officials” (one administrative official, one technical officer, and one patroller) for the 91,235 small reservoirs; issued the *Regulations on the Dispatch and Operation of Large and Medium Reservoirs in Flood Season (Trial)* to standardize the dispatch and operation of large and medium reservoirs in flood season; and sent 7 inspection teams to the seven major river basins to supervise flood preparation. Local authorities were urged to rectify in time any problems found to eliminate potential hazards during the flood season. The Ministry adhered to an holistic approach to river basin governance, organized seven major river basin commissions for meetings, carried out flood control and dispatch drills, and gave full play to the role of the river basin commissions in organizing, guiding, coordinating and supervising. The Ministry also supervised and guided the local governments to repair 14,700 flood control engineering facilities damaged by floods to restore their flood control and disaster mitigation functions in a timely manner.

2.4.2 预报预警

按照降雨—产流—汇流—演进规律，水利部门加密雨水情监测，发布洪水预报 44.2 万站次，关键场次洪水预报精度达到 85%；发布水情预警 1653 次、淤地坝风险预警 4069 坝次。

汛期，水利部长江水利委员会（以下简称长江委）发布汛情通报 27 期、干支流水情预报 458 期、短中长期降雨预报 339 期、重要水雨情报告及分析材料 205 期，发布编号洪水信息 4 期、洪水预警信息 24 期，发送实况信息、预警预报信息、水雨情综合分析等各类短信共 6.8 万余条，推送热点水情消息 5.4 万余人次，尤其在应对台风“烟花”、长江上游和汉江秋汛过程中，提前 10 天锁定重点区域洪水过程，及时发布预警。水利部黄河水利委员会（以下简称黄委）发布重要天气预报通报 40 期、降水预报 159 期、洪水预报 278 期、水情通报简报 27 期、洪水预警 17 期、径流预报 27 期、水情日报 153 期，开展洪水常态化预报 2806 站次，接收雨水情信息 1400 余万份。水利部淮河水利委员会（以下简称淮委）发布气象预报 168 期、水情预报 70 期、水情预警 4 次。水利部海河水利委员会（以下简称海委）强化雨水情分析及预警，通过“海委水文”微信公众号推送信息 161 期，提供雨水情预报分析成果 93 期。水利部珠江水利委员会（以下简称珠江委）发布洪水预报 1200 余站次，发送预警短信 17 万余条。水利部松辽水利委员会（以下简称松辽委）累计完成水雨情预报 5000 站次，发布洪水预警 43 次、编号洪水信息 4 次。水利部太湖流域管理局（以下简称太湖局）发布日常化流域水位预报 154 期、周预报 22 期、月预报 5 期、专题水位预报 5 期、太湖水位过程预报 22 期、流域超警戒超保证水位与淹涝风险预测 13 期。

2.4.2 Forecast and early warning

Bearing in mind the development pattern from rainfall to runoff generation, to confluence, and then to dynamic evolution, the water resources departments intensified the monitoring of rain and water regime conditions and issued flood forecast by 442,000 station-times, with the forecast accuracy for key flood events reaching 85%. Water regime warnings were issued for 1,653 times, and risk alerts for check dams 4,069 dam-times.

During the flood season, the Changjiang Water Resources Commission (hereinafter the Changjiang Commission) issued 27 flood briefings, 458 river regime forecasts for the main-stem Yangtze and its tributaries, 339 short, medium and long-term rainfall forecasts, 205 important water regime and rain situation reports and analysis materials, 4 on numbered flood information, and 24 on flood warning information. The Changjiang Commission sent more than 68,000 short messages on real-time information, early warning and forecast information, and comprehensive analysis of water regime and rain conditions, and also pushed latest news messages for more than 54,000 person-times. In particular, in response to typhoon “In-Fa” and the autumn floods in the upper reach of the Yangtze River and the Hanjiang River, the flood processes in key areas were identified 10 days in advance and early warnings were issued in time. The Yellow River Conservancy Commission (hereinafter the Yellow River Commission) issued 40 briefings on important weather forecasts, 159 precipitation forecasts, 278 flood forecasts, 27 water regime reports, 17 flood warnings, 27 runoff forecasts, and 153 daily news on water regimes. The Yellow River Commission carried out regular flood forecasting for 2,806 station-times and received more than 14 million pieces of rain and water regime information. The Huaihe River Commission (hereinafter the Huaihe Commission) issued 168 briefings on weather forecasts, 70 water regime forecasts, and 4 water regime warnings. The Haihe River Water Conservancy Commission (hereinafter the Haihe Commission) strengthened the analysis and early warning of rainfall and water regime, posting 161 messages and 93 editions of rainfall and water regime forecast analysis on the “Haihe River Commission Hydrology” WeChat Official Account. The Pearl River Water Resources Commission (hereinafter the Pearl River Commission) issued flood forecasts for more than 1,200 station-times and sent more than 170,000 early warning messages. The Songliao Water Resources Commission (hereinafter the Songliao Commission) issued water regime and rainfall forecasts for a total of 5,000 station-times, 43 flood warnings and 4 briefings on numbered floods. The Taihu Basin Authority (hereinafter the Taihu Authority) issued 154 daily forecasts on basin-wide water level, 22 weekly forecasts, 5 monthly forecasts, 5 special water level forecasts, 22 water level process forecasts of the Taihu Lake, and 13 forecasts on floods above the warning water level and inundation risk in the basin.

案例 1 黑龙江省凌汛、夏汛预报

2021 年，黑龙江省气候异常，先后经历了凌汛、春汛、夏汛三连击，松花江发生了流域性较大洪水；嫩江、松花江共发生 4 次编号洪水，历史罕见。黑龙江省积极落实“四预”措施，较好地完成了 2021 年水文情报预报工作任务。

凌汛预报：黑龙江省组织多次防凌汛会商，预报黑龙江上游、松花江中下游将发生冰坝，黑龙江上游将在 4 月 23—27 日开江、松花江干流将在 4 月 2—11 日开江、嫩江干流将在 3 月 31 日至 4 月 16 日开江、乌苏里江干流将在 4 月 5—11 日开江。实际在松花江下游佳木斯段，黑龙江上游漠河下游 10 处、北红段、瓦干段，黑河大黑河岛、小黑河岛、黄河口岛和女雅通岛等发生冰坝，与预报相符；黑龙江上游开江日期预报误差为 0 天，松花江开江日期预报误差为 2 天，嫩江开江日期预报误差为 2 ~ 4 天，乌苏里江开江日期预报误差为 0 天，为 2021 年黑龙江省防凌安全提供了技术保障。

夏汛预报：在推广“3 天预报、3 天预测、3 天展望”预报模式的基础上，坚持短、中、长期预报相结合，进一步延长预见期。6 月 21 日提前 6 天发布了黑龙江上游将发生重现期超 50 年特大洪水的预报，为防洪减灾指挥决策留出了宝贵的准备时间。在黑龙江三道卡段堤防防守决策的关键时刻，预报判断水位上涨不超过 20 厘米，并制定了堤防抢险加固方案，确保洪水顺利通过。8 月 3 日提前 9 天预报黑龙江同江至抚远江段将超过保证水位、发生重现期超 30 年大洪水，为下游防汛提供了半个月的预见期。8 月 12 日提前 10 天发布松花江哈尔滨站将发生超警戒洪水、松花江将发生流域性大洪水的预报。

2021 年，针对黑龙江省三条大江和多条中小河流发生的超警戒洪水，制作并发布洪水预报 544 站次，预报总体合格率 71%，其中黑河、同江、勤得利、抚远、木兰、通河、依兰、佳木斯等关键站洪峰预报误差均在 5 厘米以内，哈尔滨站、富锦站洪峰预报实现零误差，且松花江干流预报合格率达 100%，为历史首次；在退水预报上，黑龙江干流全线退至警戒水位以下预报的时间误差为 0 天，真正实现了精准预报，为各级防汛指挥决策部门提供重要的技术支撑。

Case 1 Forecast on ice flood and summer flood in Heilongjiang Province

In 2021, Heilongjiang Province was subject to abnormal climatic conditions, as manifested in the successive strikes of an ice flood, a spring flood and a summer flood. The Songhua River experienced a large basin-wide flood; the Nenjiang River and the Songhua River had 4 numbered floods, which was rare in history. Heilongjiang Province implemented the four preemptive pillars for flood prevention and control and performed well on hydrological intelligence collection and forecasting in 2021.

Ice flood forecast: Heilongjiang Province organized multiple meetings for ice flood control. It was predicted that ice dams would occur in the upper reach of the Heilong River and the middle and lower reaches of Songhua River, that the upper reach of Heilong River would unfreeze by April 23-27, the main-stem Songhua River would unfreeze by April 2-11, the main-stem Nenjiang River would unfreeze by March 31 to April 16, and the main-stem Wusuli River would unfreeze by April 5-11. In reality, ice dams did occur in the Jiamusi section of the lower reach of the Songhua River, in the place that was 10 km downstream the Mohe (in the upper reach of the Heilong River), in the Beihong section, the Wagan section, the Daheihe Island, Xiaoheihe Island, Huanghekou Island, and the Nyuyatong Island in the Heihe River. The situation was consistent with the forecasts. The river unfreezing forecast for the upper reach of the Heilong River deviated by 0 day, for the Songhua River by 2 days, for the Nenjiang River by 2-4 days, and for the Wusuli River by 0 day. Precise forecasts provided a technical guarantee for the ice flood control of Heilongjiang Province in 2021.

Summer flood forecast: While reinforcing the forecasting mechanism of "prediction and forecast covering three days earlier and three days forward", the short, medium and long-term forecasts were combined to further extend the forecast lead time. On June 21, the forecast of an extreme flood with a return period of more than 50 years in the upper reach of the Heilong River was released six days in advance, winning valuable preparation time for the command and decision-making of flood control and disaster reduction. At the critical moment of the decision-making on the defense of the embankment in the Sandaoka section of the Heilong River, it was predicted that the water level would rise no more than 20 cm. A plan to protect and reinforce the embankments was made to ensure the smooth passage of the flood. On August 3, nine days ahead of the occurrence, it was predicted that the section from Tongjiang to Fuyuan of the Heilong River would have floods above the guaranteed water level with the return period exceeding 30 years, providing a lead time up to half a month for downstream flood control. On August 12, forecast was made 10 days in advance that floods above the warning water level would occur at the Harbin Station on the Songhua River, and that there would be basin-wide large floods in the Songhua River.

In 2021, in response to floods above the warning water level in three major rivers and many small and medium-sized rivers in Heilongjiang Province, 544 station-times of flood forecast were produced and released, and the overall accuracy rate was 71%. Among them, the flood peak forecast for the Heihe, Tongjiang, Qindeli, Fuyuan, Mulan, Tonghe, Yilan, Jiamusi and other key stations had deviations of less than 5 cm, Harbin Station and Fujin Station achieved zero deviation, and the accuracy rate for the main-stem Songhua River was 100%, being unprecedented in history. In terms of flood retreat forecast, the time forecast for the water level of the whole main-stem Heilong River to fall below the warning water level deviated by 0 day. The accurate forecasts had provided important technical support for flood control command and decision-making departments at all levels.

2.4.3 演练预演

水利部根据防洪形势、工程状况和洪水预报，开展洪水模拟预演和方案比选，将洪水预报情报、会商决策意见及应对措施建议第一时间直达重点流域、重点地区防御一线，提醒有关地方针对风险做好防范。长江委选取汉江“1983 · 10”洪水作为 2021 年长江流域典型洪水开展模拟防洪调度演练；在陆水水库组织开展了委管水库防洪应急抢险演练；会同湖南省水文部门联合开展了水文应急监测演练，117 个主要水文站组织完成高水位洪水测报演练。黄委以黄河“1958 · 7”洪水为原型，模拟三花区间发生大洪水，叠加山陕区间高含沙洪水的大洪水过程；各级河务部门以练为战，集结专业机动抢险队开展防汛抢险实战演练，传承黄河抢险技术，提高抢险实战能力，汛前共开展防汛抢险演练 50 余次，参演人数近 6000 人。淮委按照“需求牵引、应用至上、数字赋能、提升能力”要求，开展 2021 年淮河水旱灾害防御“四预”演练，利用新开发的淮河正阳关以上智慧防汛系统，进行在数字流场条件下的实时洪水预报调度预演。海委选取永定河系开展“四预”试点，运用数字化、信息化、智慧化手段，构建数字化模型，建设数字流域。珠江委加快推进建设流域智慧调度和会商预演平台，搭建流域雨水情信息共享平台，加强预报调度基础研究，建立预报预警“三级”校审制度，努力提升“四预”能力和流域水工程联合调度水平。松辽委以 2013 年典型洪水为背景，开展 2021 年松花江流域重要水利工程防洪调度演练，模拟尼尔基水库库区突降暴雨以及嫩江、松花江干流发生重现期超 100 年特大洪水的应对场景。太湖局以太湖发生超标准洪水并遭遇台风强降雨正面袭击为背景，设置环湖大堤出现溃口、直管工程发生险情等演练场景，组织开展防汛救灾应急演练；以太湖流域水情为背景，叠加 2020 年同期降雨，利用流域数学模型预演不同调度方案下太湖及区域河网水位、超警戒超保证水位时间、淹没面积等；联合专业救援队组织开展了水上安全应急演练；以台风“烟花”的预报降雨过程为背景，预演流域骨干水利工程不同调度方式下的太湖和地区河网水位变化过程及地区淹涝情况。

2.4.3 Exercises and drills

Based on the flood control situation, engineering conditions and flood forecasting, MWR would hold flood simulation runs, compare and select schemes to send without delay the flood forecast information, consultation decisions and suggestions of countermeasures to the key river basins and key areas to warn the local departments about the risks. The Changjiang Commission selected the "October 1983" flood of the Hanjiang River as a typical flood for the Yangtze River basin in 2021 to carry out simulated flood control dispatching drills; organized and carried out flood control emergency drills at the Lushui Reservoir for all reservoirs under the administration of the Commission; and jointly carried out hydrological emergency monitoring drills with the hydrological departments of Hunan Province by organizing 117 major hydrological stations to perform high-level flood forecasting and reporting exercises. Taking the "July 1958" flood of the Yellow River as the prototype, the Yellow River Commission simulated the large flood processes in the Sanmenxia-Huayuankou section with high sediment content in the Shanxi-Shaanxi section. River affairs departments at all levels took the exercises seriously, gathering professional mobile rescue teams to carry out flood control and rescue exercises and improving the rescue and combat capability. More than 50 flood control drills were carried out before the flood season with nearly 6,000 participants. In accordance with the requirements of "demand orientation, application first, digital empowerment, and capacity enhancement", the Huaihe Commission carried out exercises the four preemptive pillars for the control of flood and drought disasters in the Huaihe River in 2021, and used the newly developed smart flood control system upstream the Zhengyangguan station on the Huaihe River to conduct a real-time flood forecasting and dispatching rehearsal in a digital flow field. The Haihe Commission selected the Yongding River System to carry out the four preemptive pillars pilot, using digital, information, and intelligent means to develop digital models and build digital watersheds. The Songliao Commission uses the conditions from a typical flood in 2013 and carried out the flood control and dispatching exercise of important water projects in the Songhua River basin in 2021, simulating the response scenario of sudden rainstorms in the reservoir area of Nierji Reservoir and floods with the return period exceeding 100 years in the main-stem Nenjiang River and the Songhua River. The Pearl River Commission accelerated the construction of a river basin intelligent dispatching and consultation platform, built a river basin rain and water regime information sharing platform, strengthened basic research on forecasting and dispatching, established a three-level review system for forecasting and early warning messages, and strove to improve the four preemptive pillars capabilities and the ability to jointly dispatch water projects in the river basin. The Taihu Authority set up drill scenarios—such as an embankment breach around the lake and other hazards occurring in projects under the direct administration of the Authority—against the background of excessive floods in the Taihu Lake and the direct assault of the typhoon and heavy rainfall, and organized emergency drills for flood control and disaster relief. Taking the water regime of the Taihu Lake Basin as basic conditions and combining the rainfall in the same period in 2020, the Authority used the mathematical models of the basin to simulate the water levels of Taihu Lake and the regional river network, the duration of floods exceeding the guaranteed water levels and the submerged areas under different dispatching schemes. Waterborne emergency drills were organized with professional rescue teams. Taking the rainfall process forecast of typhoon "In-Fa" as basic conditions, rehearsal was held on the water level change process of Taihu Lake and the regional river network, as well as the regional inundation situation, under different dispatching methods of the backbone water projects in the basin.

案例 2 淮河水旱灾害防御"四预"演练

2021 年，按照水利部水旱灾害防御工作会议要求和李国英部长关于智慧流域防洪体系建设的总体部署，研究部署推进智慧流域防洪体系建设；成立数字淮河和智慧流域防洪体系建设工作专班，编制智慧流域防洪体系建设方案，制定 2021 年水旱灾害防御"四预"演练方案，确定主要技术支撑单位，配合做好"四预"演练各项准备工作。

6 月 9 日，淮委会同河南、安徽两省水利厅组织开展了 2021 年淮河水旱灾害防御"四预"演练。演练基于淮河现状工程条件，在淮河正阳关以上区域，选取 2020 年淮河暴雨洪水复盘（降雨偏南型）、2007 年暴雨放大 10%（降雨均匀型）和现场确定暴雨量级，利用最新构建的淮河王家坝至正阳关区域的数字流场和淮河正阳关以上分布式水文模型及河段一维、二维水动力学数学模型，结合已初步建成的淮河洪水预报调度一体化系统，进行水文预报—洪水预警—调度方案—数字模拟—预案生成—动态展示等全链条洪水预报调度演练，检验了"四预"各项措施。

演练充分运用云计算、物联网、大数据、移动互联、数字映射、数字孪生、人工智能等新一代信息技术，初步实现数字流域场景中的动态交互、实时融合和仿真模拟，初步实现流域防洪"预报预警实时化、预演实景化、预案实地化"的目标，提升了流域水旱灾害防御数字化、智能化、智慧化水平，也为智慧流域防洪体系建设进行了有益的探索。

"四预"演练取得了多项创新技术成果。融合集成了多源多尺度高分辨率数据；首创了适用于国产操作系统的淮河洪水预报调度一体化系统和基于水文学方法的"四预"模拟系统；首次实现了超大规模水文水动力学一体化实时动态模拟预报并行计算；初步实现了数字流场、数字孪生和数字映射三维可视化展示；实现了多技术融合与多平台协同。

Case 2 Exercising the four preemptive pillars of flood and drought disaster prevention for the Huaihe River

In 2021, the Huaihe Commission advanced the development of an intelligent basin-wide flood control system in accordance with the requirements set at the Working Meeting on Flood and Drought Disaster Prevention of MWR and Minister Li Guoying's overall instructions. Special task force was set up for digital Huaihe and intelligent basin-wide flood control system and plans were subsequently made; the exercise plan was made for the four preemptive pillars of flood and drought disaster prevention in 2021 and the major technical supporting institutions were identified.

On June 9, the Huaihe Commission, together with the water resources departments of Henan and Anhui provinces, organized an exercise on preemptive plans. The exercise was based on the current engineering conditions of the Huaihe River. For the area upstream of Zhengyangguan, the rainstorm and floods in the Huaihe River basin in 2020 (more rains were in the south), the 2007 rainstorm amplified by 10% (rains evenly distributed) and the rainstorm magnitude determined on-site were selected. Using the newly constructed digital flow field in the area from Wangjiaba to Zhengyangguan of the Huaihe River, the distributed hydrological model for areas upstream of Zhengyangguan, and the one-dimensional and two-dimensional hydrodynamic mathematical models of the river section, and combining the existent Integrated Huaihe River Flood Forecasting and Dispatching System, a full-cycle exercise on flood forecasting and dispatching including hydrological forecasting, flood early warning, dispatch planning, digital simulation, contingency planning generation, and dynamic display were carried out.

The drill tapped into next-generation information technologies such as cloud computing, Internet of Things, big data, mobile connectivity, digital mapping, digital twins, and artificial intelligence to enable dynamic interaction, real-time integration and simulation in the scenario of a digital river basin; the objectives of "real-time forecasting and early warning, real scenario-based drilling, and site-specific planning" were advanced. This drill improved the digital, intelligent and smart level of the river basin flood and drought disaster prevention, and contributed to the development of an intelligent basin-wide flood control system.

The drill produced a number of innovative technological achievements, including the integration of multi-source and multi-scale high-resolution data, the pioneering of the integrated Huaihe River flood forecasting and dispatching system suitable for domestic operating systems and the preemptive simulation system based on hydrological methods, the ultra-large-scale parallel computing for real-time dynamic simulation and forecast of hydrology and hydrodynamics integration, the initiation of a three-dimensional visual display of digital flow field, digital twin and digital mapping, and the realization of multi-technology integration and multi-platform collaboration.

2.4.4 会商响应

水利部建立并坚持汛期 24 小时值守和主汛期每日会商机制，累计会商 172 次。启动水旱灾害防御Ⅳ级、Ⅲ级应急响应 11 次共 108 天，其中Ⅳ级 6 次 55 天、Ⅲ级 5 次 53 天，先后发出工作部署通知 229 个，编发水旱灾害防御信息 119 期。派出 122 个部本级工作组，协助地方做好防洪抗洪工作。全国各地水利部门共派出 4.39 万个工作组、19.79 万人次赴防汛一线开展水旱灾害防御工作。

2.4.4 Consultation and responses

MWR adhered to a 24-hour on-duty working mechanism during the flood season and a daily consultation mechanism during the main flood season. A total of 172 consultations were held. The Level III and Level IV emergency response to flood and drought disasters were made 11 times and lasted 108 days, among which Level III response were 5 times lasting 53 days, and Level IV response were 6 times lasting 55 days. Successively 229 work deployment notices were issued, and 119 briefings on flood and drought disaster prevention were issued. In total, 122 ministerial-level working groups were dispatched to assist the local departments in flood prevention and control. Nationwide, 43,900 working groups and 197,900 person-times from water resources department were sent down to the front line.

表 2-4　2021 年水利部水旱灾害防御应急响应启动情况
Table 2-4　Emergency responses against flood and drought disasters by the Ministry of Water Resources in 2021

序号 No.	启动日期 Start date	应急响应级别 Emergency response level	事由 Cause	终止日期 End Date
1	6 月 21 日 June 21	Ⅲ级 Level III	嫩江、黑龙江部分江段超警戒 Some sections of the Nenjiang River and the Heilong River experienced floods above the warning water level	7 月 2 日 July 2
2	7 月 2 日 July 2	Ⅳ级 Level IV	黑龙江部分江段超警戒 Some sections of the Heilong River experienced floods above the warning water level	7 月 14 日 July 14
3	7 月 18 日 July 18	Ⅲ级 Level III	永安水库、新发水库垮坝 Yong'an Reservoir and Xinfa Reservoir collapsed	7 月 20 日 July 20
4	7 月 20 日 July 20	Ⅳ级 Level IV	诺敏河洪峰汇入嫩江干流，嫩江干流水位缓涨，下游江段超警戒；海河南系、黄河中游、淮河上游部分支流发生洪水 The flood peak of the Nuomin River merged into the main stream of the Nenjiang River, causing the water level to rise slowly and leading to floods above the warning water level in the downstream. Floods occurred in the southern part of the Haihe River basin, the middle reach of the Yellow River, and the upper reach of the Huaihe River	7 月 21 日 July 21
5	7 月 21 日 July 21	Ⅲ级 Level III	河南郑州等地降特大暴雨，黄河、淮河、海河等流域多条河流发生超警戒洪水 Heavy rains fell in Zhengzhou, Henan and other places. Floods above the warning water level occurred in many rivers in the Yellow River basin, Huaihe River basin, Haihe River basin	8 月 2 日 August 2
6	8 月 2 日 August 2	Ⅳ级 Level IV	海河流域部分河流、太湖水位回落；黑龙江部分江段可能发生超警戒洪水 Water levels of some rivers in the Haihe River basin and the Taihu Lake had fallen; some sections of the Heilong River might experience floods above the warning water level	8 月 16 日 August 16
7	8 月 16 日 August 16	Ⅲ级 Level III	松花江发生流域性较大洪水 Large basin-wide flood occurred in the Songhua River	8 月 24 日 August 24
8	8 月 24 日 August 24	Ⅳ级 Level IV		9 月 10 日 September 10
9	9 月 13 日 September 13	Ⅳ级 Level IV	2114 号台风“灿都”登陆，部分地区出现台风暴雨洪水 Typhoon No. 2114 "Chanthu" made landfall, causing rainstorms and floods in some areas	9 月 16 日 September 16
10	9 月 27 日 September 27	Ⅲ级 Level III	黄河中游下游发生较大洪水 Large floods in the middle and lower reaches of the Yellow River	10 月 14 日 October 14
11	10 月 14 日 October 14	Ⅳ级 Level IV		10 月 21 日 October 21

汛期，长江委组织会商156次，编发水旱灾害防御信息85期，启动水旱灾害防御应急响应7次，其中Ⅳ级1次8天、Ⅲ级6次共68天，先后派出35个工作组、专家组120人次指导抗洪抢险工作。黄委组织会商122次，启动水旱灾害防御应急响应6次，其中Ⅳ级3次、Ⅲ级3次，共65天，传达国务院领导指示批示精神和国家防总、水利部工作部署32份，编发黄河水旱灾害防御简报38期，先后派出78个工作组、专家组260人次指导抗洪抢险工作。特别是黄河秋汛期间，发布工作部署112份，向黄河防总总指挥报告黄河秋汛防御工作情况7次，向水利部水旱灾害防御司上报黄河洪水防御情况报告28期。淮委组织防汛会商71次，发出防汛通知17份、水旱灾害防御信息38期，启动水旱灾害防御应急响应5次，其中Ⅳ级1次13天、Ⅲ级4次共12.5天，先后派出17个工作组、专家组57人次检查指导暴雨洪水防御工作。海委组织会商116次，先后启动水旱灾害应急响应13次，其中Ⅳ级5次、Ⅲ级5次、Ⅱ级2次、Ⅰ级1次，先后派出46个工作组、专家组督导协助开展防洪调度及抢险等工作。珠江委组织会商103次，编发防汛抗旱简报、汛情通报95期，启动水旱灾害防御Ⅳ级应急响应7次共35天，派出6个工作组、专家组20人次协助地方开展水旱灾害防御和应急抢险工作。松辽委组织会商82次，启动水旱灾害防御应急响应6次，其中Ⅳ级3次、Ⅲ级3次，先后派出23个工作组、专家组80人次指导地方堤防巡查防守、水工程调度、险情处置等工作。太湖局组织会商219次，启动水旱灾害防御应急响应6次，其中Ⅳ级、Ⅲ级、Ⅱ级各2次，共52天，先后派出12个工作组、专家组36人次协助地方开展强降雨防御工作。

During the flood season, the Changjiang Commission organized 156 consultations, issued 85 briefings on flood and drought disaster prevention, and initiated 7 emergency responses against flood and drought disaster, including 1 time at Level IV for 8 days and 6 times at Level III for 68 days. In total 35 working groups and expert teams were sent down to guide flood fighting and rescue for 120 person-times. The Yellow River Commission organized 122 meetings and initiated 6 emergency responses for flood and drought disaster prevention, including 3 times at Level IV and 3 time at Level III for a total of 65 days. The Commission carried the instructions of the State Council, 32 communications of work arrangements from SFDH and MWR. It issued 38 flood and drought disaster prevention briefings on the Yellow River, and dispatched 260 person-times in 78 working groups and expert teams. Especially during the autumn flood season of the Yellow River, 112 communications of work arrangements were issued, 7 reports were submitted to the commander-in-chief of the Yellow River Flood Control and Drought Relief Headquarters, and 28 reports were submitted to the Department of Flood and Drought Disaster Prevention of MWR. The Huaihe River Commission organized 71 flood control meetings, issued 17 flood control notices, 38 briefings on flood and drought disaster prevention, and initiated 5 emergency responses against flood and drought disasters, including 1 time at Level IV for 13 days and 4 times at Level III for 12.5 days. In total 57 person-times in 17 working groups and expert teams were sent. The Haihe Commission organized 116 meetings and initiated 13 emergency responses against flood and drought disasters, including 5 times at Level IV, 5 times at Level III, 2 times at Level II, and 1 time at Level I. Successively 46 working groups and expert teams were sent. The Pearl River Commission organized 103 meetings, issued 95 briefings on flood control and drought relief briefings, and flood situation, initiated 7 emergency responses to flood and drought disasters of Level IV for 35 days, and sent 20 person-times in 6 working groups and expert teams to assist the local governments. The Songliao Commission organized 82 consultations and initiated 6 emergency responses against flood and drought disasters, including 3 times at Level IV and 3 times at Level III. The Commission sent 80 person-times in 23 working groups and expert teams to guide local dike inspections and defenses, water engineering scheduling, and de-risking. The Taihu Authority organized 219 consultations, initiated 6 emergency responses to flood and drought disasters, including 2 times at Level IV, 2 times at Level III, and 2 times at Level II for a total of 52 days, and sent 36 person-times in 12 working groups and expert teams to assist the local governments.

2.4.5 防洪调度

坚持“系统、统筹、科学、安全”原则，以流域为单元，联合调度运用水库、河道及堤防、蓄滞洪区等组成的流域防洪工程体系，科学安排洪水出路。流域、省、市、县 4 级共下达水库调度指令近 2.3 万道次，调度运用大中型水库 4347 座次，共拦蓄洪水 1390 亿立方米，极大地减轻了下游地区防洪压力。

长江委结合预测预报情况，统筹上下游、干支流、江河湖库防洪需求，科学精准调度以三峡为核心的长江上游水库群和以丹江口为核心的汉江上中游水库群拦洪削峰错峰，共发布调度指令 87 道次，印发调度意见 6 份，调度长江上中游控制性水库联合拦洪 386 亿立方米，有效应对长江上游、汉江流域多次较大洪水过程。黄委在防御秋汛过程中，实施水库群联合调度，在调度范围上，突出大空间尺度，大小水库能用尽用，同时利用三盛公、南水北调东线等工程增加洪水出路；在调度精度上，“一个流量、一方库容、一厘米水位、两小时为时段”精细调度水库，在确保水库安全和滩区不漫滩的前提下，充分发挥了水库拦蓄洪功能和河道排洪能力。淮委共发布调度指令 171 道次，协调流域有关省有效调度沙颍河周口闸、阜阳闸等敞泄行洪，调度昭平台水库、燕山水库等拦洪削峰，调度洪泽湖及沂沭泗重要闸坝分泄洪水，成功防御了沙颍河上游暴雨洪水，有效应对了台风“烟花”影响。海委强化水工程安全运行和科学调度，滚动优化实时调度方案，严格控制蓄泄关系，实施骨干水库、控制性枢纽、分洪河道等联合调度，最大限度发挥工程体系防灾整体作用，流域各河系 269 座次大中型水库共拦蓄洪水 84.55 亿立方米。珠江委会同流域各省（自治区）科学调度流域大中型水库 571 座次，拦蓄洪水 101 亿立方米。防御松花江流域性较大洪水期间，松辽委共制定水库调度方案 300 余个，先后下达水库调度指令 31 道次，科学调度尼尔基、察尔森等水库拦洪削峰错峰，有效应对嫩江、松花江洪水，规避了嫩江、黑龙江“两线作战”，为诺敏河洪水错峰，保障了嫩江干支流堤防安全。防御 2021 年太湖第 1 号洪水期间，太湖局持续应急响应 52 天，时长列近十余年来第 2 位；督促流域沿长江、沿杭州湾、沿海等工程全力排水，同时错峰调度太浦闸和望亭水利枢纽，统筹流域防洪与区域排涝，利用太湖拦蓄上游洪水 25 亿立方米，有效缓解下游防洪压力。

2.4.5 Flood control and dispatch

MWR adhered to the principle of being "systematic, coordinated, scientific, and safe", took the river basin as a whole, jointly dispatched and harnessed the river basin flood control engineering system (reservoirs, rivers, dikes, and flood detention and retention basins), and scientifically directed the passage of floods. Nearly 23,000 reservoir dispatch commands were sent to relevant departments at the river basin, provincial, municipal and county levels to operate 4,347 large and medium-sized reservoirs, retaining a total of 139 billion m^3 of flood and greatly reducing the flood control pressure in the downstream areas.

The Changjiang Commission combined the prediction and forecast to coordinate the flood control needs of the upstream and downstream, main stream and tributaries, rivers, lakes and reservoirs, and scientifically and accurately dispatch the reservoir group in the upper reaches of the Yangtze River (Three Gorges Reservoir as the core) and the reservoir group in the upper and middle reaches of the Hanjiang River (Danjiangkou Reservoir as the core), to retain floods, cut and delay peaks. A total of 87 dispatching instructions and 6 dispatching opinions were issued, dispatching the control reservoirs in the upper and middle reaches of the Yangtze River to retain floods of 38.6 billion m^3, effectively responding to many large floods in the upper Yangtze and the Hanjiang River basins. In the process of preventing autumn floods, the Yellow River Commission also implemented joint dispatch of reservoir groups. The dispatch scope was quite large so that both the large and the small reservoirs were fully tapped. At the same time, the Sanshenggong Project, Eastern Route of the South-to-North Water Diversion Project and other water projects were used to increase flood outlets. In terms of dispatch accuracy, reservoirs were dispatched by every 1 m^3/s, to every 1 m^3 of storage, to every one cm of water level, and in every two hours. On the premise of ensuring the safety of the reservoir and no overflow onto the floodplain area, the flood storage function of the reservoirs and the flood discharge capacity of the river channels were fully brought into play. The Huaihe Commission issued a total of 171 dispatching instructions to coordinate the relevant provinces in the basin to dispatch sluices such as the Zhoukou Gates and Fuyang Gates on the Shaying River to discharge floods, to dispatch the Zhaopingtai Reservoir and Yanshan Reservoir to retain floods and cut peaks, and to dispatch the gates and dams in the Hongze Lake and the Yihe-Shuhe-Sihe River System to discharge floods, successfully controlling the heavy rains and floods in the upper reach of the Shaying River and effectively reducing the impact of typhoon "In-Fa". The Haihe Commission strengthened the safe operation and scientific dispatch of water projects, rolled and optimized real-time dispatch plans, strictly controlled the relationship between storage and discharge, implemented joint dispatch of backbone reservoirs, controlling water complexes and flood diversion channels, and maximized the overall role of the engineering systems in disaster prevention. The 269 large and medium-sized reservoirs in the river systems of the river basin retained 8.455 billion m^3 of floods. The Pearl River Commission, together with the provinces/autonomous region of the river basin, scientifically dispatched the 571 large and medium-sized reservoirs in the basin to retain 10.1 billion m^3 of floods. When fighting the large floods in the Songhua River Basin, the Songliao Commission formulated more than 300 reservoir dispatching plans, issued 31 reservoir dispatching instructions successively, and scientifically dispatched reservoirs such as Nierji and Chaersen to retain floods, cut and delay peaks, effectively responding to the floods in the Nenjiang River and the Songhua River, avoiding simultaneous flooding in the Nenjiang River and the Heilong River, delaying flood peaks in the Nuomin River, and ensuring the safety of dikes in the main channel and tributaries of the Nenjiang River. When fighting the No. 1 Flood in Taihu Lake in 2021, the Taihu Authority initiated continuous emergency response for 52 days, the second longest duration in the past ten years. The Authority urged the projects along the Yangtze River, Hangzhou Bay, and the coastline to discharge floods in their full capacities, and at the same time dispatch the Taipu Gates and Wangting water complex to delay flood peaks, coordinating the basin-wide flood control and regional water-logging drainage, using the Taihu Lake to retain the upstream floods of 2.5 billion m^3 to effectively relieve the downstream flood control pressure.

案例 3 长江上游和汉江秋汛调度

2021 年，长江流域发生多次强降雨过程，主汛期多条支流发生超警戒洪水，长江上游及汉江流域发生明显秋汛。

防御长江上游秋汛期间，长江委调度三峡水库，将入库流量由 55000 立方米每秒削减至 28000 ~ 33000 立方米每秒，沙市、城陵矶水位控制在警戒水位以下 2.1 ~ 3.2 米，显著减轻了中下游地区防洪压力；联合调度乌东德、白鹤滩、溪洛渡、向家坝等水库，将金沙江 12000 立方米每秒左右的来水削减至 6500 立方米每秒左右；会同四川省水利厅调度亭子口水库，将出库流量控制在 700 立方米每秒，加快寸滩站水位退出警戒水位，减轻重庆市和川渝河段防洪压力。三峡及上游水库群共拦蓄洪水 116 亿立方米，其中三峡水库拦蓄 75 亿立方米。

防御汉江秋汛过程中，长江委联合调度丹江口和石泉、安康、潘口、黄龙滩、鸭河口等干支流控制性水库拦洪削峰错峰，累计拦蓄洪水总量 145 亿立方米，其中丹江口水库拦蓄 98.6 亿立方米，最大削峰率为 71%，降低汉江中下游干流洪峰水位 1.50 ~ 3.50 米，缩短超警戒水位天数 8 ~ 14 天，有效避免了丹江口以下河段超保证水位和杜家台蓄滞洪区分洪运用。

Case 3 Scheduling to cope with autumn floods in the upper reach of the Yangtze River and the Hanjiang River

In 2021, multiple heavy rainfall processes occurred in the Yangtze River basin. Floods above the warning water level occurred in many tributaries during the main flood season, and the pattern of autumn floods was apparent in the upper reach of the Yangtze River and the Hanjiang River basin.

During the autumn flood period in the upper reach of the Yangtze River, the Changjiang Commission commanded reducing the inflow to the Three Gorges Reservoir from 55,000 m^3/s to 28,000-33,000 m^3/s, and the water levels in Shashi and Chenglingji were controlled at 2.1-3.2 m below the warning water level, thereby significantly reducing the flood control pressure in the middle and lower reaches. The joint dispatch of reservoirs including Wudongde, Baihetan, Xiluodu, and Xiangjiaba reduced the inflow from the Jinsha River from about 12,000 m^3/s to about 6,500 m^3/s. Coordinating with the Sichuan Provincial Water Resources Department, the Commission regulated the Tingzikou Reservoir to discharge at 700 m^3/s, so as to draw down the water level at Cuntan Station from the warning water level as soon as possible, and to reduce the flood control pressure in Chongqing and the Sichuan-Chongqing section. The Three Gorges and its upstream reservoirs retained 11.6 billion m^3 of floodwater, of which 7.5 billion m^3 were stored in the Three Gorges Reservoir.

In coping with the autumn floods in the Hanjiang River, the Changjiang Commission jointly dispatched the controlling reservoirs on the main-stems and tributaries (including Danjiangkou, Shiquan, Ankang, Pankou, Huanglongtan, and Yahekou reservoirs) to retain floods, and cut and delay peaks. The total amount of retained floodwater was 14.5 billion m^3. The Danjiangkou Reservoir retained 9.86 billion m^3 with the maximum peak shaving rate of 71%. This worked to reduce the flood peak level of the middle and lower reaches of the Hanjiang River by 1.5-3.5 m and shorten the duration of floods above the warning water level by 8-14 days, thereby effectively avoiding floods above the guaranteed water level in the river sections downstream of the Danjiangkou Reservoir and also avoiding activating the Dujiatai flood detention and retention basin.

案例 4 黄河秋汛调度

2021 年 8 月下旬至 10 月底，黄河中下游遭遇新中国成立以来最严重秋汛，干流共形成 3 次编号洪水，潼关站发生 1979 年以来最大洪水。为有效应对罕见秋季洪水过程，李国英部长 4 次视频连线黄委及相关省，密切、滚动、连续做好“四预”工作。黄委按照“系统、统筹、科学、安全、依法”的原则，成立工作专班，加密调度频次，逐时段滚动预报预警预演，联合调度黄河中游干支流骨干水库拦洪削峰错峰运用，最大限度挖掘支流水库防洪运用潜力。

秋汛前期（8 月 20 日至 9 月 17 日），泾渭河、伊洛河发生多场洪水，黄河黑石关站 9 月 2 日 10 时 30 分洪峰流量 1890 立方米每秒，潼关站 9 月 7 日 21 时 36 分洪峰流量 3300 立方米每秒。联合调度三门峡、小浪底、陆浑、故县水库，以控制黄河下游不出现编号洪水为目标拦洪错峰运用，在确保防洪安全的前提下兼顾洪水资源化利用。将花园口站还原后的天然洪水流量由最大 6180 立方米每秒削减为 2390 立方米每秒，有效减轻了黄河下游河道和滩区防洪压力。秋汛关键期（9 月 18 日至 10 月 19 日），渭河、伊洛河、沁河等支流发生多场洪水，黄委按照水利部“人员不伤亡、洪水不漫滩、工程不跑坝”的洪水防御目标，综合考虑秋汛洪水特点、下游保滩需求及“二级悬河”等因素，坚持每 2 小时滚动修订水库调度方案，以时段 30 分钟、流量 50 立方米每秒为调度控制单元，精细实施三门峡、小浪底、陆浑、故县、河口村水库联合调度，洪水前陆浑、故县、河口村等支流水库预泄腾库，洪水到达后干支流水库全力拦洪保滩运用，尽量缩短小浪底水库高水位持续时间，同时利用引调水工程为洪水寻找出路。经干支流水库联合防洪调度，将花园口站天然洪水最大流量 12500 立方米每秒（还原后）削减至 5220 立方米每秒，保障了下游滩区防洪安全。秋汛退水期（10 月 20—31 日），综合考虑落水期下游河段水位变化、工程出险和河势变化等因素，小浪底水库逐步压减下泄至发电流量，控制库水位不超过 270 米，万家寨、三门峡、陆浑、故县、河口村水库水位逐步向非汛期运用水位和正常蓄水位过渡。

拦洪运用期间，河口村水库最高水位 279.89 米，故县水库最高水位 536.59 米，陆浑水库最高水位 319.39 米，小浪底水库最高水位 273.50 米，除陆浑水库外均创历史新高。小浪底水库最大削峰率 85%，故县、陆浑、河口村水库最大削峰率为 59% ~ 91%。9 月 27 日至 10 月 20 日，花园口站平均日均流量 4783 立方米每秒，调度误差 −0.35%，两次将花园口站天然洪峰流量由超 10000 立方米每秒削减至 5000 立方米每秒左右，避免了下游滩区 140 万人转移和 266 千公顷耕地受淹。

Case 4 Scheduling to cope with autumn floods in the Yellow River basin

From the end of August to the end of October 2021, the middle and lower reaches of the Yellow River suffered the worst autumn flood since 1949. The main-stem experienced three numbered floods, and the Tongguan Station recorded the largest flood since 1979. In response, Minister Li Guoying reached out and listened to updates from the Yellow River Commission and related provinces and urged them on enhancing the four preemptive pillars in close, timely, and non-stop manner. In accordance with the principle of being “systematic, coordinated, scientific, safe, and legal”, the Yellow River Commission set up a special task force, increased the frequency of dispatching, implemented forecast, early warning and exercises on an hourly basis, jointly dispatched the backbone reservoirs of the main-stem and tributaries of the middle reach of Yellow River to retain floods and shave peaks, and maximize the flood control and operation capacity of reservoirs on tributaries.

During the early period of the autumn flood season (August 20 to September 17), multiple floods occurred in the Jinghe-Weihe River and the Yiluo River. The peak flow at the Heishiguan Station on the Yellow River was 1,890 m^3/s at 10:30 on September 2, and that of Tongguan Station was 3,300 m^3/s at 21:36 on September 7. The Sanmenxia, Xiaolangdi, Luhun and Guxian Reservoirs were jointly dispatched to retain floods and delay peaks to prevent numbered floods from happening in the lower reaches of the Yellow River, while taking into account the safe utilization of flood resources. The peak flow at Huayuankou Station was reduced from a maximum of 6,180 m^3/s (calculated) to 2,390 m^3/s, effectively reducing the flood control pressure in the lower reach of the Yellow River and the floodplain areas. During the gravest period of autumn flood (from September 18 to October 19), many floods occurred in the tributaries of the Weihe River, Yiluo River and Qinhe River. The Yellow River Commission acted on the flood defense goal set by MWR to ensure “no casualties, no flooding over the banks, and no embankment displacement” in the Yellow River, while taking into account the characteristics of autumn flood, the demand for floodplain protection in the downstream area, as well as the existence of suspended rivers, etc. Consequently, the Commission managed to update the reservoir operation plans every 2 hours and narrowed the scheduling time unit by a 30-minute period and regulated the flow by every 50 m^3/s for Sanmenxia, Xiaolangdi, Luhun, Guxian and Hekoucun Reservoirs. Before the flood set in, reservoirs on the tributaries such as the Luhun, Guxian and Hekoucun were drawn down in advance. When the flood arrived, reservoirs on the main-stem and the tributaries work in full capacity to retain the floods and protect the floodplain, so as to shorten the duration of high water level in the Xiaolangdi Reservoir as much as possible. Water diversion projects were also used to make room for the floods. Through the joint flood control operation of the reservoirs on the main-stem and the tributaries, the maximum natural flood flow of 12,500 m^3/s (calculated) at Huayuankou Station was reduced to 5,220 m^3/s, ensuring the safety of flood control in the downstream floodplain areas. During the period when the autumn flood retreated (October 20-31), taking into account factors such as water level changes in the lower reach of the river during the flooding period, engineering risks and potential changes in river regimes, etc., the Xiaolangdi Reservoir gradually reduced the discharge to what can sustain the power generation requirements, and the water level was controlled to not exceed 270 m. The water levels in Wanjiazhai, Sanmenxia, Luhun, Guxian, and Hekoucun Reservoirs gradually transitioned to the non-flood season operating water level and normal water storage level.

During the flood retaining period, the highest water level of Hekoucun Reservoir was 279.89 m, Guxian Reservoir 536.59 m, Luhun Reservoir 319.39 m, and Xiaolangdi Reservoir 273.50 m. Except for the Luhun Reservoir, all reached record highs. The maximum peak shaving rate of Xiaolangdi Reservoir was 85%, while that of Guxian, Luhun and Hekoucun Reservoirs was between 59% and 91%. From September 27 to October 20, the average daily flow of Huayuankou Station was 4,783 m^3/s, with a scheduling deviation of -0.35%. The natural peak flow of Huayuankou Station was reduced to about 5,000 m^3/s twice from beyond 10,000 m^3/s, thereby avoiding the evacuation of 1.4 million people in the downstream floodplain area and the inundation of 266,000 hectares of cropland.

案例 5 2021 年漳卫河系洪水调度

2021 年入汛后，海河流域局地极端强降雨多发频发，漳卫河先后形成 2 次编号洪水，发生历史罕见的夏秋连汛。

夏汛期间（6 月 1 日至 8 月 20 日）：自 7 月 19 日起，卫河支流淇河盘石头水库开始拦洪，最大入库洪峰流量 2712 立方米每秒（超过建库以来最大值），最大下泄流量 303 立方米每秒，削峰率 88.83%，至 8 月 20 日共拦蓄洪水 2.49 亿立方米，有效控制了淇河入卫河洪水。7 月 19—23 日，岳城水库拦蓄洪水，零下泄，削峰率 100%。7 月 23 日卫河洪峰过后，调度岳城水库泄洪，至 27 日最大下泄流量 700 立方米每秒。7 月 28 日，根据台风“烟花”将影响漳卫河下游地区预测预报结果，调度岳城水库闭闸错峰，全力拦蓄漳河上游来水，大幅减轻下游山东、河北等地防洪压力，为下游地区防范应对台风“烟花”创造了有利条件。7 月 21 日 19 时至 30 日 0 时，河南省相继启用了崔家桥、广润坡、共渠西、良相坡、柳围坡、长虹渠、白寺坡、小滩坡 8 个蓄滞洪区，最大蓄洪量 10.68 亿立方米，淹没面积 781.41 平方公里，转移避险 64.69 万人，通过启用蓄滞洪区，有效缓洪滞洪，减轻了下游防洪压力，未发生人员伤亡。

秋汛期间（8 月 21 日至 10 月 20 日）：海委下足“绣花”功夫，在狭小的调度空间内连续实施精细化调度，力求做到“流量控制到 1 立方米每秒、水位控制到 1 厘米”，共计调度岳城水库 27 次，最高运用至 152.30 米，远超历史最高库水位（149.08 米，1971 年），努力克服水库调度存在的移民征地限制问题，充分发挥流域协调、联动机制，紧急实施漳河上游水库群联合调度，避免了大名蓄滞洪区启用，最大限度减少了下游淹没损失和群众转移。河南省自 9 月 28 日起将盘石头水库下泄流量从 180 立方米每秒逐步压减至 50 立方米每秒，小南海、彰武等水库适时闭闸错峰，在降低了良相坡、共渠西等蓄滞洪区启用概率的同时，大幅减轻了下游卫运河和漳卫新河的防洪压力。在下游洪水防御过程中，沿河各地、上下游、左右岸协同发力，天津市调引南运河洪水资源补充北大港水库和沿线生态用水，9 月 26 日 16 时四女寺枢纽南运河节制闸开闸，至 10 月 31 日累计下泄 2.65 亿立方米，既减轻上游洪水压力又充分实现洪水资源化利用，为河北省衡水及沧州地区地下水回补、天津北大港水库蓄水发挥了重要作用；山东省抓住有利时机向马颊河分洪，降低漳卫新河河道水位。至 10 月 15 日 4 时，洪峰平稳通过漳卫河系最后一道控制性工程辛集闸，洪峰流量 947 立方米每秒。

Case 5 Scheduling to cope with the floods in the Zhanghe−Weihe River System in 2021

Since the flood season began, extreme rainfall occurred frequently in the Haihe River basin, and the Zhanghe-Weihe River withstood two numbered floods in succession, resulting in rare summer and autumn floods.

During the summer flood period (June 1 to August 20): Since July 19, the Panshitou Reservoir on the

Qihe River, a tributary to the Weihe River, began to hold back floodwater, with a maximum inflow of 2,712 m^3/s (exceeding the maximum inflow since the establishment of the reservoir), a maximum discharge flow of 303 m^3/s, and a peak shaving rate of 88.83%. By August 20, a total of 249 million m^3 of floodwater was detained and retained, and floodwater from the Qihe River into the Weihe River was controlled. From July 19 to 23, the Yuecheng Reservoir held back floodwater and stopped discharging at all, meaning the peak shaving rate was 100%. After the flood peak in the Weihe River was gone on July 23, Yuecheng Reservoir was dispatched to discharge floodwater, and the maximum discharge rate was 700 m^3/s on the 27th. On July 28, according to the forecast that Typhoon "In-Fa" was to affect the lower reaches of the Zhanghe-Weihe River, Yuecheng Reservoir closed the gates and delay the flood peaks, thereby holding back water from the upper reaches of the Zhanghe River and greatly easing the flood control pressure in provinces like Shandong and Hebei downstream, and allowing for greater maneuvers downstream to prevent and respond to typhoon "In-Fa". From 19:00 on July 21 to 0:00 on July 30, Henan Province successively activated 8 flood detention and retention basins, namely Cuijiaqiao, Guangrunpo, Gongquxi, Liangxiangpo, Liuweipo, Changhongqu, Baisipo and Xiaotanpo, with a maximum flood storage of 1.068 billion m^3. In total 781.41 km^2 were inundated and 646,900 people evacuated to avoid danger. The flood detention and retention basins worked effectively to alleviate flood control pressures downstream, and no casualties occurred.

During the autumn flood period (August 21 to October 20): the Haihe Commission was meticulous in refining the precise scheduling even when the room for maneuvering was limited, with the goal of "regulating the flow by every 1 m^3/s and the water level by every 1 cm". Yuecheng Reservoir was operated 27 times. Its water level was once raised to 152.30 m, far exceeding its highest level ever (149.08 m,1971). Considering the limitations created by resettlement requirements in cases of reservoir impoundment, basin-wide coordination and linkage was initiated and reservoirs in the upper reaches of the Zhanghe River were urgently scheduled. As a result, the Daming flood detention and retention basin was not used and hence inundation and population relocation were minimized. Since September 28, Henan Province had gradually reduced the discharge from Panshitou Reservoir from 180 m^3/s to 50 m^3/s, and reservoirs like Xiaonanhai and Zhangwu were timely shut down to delay the flood peaks. It greatly reduced the flood control pressure in the downstream Wei Canal and Zhangwei New River while reducing the activation probability of flood detention and retention basins such as Liangxiangpo and Gongquxi. In fighting the floods downstream, all regions along the river, in the upstream and the downstream, and on the left and right banks made concerted efforts. Tianjin Municipality transferred the floodwater from the South Canal to supplement the Beidagang Reservoir and ecological flow along the route. At 16:00 on September 26, the South Canal control gate at the Sinvusi water conservancy complex was opened and a total of 265 million m^3 were discharged by October 31. It not only reduced the upstream flood pressure but also fully harnessed the flood resources, and contributed to the recharge of groundwater in Hengshui and Cangzhou areas and the storage of water in Tianjin Beidagang Reservoir. Shandong Province smartly diverted floodwater to the Majia River and reduced the water level in the Zhangwei New River. By 4:00 on October 15, the flood peak safely passed through the Xinji Gate, the most downstream control project on the Zhanghe-Weihe River System, and the peak flow was 947 m^3/s.

案例 6 嫩江 3 次编号洪水调度

2021 年，嫩江发生 3 次编号洪水，干流及 13 条支流发生超警戒洪水，其中 9 条河流发生超保证洪水，3 条河流发生建站以来最大洪水，诺敏河发生特大洪水。

洪水期间，在水利部指导下，松辽委科学精细调度尼尔基水库，充分发挥骨干水库拦洪削峰错峰作用。在应对 3 次编号洪水调度中，尼尔基水库共拦蓄洪水 26 亿立方米，最大削峰率分别为 61.6%、100%、39.5%，有效降低嫩江干流水位 0.37 ~ 1.27 米，实现了李国英部长提出的避免黑龙江省"两线作战"的工作目标。特别是 7 月 18 日嫩江支流诺敏河发生特大洪水时，自 16 时 45 分起关闭尼尔基水库溢洪道闸门和发电机组，出库流量由 1300 立方米每秒减小至零，并持续 27 小时零出流，共拦蓄洪水 2.84 亿立方米，降低了嫩江干流同盟以下江段水位 0.37 ~ 0.60 米，避免了嫩江同盟至富拉尔基江段水位超警戒、大赉江段水位超保证，有效保障了嫩江汉古尔堤及诺敏河干流堤防防洪安全。同时，松辽委每日滚动会商研判，强化监测预报和信息共享，及时启动应急响应，累计派出 10 个工作组赶赴防汛一线检查指导工作，派出 2 个调查组专题调研干流洪水演进和河道内围堤影响情况。

Case 6 Scheduling to cope with the No. 3 flood in the Nenjiang River

In 2021, there were 3 numbered floods in the Nenjiang River, floods above the warning water level hit the main-stem and 13 tributaries, of which 9 rivers experienced floods above the guaranteed water level, 3 rivers experienced the largest flood since the establishment of the stations, and the Nuomin River experienced extreme floods.

During the floods, under the guidance of MWR, the Songliao Commission dispatched the Nierji Reservoir and gave full play to the role of the backbone reservoirs in flood control and peak shaving. In response to the three numbered flood, the Nierji Reservoir held back a total of 2.6 billion m^3 of floodwater, and the maximum peak shaving rates were 61.6%, 100% and 39.5%, respectively. As a result, the water level of the main-stem Nenjiang River was reduced by 0.37-1.27 m, and the goal of avoiding "fighting on two fronts" in Heilongjiang Province raised by Minister Li Guoying was realized. In particular, when an extreme flood occurred in the Nuomin River, a tributary to the Nenjiang River, on July 18, the spillway gates and generation units of the Nierjii Reservoir were shut down from 16:45; the outflow was reduced from 1,300 m^3/s to zero and remained zero for 27 hours, holding back 284 million m^3 of floodwater. The water level in the section downstream the Tongmeng station on the main-stem Nenjiang was reduced by 0.37-0.60 m, the water level in the Tongmeng-Fularji reach on the Nenjiang did not go beyond the warning level, and the water level in the Dalai River reach did not go beyond the guaranteed level, thereby protecting the Hangur dike on the Nenjiang and the dikes on the main-stem Nuomin River. At the same time, the Songliao Commission held on-call working meetings to assess the situation, strengthen monitoring, forecasting and information sharing, and timely initiate emergency response. A total of 10 working groups were sent down to the front line for inspection and guidance, and 2 survey teams were sent to investigate the flooding development in the main stream and the impact on the embankments in the river channels.

2.4.6　部门协作

水利部强化部门合作，向国家防总、应急管理部通报实时汛情和预测预报情况，共享水情信息，先后通报汛情信息 61 期；会同发展改革委、财政部、住房和城乡建设部稳步推进防汛抗旱水利提升工程实施；商财政部下达中央水利救灾资金 29 亿元，其中洪涝部分 22.5 亿元，用于支持地方做好安全度汛、水毁修复等工作；完善水利、气象部门联合发布天气预报的工作机制，发布气象预警 145 期。各流域管理机构坚持流域统筹，做好信息共享、方案协调、统一调度等工作。地方各级水利部门上下联动、密切配合，细化实化各项防御措施，形成了水旱灾害防御强大合力。

2.4.6　Cross-departmental collaboration

MWR strengthened cross-departmental collaboration by notifying the SFDH Office and the Ministry of Emergency Management of real-time flood and forecast conditions and sharing water regime information, sharing with them 61 briefings of flood information. The Ministry also steadily improved flood control and drought mitigation projects in collaboration with the National Development and Reform Commission, the Ministry of Finance, and the Ministry of Housing and Urban-Rural Development. The Ministry allocated flood and drought disaster relief fund billing 2.9 billion RMB in consultation with the Ministry of Finance, including 2.25 billion RMB for fighting floods and supporting local governments to ensure safety of flood control and repair water-damaged works. The Ministry improved the working mechanism between water resources and meteorological departments to jointly issue 145 editions of meteorological warnings. All river basin management agencies adhered to the overall basin-wide plannings and implemented information sharing, plan coordination and unified scheduling. Local water resources departments at all levels made linked efforts and cooperated closely to refine and implement various prevention measures, forming a strong joint force for flood and drought disaster prevention.

2.4.7 抢险支撑

全国水利部门全力做好抢险技术支撑工作，共派出 1.3 万组次、5.1 万人次水利专家，奋战在沿江滨河环湖抗洪一线，指导协助处置各类工程险情，成功处置了河南浚县卫河新镇镇河段堤防决口、湖北竹溪县鄂坪水库溢洪道局部水毁、西藏定日县绒辖河堰塞湖等险情。秋汛高峰期，9.9 万名党员干部和群众日夜坚守在黄河、漳卫河防汛一线，加强堤防、河势控导工程等重点部位巡查防守，及时抢护险情。在南水北调工程险情处置中，水利部派出水利专家组驻守现场，建管单位科学应对、日夜奋战、巡查排险，有效处置各类险情，确保了重要基础设施安全。在应对 8 月湖北随州、襄阳等地暴雨灾害过程中，当地水利部门落实驻坝巡查值守、转移避险和应急抢护等措施，通过采取扩挖溢洪道、加筑子堤、铺设彩条布防护大坝背水坡等措施，有效控制了 5 座水库漫坝险情，保障了大坝主体完好，无一人伤亡。

2.4.7 Rescue support

Water resources departments nationwide made every effort in supporting emergency rescue, sending 51,000 person-times of water experts in 13,000 group-times to the front line of flood fighting along rivers and lakes, guiding and assisting in the response to various engineering dangers. They successfully handled the dike breach in the Xinzhen Township section of the Weihe River in Jun County, Henan Province, the partial flood-damaged spillway of the Eping Reservoir in Zhuxi County, Hubei Province, and the barrier lake in the Rongxia River, Tingri County, Tibet Autonomous Region. During the peak period of the autumn flood season, 99,000 CPC members, cadres and citizens stayed on front line of the Yellow River and Zhanghe-Weihe River day and night, strengthening the inspection and defense of key parts such as dikes and river control works, and promptly responding to emergencies. When handling hazards in the South-to-North Water Diversion Project, MWR sent a water expert group to the site, and the construction and management agencies responded scientifically, fought day and night, inspected and averted risks, effectively handled various dangerous situations, and ensured the safety of important infrastructure. In response to heavy rain disasters in Suizhou, Xiangyang and other places in Hubei Province in August, the local water resources department implemented measures such as dam inspection and arrangement of persons on duty, relocation to avoid dangers, and emergency rescue. By taking measures such as expanding spillways, adding sub-dikes, and laying colored stripes to protect the backwater slope of the dam, the local water resources departments effectively subdued the hazards of five reservoirs and ensured that the main body of the dam was intact and no one was injured or killed.

案例 7 湖北竹溪县鄂坪水库溢洪道险情处置技术支撑

2021 年 8 月 25—30 日，湖北十堰市竹溪县鄂坪水库上游镇坪县发生特大暴雨，过程降水量 195.8 毫米，加之上游水库泄洪影响，鄂坪水库发生了重现期为 20 年的大洪水过程，启用溢洪道泄洪。8 月 30 日 15 时，溢洪道运行异常，溢洪道泄槽末端连接挑流鼻坎反弧段的连接段被冲毁，溢洪道右侧边墙外山体局部垮塌沉陷。

险情发生后，水利部专家组、长江委专家组连夜出发，于 9 月 2 日清晨抵达现场，立即查看了溢洪道泄槽末端与挑流鼻坎反弧段连接段的水毁情况，初步判断溢洪道水毁险情的主要原因是地质条件差、混凝土结构带病运行等，在长时间、高强度泄洪时，高速水流将泄槽和挑流鼻坎的部分混凝土结构和基岩冲毁、淘空，形成冲坑，并导致右岸山体局部垮塌。针对现场情况，专家组立即与省应急厅、省水利厅、十堰市政府等相关部门研究制订应急抢险方案，商讨落实省政府的意见。讨论认为，溢洪道抢修的重点是覆盖被冲蚀暴露的侧墙和底板的基岩，保持侧墙稳定，防止基岩淘刷，通过回填浇筑混凝土尽量恢复泄槽体型，并加强短龄期混凝土的表面保护，使溢洪道尽快具备过流条件；加强大坝、溢洪道、山体、边坡的巡视、监测、检查，对发现的隐患和缺陷尽可能采取修复措施，密切关注各建筑物的运行状态；排查下游影响区域群众，做好转移安置工作。

9 月 3 日，考虑到溢洪道抢险现场施工面狭窄、施工进度不理想，专家组与湖北省水利厅和现场指挥部进行会商，认为应尽量简化施工工序，减少混凝土浇筑量，将原恢复溢洪道过流断面的方案调整为在现有回填混凝土基础上浇筑数级台阶 + 倾斜断面，利用钢板支模和保护的方案。9 月 4 日凌晨，值班人员发现现场未按预定的抢险方案实施，专家组成员立即赶赴现场研究处理。考虑到现场工期紧迫，经会商，专家组原则上同意现场已完成的施工现状，但针对存在的结构单薄、稳定性差、新浇混凝土抗冲能力差等问题，提出了相应的整改措施和下一步的施工方案。

9 月 5 日，根据水情测报和溢洪道状态，专家组讨论制定了应对即将来临洪水的初步调度方案：从 5 日 20 时 30 分起，下泄流量由 30 立方米每秒逐渐加大至 500 立方米每秒，待洪峰过后逐渐减小泄量，并视水情、险情随时调整泄量。6 日 10 时 50 分溢洪道泄量加大至 500 立方米每秒，运行半小时后溢洪道泄槽底板再次发生损坏，经研判建议溢洪道泄量立即减小至 300 立方米每秒。此后泄槽底板破坏范围无明显扩大，故又将泄量逐渐加大至 590 立方米每秒。7 日 6 时 25 分，溢洪道左侧边墙基础被水流击穿，部分水流冲入左侧边墙与山体之间，经研判认为该破坏影响不大，不需减小泄量，但要密切关注该破坏的发展。4 小时后该破坏基本稳定，险情应急处置结束。

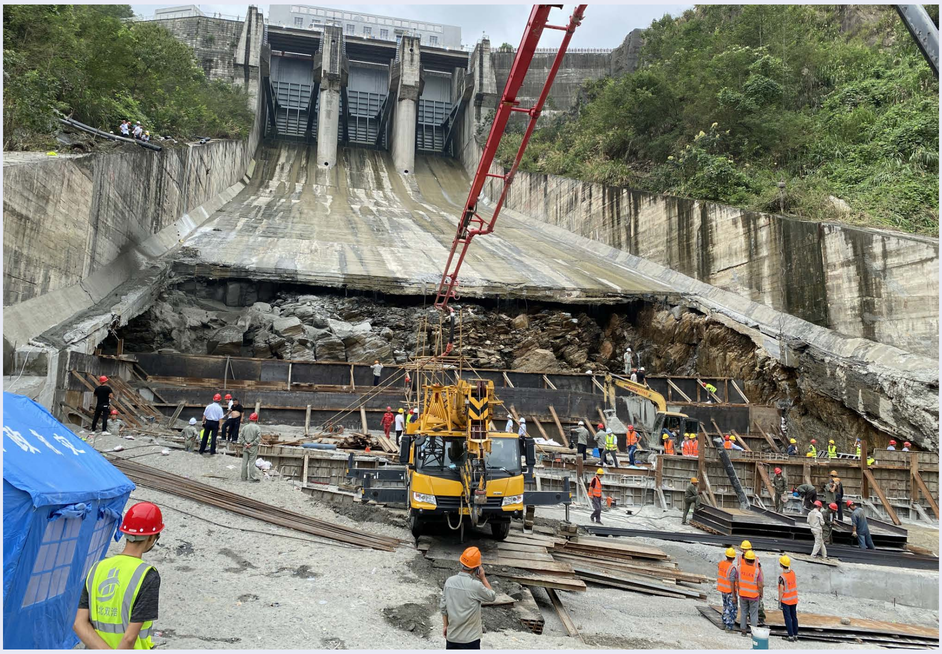
Case 7 Elimination of the spillway hazard at Eping Reservoir, Zhuxi County, Hubei Province

From August 25 to 30, 2021, an extreme rainstorm lashed Zhenping County (upstream of the Eping Reservoir in Zhuxi County, Shiyan City, Hubei Province) and dumped a period precipitation of 195.8 mm. With additional impact of flood discharge from the reservoirs upstream, the Eping Reservoir experienced a major 20-year flood process and had to open its spillway. At 15:00 on August 30, the spillway was functioning ill, with the connecting section between the reverse-arc section of the deflecting nose bridge and the spillway chute end being washed away, and the mountain mass outside the right side wall of the spillway partially collapsed and subsided.

One expert group from MWR and another from the Changjiang Commission set out overnight and arrived at the site in the early morning of September 2. Damages to the connecting section between the reverse-arc section of the deflecting nose bridge and the spillway chute end were checked, and it was suspected that the main causes were poor geological conditions and the concrete structure being ill-serviced. During long-term and high-intensity flood discharge, the jet streams washed away, scoured, and formed cavities at part of the concrete structure and bedrock of the chute and the deflecting nose bridge, and led to the partial collapse of the mountain body on the right bank side. The expert groups studied and formulated emergency plans with the Provincial Emergency Management Department, the Provincial Water Resources Department, the Shiyan Municipal Government and other relevant departments, and discussed on how to implement the opinions of the provincial government. It was concluded during the discussions that the focus of spillway emergency repair was to cover the eroded and exposed bedrock of the side wall and the floor, keep the side wall stable, prevent bedrock scouring and erosion, restore the shape of the chute as much as possible through concrete back filling and placing, and strengthen the surface protection of freshly placed concrete, so that the spillway could allow for flood passage as soon as possible. In addition, patrolling, monitoring and inspection of dams, spillways, mountain bodies and slopes were stepped up, prompt rectification was made to eliminate hazard risks, and the operation status of each facilities and structure was under close watch; investigation of affected communities downstream and proper relocation was made.

On September 3, considering the narrow construction access at the spillway damage site and the unsatisfactory progress, the expert groups consulted with the Hubei Provincial Water Resources Department and the on-site command and suggested that the construction process should be simplified as much as possible and the amount of concrete placing be reduced. The original plan of restoring the spillway overflow section was proposed to be changed to placing stepped concrete and an inclined cross-section on the existing back-filled concrete foundation, using steel plate formed supports. In the early morning of September 4, the personnel on duty found that the preciously agreed plan was not followed at the construction site, and members of the expert groups immediately went back to the site to check and study. Considering the time is pressing, after consultation, the expert groups approved in principle the status quo at the construction site, and put forward corresponding rectification measures and next steps of construction in order to address risks such as thin structure, poor stability and poor impact resistance of newly placed concrete.

On September 5, judging from the water regime forecasting and spillway status, the expert groups discussed and drafted a preliminary flood dispatch plan for the upcoming flood: from 20:30 on the 5th, the discharge will gradually increase from 30 m^3/s to 500 m^3/s; it would gradually decrease after the flood peak and be adjusted dynamically according to the development of the water regime and the hazard. At 10:50 on September 6, discharge from the spillway increased to 500 m^3/s; half an hour later, damages occurred at the floor of the spillway chute again, and it was suggested that the spillway discharge be immediately reduced to 300 m^3/s. Since then, the damage range of the chute floor had not increased notably, so the discharge gradually was raised to 590 m^3/s. At 6:25 on September 7, the foundation of the left side wall of the spillway was pierced through by the water current, and part of the water stream ran to the area between the left side wall and the mountain body. It was believed that the damage had limited impact, hence no need to reduce the flow but only a close watch. Four hours later, the destruction was basically stable, and the emergency response to the spillway hazard was over.



鄂坪水库水毁现场（9 月 5 日）
Flood damage site of Eping Reservoir（September 5）

2.4.8 消除隐患

汛前，各地加快推进防洪工程水毁修复进度，加大河道“清四乱”力度，累计拆除违法建筑 4700 多万平方米，清除阻水围堤 1 万多公里，畅通和扩大行蓄洪空间。组织 39 个督导检查组开展水利工程安全隐患专项排查，共排查 769 个安全隐患并督促整改到位。派出 1092 组次、3522 人次对防汛关键环节开展明察暗访，发现问题立即督促整改。抽查 7296 座水库责任人履职情况，督查 1057 座大中型水库调度运用和汛限水位执行情况，共发现问题 323 个并督促整改。汛期，严格执行大中型水库调度运用规定和汛限水位监管规定，病险水库主汛期原则上一律空库运行；针对水库垮坝、堤防决口等事件，先后派出多个调查组进行调查评估，指导防汛工作。汛后，开展了覆盖范围最广、参与部门最多、查找问题最深的水旱灾害防御“大体检”，全面部署防汛查弱项、补短板工作，为打赢防汛抗洪硬仗奠定坚实基础、做好充分准备。

2.5 防御成效

2.5.1 保障了防洪安全

2021 年，水利部组织联合调度运用水库、河道及堤防、蓄滞洪区，有效应对了江河洪水，有力保障了防洪安全。长江委按照“依法防控、科学防控，坚持统一调度、团结抗洪”的工作原则，成功应对了流域多轮强降雨过程和台风“烟花”，有效防御了长江 2021 年 1 号洪水和长江上游及汉江、嘉陵江等河流多轮秋季洪水，取得了长江流域防汛抗洪的胜利。黄委强化“四预”措施，实施大范围、高精度水库群联合调度，全力迎战新中国成立以来最严重的黄河秋季洪水，避免了下游 140 万名群众转移、266 千公顷耕地受淹，实现了“人员不伤亡，洪水不漫滩，工程不跑坝”的防御目标。海委组织协调流域各地抓细抓实各项防御措施，有效应对了漳卫河历史罕见夏秋连汛，为流域防洪安全和经济社会发展提供了有力保障。淮委统筹上下游、干支流、河湖库防洪需求，采取泄、分、控、蓄等综合措施，科学精准调度水工程，有效保障了流域防洪安全。珠江委以流域大中型水库汛限水位“线上＋线下”监管为手段，以强化小型水库落实“三个责任人”“三个重点环节”为核心，突出病险水库监管，全力抓好水库安全度汛工作。松辽委压实防汛责任、强化预测预报预警、加强会商研判、科学精细调度、强化信息报送与共享，有效应对黑龙江干流上游特大洪

2.4.8 Risk elimination

Before the flood season, all local governments sped up repairing flood control projects that had been damaged by floods, stepped up efforts to eliminate river space encroaching, illegal dredging, littering, and illegal in-river construction. More than 47 million m^2 of illegal buildings were demolished, more than 10,000 km of water blocking dikes were removed, and the flood storage space was cleared and expanded. Thirty-nine supervision and inspection teams were organized to carry out special investigation of potential hazards in water projects, with a total of 769 potential hazards investigated and rectified in place. A total of 3,522 person-times in 1,092 group-times were sent to conduct both announced and unannounced inspections to key links of flood control, and rectifications were immediately urged when problems were found. Performances of the responsible persons of 7,296 reservoirs were randomly checked, and the operation of 1,057 large and medium-sized reservoirs and the implementation of flood control water level were supervised. A total of 323 problems issued for identified and urged for rectification. During the flood season, regulations were strictly implemented on the operation of large and medium-sized reservoirs and on the supervision of the flood control water level. In principle, all hazard-prone reservoirs will operate empty during the main flood season. In response to incidents such as dam collapse and dike breach, multiple investigation teams were sent to investigate, evaluate and guide the flood control work. After the flood season, wide, thorough,and extensive forensic studies were carried out to find where the weakest links of flood control lied and how things should be improved. These work paved the way for fighting the arduous and harsh battle against flood disasters in 2021.

2.5 Effectiveness of Flood Disaster Prevention

2.5.1 Flood control safety

In 2021, MWR commanded the joint dispatch and operation of reservoirs, river channels, dikes, and flood retention and detention basins to effectively cope with river floods and ensure flood control safety. The Changjiang Commission conducted flood prevention and control based on rule of law and sciences, and implemented coordinated scheduling in unison. The Commission was successful in fighting against multiple rounds of heavy rainfall and typhoon “In-Fa”, and also the 2021 No. 1 flood of the Yangtze River and multiple rounds of autumn floods in the upper reaches of the Yangtze River, the Hanjiang River, and the Jialing River. The Yellow River Commission strengthened the four preemptive pillars of disaster prevention, implemented large-scale and high-precision reservoir group joint dispatch, fought the worst autumn flood in the Yellow River since 1949, and hence avoided the transfer of 1.4 million people downstream and the flooding of 266,000 hectares

水、中游大洪水，松花江流域性较大洪水及嫩江、松花江编号洪水，确保流域防洪安全。太湖局全力落实“四预”措施，科学调度工程，全力防御台风“烟花”暴雨和盛夏连阴雨，切实确保防洪安全，及时实施引江济太，有力保障供水安全。

2.5.2 减少了灾害损失

2021 年汛期，全国有 4347 座次大中型水库投入拦洪运用，拦洪量 1390 亿立方米，11 个国家蓄滞洪区投入分蓄洪运用，分蓄洪水 13.28 亿立方米；全国减淹城镇 1494 座次，减淹耕地 1689.36 千公顷，避免人员转移 1524.63 万人次，最大程度保障了人民群众生命财产安全。

表 2-5 2021 年各流域减淹城镇、耕地及避免人员转移情况
Table 2-5 Cities/towns and cropland protected from floods, and population avoiding evacuation

流域 River/lake basin	减淹城镇 / 座次 Cities/towns cumulatively protected from floods	减淹耕地 / 千公顷 Cropland protected from floods/1,000 hectares	避免人员转移 / 万人次 Population avoiding evacuation/10,000 person-times
全国 Nationwide	1494	1689.36	1524.63
长江流域 The Yangtze River	429	396.99	483.19
黄河流域 The Yellow River	115	558.77	286.45
淮河流域 The Huaihe River	198	118.89	262.75
海河流域 The Haihe River	258	249.41	207.49
珠江流域 The Pearl River	315	134.95	130.30
松辽流域 The Songhua-Laohe River	48	115.48	36.18
太湖流域 The Taihu Lakes	131	114.87	118.27

of cropland. The goal of “no casualties, no flooding over the banks, and no embankment displacement” was achieved for the Yellow River basin. The Haihe Commission urged concretizing preventive measures, and effectively coped with the rare summer and autumn floods in the history of the Zhanghe-Weihe River, thereby buttressing the regional flood control safety and socio-economic development. The Huaihe Commission coordinated the flood prevention needs of upstream and downstream, main-stem and tributaries, adopted a portfolio of measures such as drainage, distribution, control, retention and storage, and effectively dispatched water projects, thereby ensuring flood control safety in the whole basin. The Pearl River Commission supervised via virtual and physical tools to keep water under the flood control level in large and medium-sized reservoirs, and put in place the mechanisms of the “three responsible officials (one administrative official, one technical officer, and one patroller)” and the “three flood control focuses (forecasting, scheduling, and contingency planning” for small reservoirs, and strengthened the supervision of hazard-prone reservoirs. The Songliao Commission consolidated flood prevention responsibilities, strengthened prediction, forecasting and early warning, strengthened consultation and judgment, undertook scientific and precise scheduling, and strengthened information reporting and sharing, effectively coping with exceptionally large floods in the upper reaches and middle reaches of the main-stem Heilong River, large floods in the Songhua River basin and the numbered floods in the Nenjiang and Songhua rivers. The Taihu Authority implemented the four preemptive pillars of disaster prevention, scientifically dispatched projects, and mitigated the impact from the downpours brought by typhoon “In-Fa” and a lengthy rainy season unusually occurring in midsummer, and timely activated the Yangtze-Taihu water diversion project to sustain water supply security.

2.5.2 Loss and damages mitigation

In the flood season of 2021, 4,347 sub-large and medium-sized reservoirs were put into use for flood detention and control, keeping in 139 billion m^3 of floodwater; 11 national flood detention and retention basins were activated to divert, detain, and retain floodwater, which totaled 1.328 billion m^3; 1,494 cities/towns cumulatively and 1,689,360 hectares of cropland were protected from being flooded, and 15.2463 million people avoided evacuation. The safety of lives and properties were protected with all-out efforts.

案例 8 台风“烟花”暴雨洪水防御

2106 号台风“烟花”于 7 月 25 日 12 时 30 分前后在浙江舟山普陀区沿海登陆，登陆时中心附近最大风力 13 级（38 米每秒），26 日 9 时 50 分在浙江平湖市沿海以强热带风暴级（10 级）再次登陆，30 日 20 时停止编号，为 1949 年有气象记录以来首个在浙江省两次登陆的台风。台风“烟花”登陆后北上，在我国大陆滞留时间长达 95 小时，为 1949 年以来第 1 位，共影响了 14 省（自治区、直辖市），50 毫米及以上降雨笼罩面积 35.2 万平方公里。受其影响，我国中东部沿海地区风雨持续时间长、累计降水量大，华东地区出现持续强降雨天气，浙江北部地区降水量 700～900 毫米，累计过程最大点降水量浙江余姚市丁家畈站 1034.3 毫米；其间，浙江、上海、江苏、山东等地 24 个站日降水量突破 7 月历史极值，28 日江苏有 6 个站突破建站以来极值。

台风“烟花”防御过程中，太湖局编制《防御“烟花”台风暴雨洪水方案》，分阶段系统安排主要工程调度方案及监测预报、会商值班、工程巡查、监督检查、技术指导等各项防御措施。提前启用望虞河常熟水利枢纽，闸泵联合全力排水；调度启用刚完成试运行的新孟河界牌水利枢纽实施闸泵联合排水；全力预降太湖及地区河网水位。台风“烟花”影响期间，坚持流域“一盘棋”，持续督促“外圈”（流域周边沿江、沿海、沿杭州湾口门）全力排水；先后关闭“内圈”（环太湖口门）太浦闸、望亭水利枢纽，充分发挥太湖拦蓄作用，缓解下游地区“四碰头”的极端不利局面，减轻其防洪压力。在做好流域骨干工程调度的同时，加强各区域间协调，统筹防洪需求。长江委指导地方调度台风可能影响区内的大中型水库提前预泄腾库，严格控制水库运行水位。淮委科学精准调度沂沭泗直管工程，合理分泄洪水，协调安徽省及时预降梅山、佛子岭、响洪甸等大型水库水位，确保水库及下游地区防洪安全。浙江省启动水旱灾害防御应急响应 8 次，共 15 天。省水利厅派出 11 个工作组、2 个水库安全度汛指导组下沉各市，姚江西排枢纽、德清大闸跨区域跨流域调度专家组进驻现场，研判形势，强化支撑。姚江流域四明湖水库共拦蓄洪水 4500 万立方米，削峰率 99.8%，姚江西排工程跨流域强排曹娥江水量 3530 万立方米，减少余姚断面 10.7% 的来水量，降低余姚水位 30 厘米，成功避免下游农防漫堤；浦阳江石壁、陈蔡和安华水库拦洪 6300 万立方米，高湖蓄滞洪区分洪 530 万立方米，有效降低诸暨站水位 90 厘米。安徽省针对水阳江流域的雨情、汛情，采取预泄、上拦、中分、下排的综合调度措施，减轻了水阳江流域防洪压力。超前调度马山埠闸外排南漪湖内水，赶在台风影响前调度水阳江上游港口湾水库将库水位降至汛限水位 3 米以下，多腾出防洪库容 9600 万立方米。强降雨发生后，控制港口湾水库下泄，将大量洪水拦蓄在库内，削峰率 90%，通过水库拦蓄洪水降低下游宣城站最高水位 1.0 米。针对上游水库拦蓄后水阳江干流水位仍持续上涨的局面，7 月 27 日调度开启双桥闸、马山埠闸分泄水阳江干流洪水 1.5 亿立方米入南漪湖，降低新河庄站水位 0.40 米。通过联合调度水阳江与南漪湖，精准控制水阳

Case 8 Responses to the rainstorms and floods by Typhoon “In−Fa”

Typhoon No. 2106 “In-Fa” landed on the coast of Putuo District, Zhoushan City, Zhejiang Province at about 12:30 on July 25. Its maximum near-center wind scale was force 13 (38 m/s) upon landfall, and landed again as a severe tropical storm (force 10) on the coast of Pinghu City, Zhejiang Province at 9:50 on the 26, and stopped being numbered at 20:00 on the 30. It was the first typhoon to make two landfalls in Zhejiang Province since meteorological records began in 1949. After making landfall, Typhoon “In-Fa” moved north and stayed on the Chinese mainland for up to 95 hours, the longest since 1949. “In-Fa” affected a total of 14 provinces/ autonomous regions/municipalities, and dumped 50 mm or more of rainfall over 352,000 km^2. Affected by it, the central and eastern coastal areas were lashed with unrelenting rain and storms, resulting in voluminous downpours. East China withstood continuous heavy rainfall weather: the precipitation in northern Zhejiang was 700-900 mm, and the maximum cumulative station-based precipitation was 1034.3 mm at Dingjiafan Station, Yuyao City, Zhejiang Province; the one-day precipitation at 24 stations in Zhejiang, Shanghai, Jiangsu, and Shandong exceeded the historical extreme value in July, and on the 28 the one-day precipitation at 6 stations in Jiangsu beat historical extreme values since the establishment of the stations.

In response to typhoon “In-Fa”, the Taihu Authority drafted the *Plan for Preventing Rainstorms and Floods by Typhoon “In-Fa”*, and laid out systematical arrangements such as key project scheduling, monitoring and forecasting, consultation and work shifting on duty, patrolling, supervision and inspection, and technical guidance. The Changshu Water Conservancy Complex on Wangyu River was activated in advance, with the gates and pumps working in full capacity to drain water. The Jiepai Water Conservancy Complex on Xinmeng River, which had just completed trial operation, was used to drain water through its sluices and pumps. The Taihu Lake and the regional river network were drained as much as possible to made room for incoming floodwater. Under the impact of typhoon “In-Fa”, the outer circle of the Taihu (gates along the rivers, along the coasts, and along the mouth of Hangzhou Bay) discharged water as much as possible, while the inner circle (gates surrounding the Taihu Lake) including the Taipu Gate and Wangting Water Conservancy Complex were closed so that the Taihu Lake could fully play its role in detaining and retaining floodwater. The pressures of flood control on the downstream areas were alleviated. While dispatching the backbone projects in the river basin, coordination among regions and across different flood prevention demands were coordinated. The Changjiang Commission instructed preemptive draw-downs in the large and medium-sized reservoirs that may be affected by the typhoon and strictly controlled the operating water levels. The Huaihe Commission dispatched the Yihe-Shuhe-Sihe river piping project to distribute floodwaters and coordinated Anhui Province to reduce the level in large reservoirs such as Meishan, Foziling, and Xianghongdian, thereby ensuring flood control safety in reservoirs and downstream areas. Zhejiang Province launched 8 emergency responses against flood and drought disaster prevention for a total of 15 days. The Provincial Water Resources Department sent 11 working groups and 2 reservoir safety guidance groups to various cities, and commanded cross-regional and cross-basin expert groups to the Xipai Water Conservancy Complex and the Deqing Gate on Yaojiang River for stronger and timely support. The Siming Lake Reservoir in the Yaojiang River basin retained a total of 45 million m^3 of floodwater, with a peak shaving rate of 99.8%, and the Yaojiang River Xipai water conservancy

江新河庄站水位仅超保证水位 0.01 米、超保证水位时间只有 5 分钟左右，大大减轻了流域防洪压力。江苏省提前一周预降洪泽湖、太湖、里下河地区河湖水位，累计腾出 14 亿立方米纳水空间；为缓解暴雨导致里下河地区水位暴涨形势，调度江都站、高港站、宝应站、大套站，会同沿海 5 港全力排水，最大流量 2838 立方米每秒；为统筹兼顾行洪与排涝，调度六塘河地涵、淮安站、淮安四站、石港站、金湖站等，及时排除片区涝水，并协调开启嶂山闸，全力下泄沂沭泗地区洪水。上海市针对苏州昆山等地普降暴雨、区域涝水下泄不畅等情况，开启蕰藻浜西闸、淀浦河西闸，协助排泄洪涝水，共 200 余座一线泵闸累计排水 1200 余闸次，闸排总历时 4900 小时，总闸排水量 7.2 亿立方米，泵排总历时 9200 小时，总排水量 2.1 亿立方米。

台风“烟花”造成浙江、上海、江苏、安徽、山东、河北、辽宁、内蒙古 8 省（自治区、直辖市）40 市 230 个县（市、区、旗）482 万人受灾，紧急转移安置 143 万人，倒塌房屋 500 余间，农作物受灾面积 358.2 千公顷，直接经济损失 132 亿元。

受台风“烟花“影响，上海市金山区朱泾镇道路积水（7 月 27 日）
Affected by Typhoon “In-Fa”, the roads were flooded in Zhujing Town, Jinshan District, Shanghai (July 27)

complex drained 35.3 million m^3 from Cao'e River across watersheds, reducing the cross-sectional inflow to the Yu-Yao section by 10.7% and reducing the water level at Yu-Yao section by 30 cm, thereby successfully avoiding over-topping at the downstream agricultural flood dikes. The Shibi, Chencai and Anhua reservoirs on Puyang River detained 63 million m^3 of floodwater, and the Gaohu flood detention and retention basin stored 5.3 million m^3, effectively reducing the water level at Zhuji Station by 90 cm. In view of the rain and flood conditions in the Shuiyang River basin, Anhui Province adopted comprehensive dispatch measures of emptying in advance, detaining in the upstream, diving in the mid-stream, and draining in the downstream, reducing the flood control pressure in the Shuiyang River basin. The Mashanbu Gates were activated to preemptively drain the Nanyi Lake, and the Gangkouwan Reservoir in the upper Shuiyang River was drawn down to at least 3 m below the flood control water level before "In-Fa" approached, freeing up an additional 96 million m^3 of reservoir capacity. When heavy rainfall occurred, the Gangkouwan Reservoir controlled discharge and kept a large amount of floodwater in the reservoir, resulting in a peak shaving rate of 90% and the maximum water level at the downstream Xuancheng Station being reduced by 1.0 m. Given that the water level of the main-stem Shuiyang River continued to rise even with the upstream reservoir holding back discharge, on July 27, the Shuangqiao Gates and the Mashanbu Gates were dispatched to divert 150 million m^3 of floodwater from the main-stem Yangjiang River into Nanyi Lake, reducing the water level at Xinhezhuang Station by 0.40 m. Through the joint dispatch of Shuiyang River and Nanyi Lake, the water level at Xinhezhuang Station on Shuiyang River was only 0.01 m above the guaranteed water level and exceeded this level for only about 5 minutes. The flood control pressure in the river basin was reduced. Jiangsu Province drew down the water levels in Hongze Lake, Taihu Lake and Lixia River a week in advance, freeing up a total of 1.4 billion m^3 of water storage room; In order to alleviate the swollen water level in the Lixia River area caused by heavy rainfall, Jiangdu Station, Gaogang Station, Baoying Station and Datao Station were dispatched, together with the five coastal ports, to drain with a maximum flow of 2,838 m^3/s; To accommodate the needs for flood passage and drainage, the Liutang River underground culvert, Huai'an Station, Huai'an IV Station, Shigang Station, and Jinhu Station were dispatched to drain access water timely, and the Zhangshan Gates were also opened to release floods from the Yihe-Shuhe-Sihe river area. In response to the extensive heavy rainfall and subsequent local water-logging in cities including Kunshan and Suzhou, Shanghai opened the Wenzaobang West Gates and the Dianpu River West Gates to help discharge floodwater. More than 200 active pumps and gates were opened to release floodwater. The gates were opened for cumulatively over 1,200 times and for 4,900 hours, discharging 720 million m^3; the pumps were used for 9,200 hours, discharging 210 million m^3.

Typhoon "In-Fa" affected 4.82 million people in 230 counties/cities/districts/banners in 40 cities in 8 provinces/autonomous regions/municipalities, including Zhejiang, Shanghai, Jiangsu, Anhui, Shandong, Hebei, Liaoning, and Inner Mongolia. A total of 1.43 million people were evacuated and relocated under emergency, more than 500 dwellings collapsed, 358,200 hectares of cropland were affected, and the direct economic losses billed 13.2 billion RMB.

3 山洪灾害防御

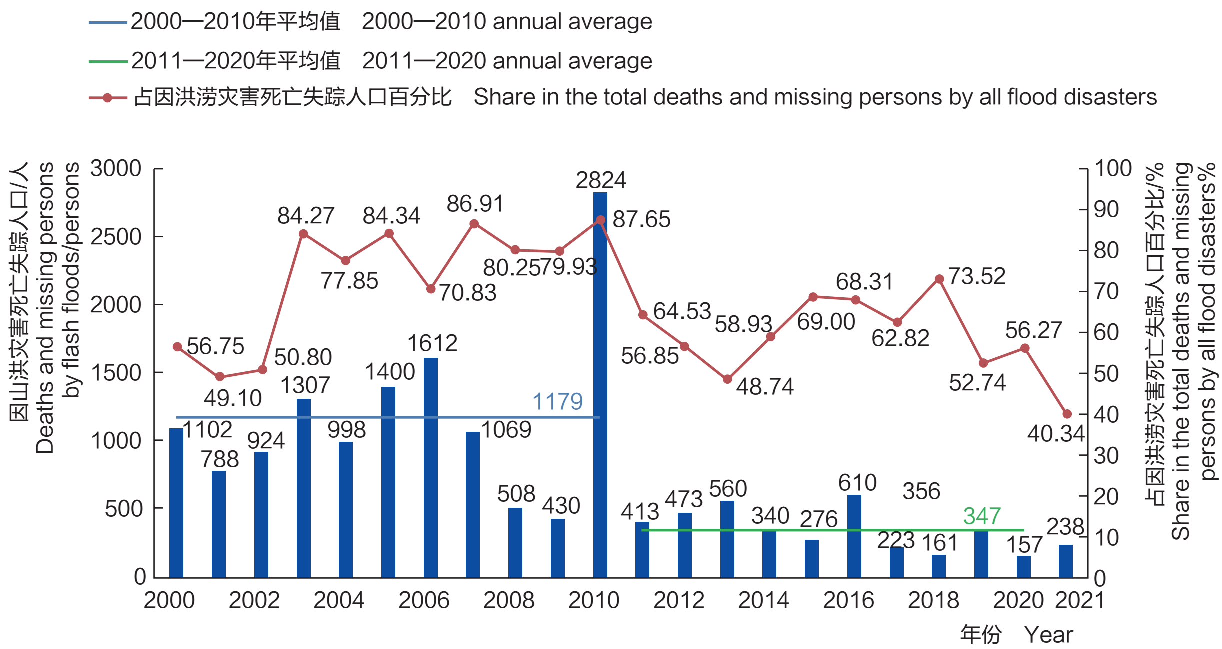
FLASH FLOOD DISASTER PREVENTION

3.1　基本情况

2021 年，全国因山洪灾害死亡失踪 238 人，占全国因洪涝死亡失踪人口的 40.3%，较 2011—2020 年因山洪灾害平均死亡失踪人口下降 33.1%。

3.1　Disasters and Losses

In 2021, 238 people were killed or went missing by flash floods in China, accounting for 40.3% of the deaths and missing persons attributed to all flood disasters. It registered a 33.1% drop from the 2011-2020 annual average in its same category.



注：2000—2010 年数据为因山洪灾害死亡人口；2011—2021 年数据为因山洪灾害死亡失踪人口。

Note: Statistics during 2000—2010 include only deaths attributed to flash floods; statistics during 2011—2021 include both deaths and missing persons attributed to flash floods

图 3-1　2000—2021 年因山洪灾害死亡失踪人口及占因洪涝灾害死亡失踪人口的百分比

Figure 3-1　Deaths and missing persons attributed to flash floods 2000—2021 and their respective shares in the total deaths and missing persons attributed to all flood disasters

2021 年，全国山洪灾害总体有 3 个特点。

灾害发生时间集中，空间分布异于常年。全国共发生 36 起有人员死亡失踪的山洪灾害事件，27 起发生在 7 月和 8 月，其中 7 月 10—20 日 11 天内共发生了 14 起。除 6 月 14 日云南镇沅县、8 月 8 日四川古蔺县、8 月 12 日湖北随县、8 月 29 日云南兰坪县山洪灾害发生在西南、华中等山洪灾害高发区外，其余 32 起均发生在华北、西北等较少发生山洪灾害地区，其中山西、河南常年较干旱的两省共发生 15 起山洪灾害事件，空间分布高度集中且异于常年。

死亡失踪人口区域集中，老幼人群占比高。死亡失踪人口集中于河南、山西、湖北、陕西 4 省共 215 人，占全国因山洪灾害死亡失踪人口的 90%。河南郑州"7·20"特大暴雨灾害造成新密、荥阳、登封、巩义 4 市（县级市）因山洪灾害死亡失踪 124 人，占全国因山洪死亡失踪人口的 52%。7 月 11 日山西泽州县因山洪死亡失踪 9 人中，55 岁以上 5 人、15 岁以下 3 人，合计占比 89%；8 月 12 日湖北随县因山洪死亡 24 人中，60 岁以上 10 人、10 岁以下 2 人，合计占比 50%。

局地极端强降雨频发，自然条件和社会因素加重灾害。山西泽州县曹河村 3 小时降水量超 190 毫米；河南荥阳市王宗店村最大 6 小时降水量 240.5 毫米，重现期超 500 年；湖北随县柳林镇最大 6 小时降水量 439 毫米，集镇断面洪峰流量重现期超 200 年。山西泽州县曹河村地处连续拐弯的"Z"字形河道及两沟汇流处，湖北随县柳林镇、河南荥阳市王宗店村均为多条沟道汇流的下游，山洪汇集冲击下游村庄，加重了灾害。另外，灾害发生所在村镇临河建设房屋、跨沟建设道路等侵占行洪通道的行为加剧了山洪灾害。

Flash flood disasters that happened in 2021 generally took on the following three characteristics:

The disasters happened in a rather concentrated period of time and largely in places that seldom had such events before. Of the 36 flash flood incidents leading to life losses, 27 occurred in July and August. In particular, 14 flash floods occurred in the 11 days from July 10-20. In terms of location, only four incidents took place in flash flood-prone areas in Southwest and Central China: namely, one in Zhenyuan county, Yunnan Province on June 14, one in Gulin County, Sichuan Province on August 8, one in Sui County, Hubei Province on August 12, and one in Lanping County, Yunnan Province on August 29. All the other 32 incidents occurred in places in North China and Northwest China where flash floods were not usual. For example, 15 flash flood incidents hit Shanxi and Henan Provinces, where drought was more often the problem at this time of year.

Certain regions claimed the biggest share of deaths and missing persons, and the senior and the teenagers were the main victim. Henan, Shanxi, Hubei and Shaanxi provinces claimed 215 deaths and missing persons, accounting for 90% of the national total attributed to flash floods. During the “July 20” extreme rainstorm that blanketed Zhengzhou city in Henan Province, 124 people were dead or missing in Xinmi, Xingyang, Dengfeng and Gongyi cities, accounting for 52% of the national total attributed to flash floods. The flash flood that stroke Zezhou County, Shanxi Province on July 11 caused nine deaths and missing persons. Five were over 55 years old and three were under 15 years old, accounting for 89%. In the flash flood incident that killed 24 people in Sui County, Hubei Province on August 12, ten were over 60 years old and two were under 10 years old, accounting for 50%.

Heavy rainfall frequented certain localities, where natural and man-made conditions aggravated the disasters. Caohe Village of Zezhou County in Shanxi Province received over 190 mm of precipitation in 3 hours. Wangzongdian Village of Xingyang City in Henan Province withstood a maximum 6-hour precipitation of 240.5 mm, exceeding that of a 500-year precipitation event. The maximum 6-hour precipitation in Liulin Town of Sui County in Hubei Province was 439 mm and the cross-section peak discharge in the downtown area exceeded that of a 200-year flood. The local natural conditions didn’t help. Caohe Village in Zezhou, Shanxi Province stood where river channels zigzagged continuously and where two gullies converged. Liulin Town of Sui County in Hubei Province and Wangzongdian Village of Xingyang City in Henan Province were at the downstream side of multiple gully confluences. By the time the torrents reached the villages, they were multiplied in their force and wreaked serious havoc. To make things worse, these villages had erected houses near the rivers and built roads crisscrossing gullies, hence compromising the natural flood passage capacity.

3.2 防御工作

2021 年，面对特殊严峻的山洪灾害防御形势、复杂艰巨的山洪灾害防御任务，水利部及地方各级水利部门积极主动作为，提早安排部署，加强监督指导，强化监测预警，推动山洪灾害防御工作取得显著成效。

3.2.1 部署安排

4 月 13 日、6 月 30 日水利部先后两次专门印发通知，对山洪灾害风险隐患排查、监测预警、提请转移避险、运行维护等方面提出明确要求。5 月，专题召开山洪灾害防御工作视频会议，对 2021 年山洪灾害防御工作进行全面部署。组织制定并印发《山洪灾害动态预警指标分析技术要求》《危险区动态管理清单编制指南》等行业技术文件，指导开展山洪灾害防治项目建设。汛前，组织各地对山洪灾害防御预案进行修订完善，落实各级各类责任人和应急处置措施。

3.2.2 监督检查

水利部编制印发《山洪灾害防御监督检查工作方案》，制定工作培训手册，组织开展山洪灾害监测预警和应治未治重点山洪沟防御措施落实情况监督检查，共检查县级监测预警平台 205 个（新检查 102 个、“回头看”复查 103 个）、自动监测站点 577 个、应治未治重点山洪沟 50 条，累计发现问题 212 个，县均发现问题较 2020 年下降 33.3%。针对发现的问题，督促指导相关地方立行立改，确保整改到位。

3.2.3 预警发布

水利部充分利用山洪灾害监测预警系统及时发布预警信息，持续推动依托“三大运营商”（中国移动、中国电信、中国联通）推行预警信息“靶向发布”和社会化发布。全国共发布县级山洪灾害预警信息 30.3 万次，利用监测预警平台向 2022 万名防汛责任人发送预警短信超过 5000 万条，启动预警广播 87.6 万次，利用“三大运营商”发布预警短信 12.19 亿条，为及时组织群众转移避险提供了有力支撑。水利部联合中国气象局发布山洪灾害气象预警 145 期（其中中央广播电视总台央视播出 30 期），并及时通报有关地方。全国已有 20 省（自治区、直辖市）水利部门和气象部门建立了联合发布山洪灾害风险预报工作机制。

3.2 Prevention and Control

In 2021, in face of the unusual and severe flash flood disasters, MWR and local water resources departments made proactive arrangements, strengthened supervision and guidance, and stepped up monitoring and early warning. Positive results were delivered.

3.2.1 Arrangements

MWR issued special notices on April 13 and June 30, respectively, setting out clear requirements for risk investigation, monitoring and early warning, requesting evacuation and relocation, and operation and maintenance. In May, the Ministry held a special video conference to chart out prevention and control tasks for 2021. The Ministry also commissioned and circulated industry technical papers such as *Technical Requirements for Dynamic Analysis of Flash Floods Early Warning Indicators* and *Guidelines for Dynamic Management Listing of Danger Zones*, and guided the development of flash flood prevention and control programs. Before the flood season arrived, the Ministry commanded review and modification of local-level flash flood contingency plans, identified the responsible officials at all levels, and put in place emergency response measures.

3.2.2 Supervision and inspection

MWR drafted and circulated the *Work Plan for Supervision and Inspection of Flash Flood Prevention and Control*, formulated a training manual, and organized the supervision and inspection of monitoring and early warning measures and the precautionary measures for major yet-to-be-treated hazard-prone gullies. This round of supervision and inspection covered 205 county-level monitoring and early warning platforms (102 are first-time checks and 103 are rechecks), 577 automatic monitoring stations, and 50 major yet-to-be-treated hazard-prone gullies. All together 212 issues were identified and the issues per county on average were down by 33.3% year on year. The Ministry also urged and guided immediate and due rectification.

3.2.3 Issuing early-warning information

MWR made full use of the flash flood monitoring and early warning system for timely information dissemination. It worked with China's three main telecom operators (China Mobile, China Telecom and China Unicom) to send customized alert messages and also more general early-warning messages to the public. A total of 303,000 flash flood alert messages were issued at county-level, more than 50 million alerts were sent to 20.22 million responsible officials for flood control through the monitoring and early warning platforms, 876,000 early warning broadcasts

3.2.4 培训演练

4 月 1 日、5 月 9 日分别组织召开 2021 年度山洪灾害防治建设管理及技术培训会、西部“三区三州”脱贫地区和民族地区山洪灾害防御技术帮扶培训，对山洪灾害防治项目建设管理、群测群防体系建设、县级监测预警系统管理使用等内容进行解读培训。全国 23 省（自治区、直辖市）组织开展超过 1 万场山洪灾害防御实战演练，以群众自主转移避险、突发灾害应急处置为重点，100 万余人次参加，有效提升了基层干部群众应急避险和自救互救能力。

3.3 防御成效

2021 年，各地充分利用已建山洪灾害监测预警系统和群测群防体系，强化预警信息发布，及时转移受威胁群众，努力实现监测精准、预警及时、反应迅速、转移快捷、避险有效，最大限度保障了人民群众生命安全。在 2021 年极端强降雨历史罕见、北方暴雨频发的情况下，因山洪灾害死亡失踪人口较 2011—2020 年平均死亡失踪人口减少 33.1%，防灾避灾效益显著。

3.3.1 贵州黔东南州锦屏县山洪灾害防御

5 月 10 日 19 时至 11 日 6 时，贵州黔东南州锦屏县铜鼓镇遭受特大暴雨袭击，累计降水量 275.3 毫米。锦屏县依托山洪灾害监测预警系统实时跟踪监测铜鼓镇降雨情况并及时发布预警信息，铜鼓镇花桥村山洪灾害“三个责任人”按照锦屏县发布的实时预警信息，应用预警广播、铜锣等预警设备通知群众转移。11 日 1 时 45 分受威胁区群众 372 人转移到安全区域，1 时 52 分山洪暴发，由于预警转移及时，避免了人员伤亡。

were announced, and 1.219 billion alert text messages were sent by the three major telecom operators. This information forcefully supported the public to stay away from dangers and to timely evacuate. MWR also collaborated with China Meteorological Administration to have issued 145 flash flood meteorological announcements (30 of which were aired on China Central Television) and promptly notified relevant localities. The water resources departments and meteorological departments in 20 provinces/autonomous regions/municipalities have established a joint working mechanism for issuing flash flood risk forecasts.

3.2.4 Training and drills

MWR organized the 2021 flash flood program management and technical training on April 1 and technical assistance and training for impoverished regions and ethnic groups in Western China on May 9. The training focused on program development and management, the development of a grassroots-based monitoring and prevention system, and the management and application of monitoring and early-warning systems at the county level. Twenty-three provinces/autonomous regions/municipalities organized more than 10,000 drills, focusing on self-initiated evacuation and emergency response to sudden disasters. The drills, involving over 1 million person-times, strengthened the community-level capacities to conduct emergency evacuation, self and mutual rescue.

3.3 Effectiveness of Flash Flood Disaster Prevention

In 2021, local governments made full use of the flash flood monitoring and warning systems and mass monitoring and prevention systems at hand. Early warning release and prompt evacuation were strengthened. Maximum efforts were made to protect lives through accurate monitoring, timely warning, rapid response, quick evacuation, and effective risk avoidance. The number of deaths and missing persons attributed to flash flood disasters in 2021, even with exceptional extreme rainfall events and heavy rainfall battering Northern China, was down by 33.1% compared with 2011-2020 annual average.

3.3.1 Flash flood in Jinping County, Qiandongnan Prefecture, Guizhou Province

From 19:00 on May 10 to 6:00 on May 11, Tonggu Town (Jinping County, Qiandongnan Prefecture, Guizhou Province) was hit by an exceptionally heavy rainstorm. The cumulative precipitation reached 275.3 mm. Tapping into the flash flood monitoring and early warning system, Jinping County tracked and monitored the rainfall dynamics in Tonggu Town in real time and timely issued alerts. The three responsible officials for flash flood prevention (one administrative official, one technical officer, and one patroller) in Huaqiao Village of Tonggu

3.3.2 福建邵武市下沙镇山洪灾害防御

6 月 28 日，福建邵武市下沙镇最大 3 小时降水量 177 毫米，最大 6 小时降水量 291 毫米，重现期均超 100 年。暴雨导致山洪暴发、水位暴涨、集镇严重进水，受淹面积超 7 万平方米，近 108 栋房屋严重进水。针对此次强降雨，邵武市通过山洪灾害监测预警平台，第一时间全面掌握雨水情信息，发布预警短信 2715 条，转移人口 2833 人，有效减少了灾害损失，避免了人员伤亡。

3.3.3 广西桂林市临桂区山洪灾害防御

6 月 30 日，受强降雨影响，广西桂林市临桂区宛田乡河段出现超警戒水位 0.55 米的洪水，水位急速上涨，部分山洪站点 1 小时降水量超过设置预警阈值，触发村级山洪灾害实时预警。村级山洪灾害防治责任人接到预警信息后，根据防御预案中转移方案原则和路线，组织群众转移避险，共转移 29 户 100 余人，因转移及时未造成人员伤亡。

Town, upon receiving the early-warning information sent down from Jinping County, broadcast or stroke gongs on the streets to notified the villagers to evacuate. A flash flood broke out at 01:52 on May 11, but no casualties were incurred because by 01:45, all the 372 villagers in the danger zone had already safely evacuated.

3.3.2 Flash flood in Xiasha Town, Shaowu City, Fujian Province

On June 28, Xiasha Town in Shaowu City of Fujian Province received a maximum 3-hour precipitation of 177 mm and a maximum 6-hour precipitation of 291 mm, both exceeding a 100-year precipitation event. Heavy downpours triggered flash floods, swollen rivers, and grave inundation in the town streets, resulting in over 70,000 m^2 of land and nearly 108 houses being flooded. By keeping a close track of the rainfall development via the flash flood monitoring and early warning system, Shaowu City issued 2,715 risk alerts and evacuated 2,833 people. Losses were contained and no casualties occurred.

3.3.3 Flash flood in Lingui District, Guilin City, Guangxi Province

On June 30, heavy rainfall jacked up the Wantian Township river section 0.55 m above the warning level in Lingui District, Guilin City of Guangxi Province. As floodwater rose rapidly, the one-hour precipitation at some flash flood stations exceeded the early-warning default threshold, thus triggering real-time flash flood risk alerts in the village. In response, the responsible officials for flash flood in the village organized evacuation according to their contingency plan, and timely transferred more than 100 people from 29 households. No casualties occurred.

福建邵武市下沙镇桥梁堵塞（6 月 28 日）
A clogged bridge in Xiasha Town, Shaowu City, Fujian Province (June 28)

3.3.4 浙江绍兴市柯桥区山洪灾害防御

受 2106 号台风“烟花”影响，7 月 23 日浙江绍兴市柯桥区普降大雨，暴发山洪。柯桥区利用山洪监测预警平台向夏履镇莲西溪小流域沿线的山洪重点村落发送准备转移和立即转移预警短信。收到预警信息后，柯桥区夏履镇迅速组织人员转移，共转移安置危险区 65 户 153 人，避免了人员伤亡。

3.3.4 Flash flood in Keqiao District, Shaoxing City, Zhejiang Province

Affected by Typhoon “In-Fa” (No. 2106), rainstorms battered vast areas of Keqiao District, Shaoxing City of Zhejiang Province on July 23 and triggered flash floods. Messages ordering “prepare for evacuation” and “evacuate now” were sent to major at-risk villages along the Lianxixi watershed in Xialyu Town. In response, prompt evacuation was organized and 153 people from 65 households transferred to safe areas. No casualties occurred.

浙江绍兴市柯桥区街道受淹（7 月 23 日）
Flooded street blocks in Keqiao District, Shaoxing City, Zhejiang Province (July 23)

3.3.5 四川凉山州山洪灾害防御

2021 年汛期，四川凉山州遭遇了 24 轮强降雨天气过程，14 县（市）144 个乡（镇）受灾，通过强化监测预警预报、细化人员转移避险方案、落实预警提前撤离及保障措施等办法，共转移山洪灾害危险区 3 万余户 17 万多人，成功避让山洪灾害 40 起，避免了人员伤亡。

3.3.5 Flash flood in Liangshan Prefecture, Sichuan Province

Liangshan Prefecture in Sichuan Province received 24 heavy rainfall processes during the 2021 flood season, affecting 144 townships/towns in 14 counties/cities. Measures taken included strengthening monitoring, early warning, and forecasting, detailing the evacuation and risk avoidance plans, and implementing early evacuation and safeguard measures. More than 170,000 people from over 30,000 households in risk zones evacuated to stay away from 40 flash flood disasters. No casualties occurred.

四川凉山州木里县项脚沟山洪泥石流灾害（7 月 5 日）
A flash flood triggered mud flows along Xiangjiao Gully at Muli County, Liangshan Prefecture, Sichuan Province (July 5)

4 干旱灾害防御

DROUGHT DISASTER PREVENTION

4.1 旱情

2021 年，甘肃西北部、内蒙古西部、云南西部和北部、广西东南部、广东大部、福建南部等地降水量较常年偏少 2 ~ 5 成，局地偏少 8 成；其他省份也出现部分时段降水偏少情况。受此影响，有 27 省（自治区、直辖市）先后出现区域性干旱，东南沿海部分地区长时间持续干旱。

2021 年，全国旱情总体有 3 个特点。

4.1 Droughts

In 2021, northwestern Gansu, western Inner Mongolia, western and northern Yunnan, southeastern Guangxi, vast areas of Guangdong, and southern Fujian received 20%-50% less precipitation than normal, and in some areas the rainfall even fell 80% short. Other provinces also were drier than normal in certain periods. As a result, 27 provinces/autonomous regions/municipalities experienced regional droughts, and some areas along the southeast coast had prolonged droughts.

Droughts in 2021 in general took on the following three characteristics:

东南沿海地区重复受旱，部分地区旱情持续时间长。由于 2020 年影响东南沿海地区的台风数量偏少、强度偏弱，降水量随之偏少，浙江、福建、广东等沿海丰水地区 2020 年秋冬季发生严重旱情，并持续到 2021 年春季。2021 年入汛后，东南沿海地区旱区大部分旱情得到缓解，但广东东部和福建南部降水和河道来水总体仍呈持续偏少态势，供水水库蓄水一直没有得到有效补充，局部地区旱情持续。2021 年秋季开始，广东东部和福建局部再度发生旱情，并呈秋冬春连旱态势。其中广东省东江、韩江流域发生 60 年以来最严重旱情，部分市（县）从 2020 年 10 月起持续干旱，至 2021 年 12 月仍未解除，持续时间长达 15 个月以上。

旱情对城镇供水影响较大，局部地区人饮困难突出。东南沿海地区经济发达、人口稠密，旱情对城镇供水影响较大。2021 年年初，浙江、广东、福建等省部分城镇出现供水紧张状况，需要采取限时、限量、限压供水等应急措施保障城镇供水。2 月初旱情高峰期，233 万人因旱供水受到影响，山丘区有 33 万群众因旱发生饮水困难。9 月，受降水持续偏少影响，东南沿海地区秋冬季旱情再次发展，广东汕头、揭阳、梅州、河源、清远、东莞和福建漳州、龙岩、三明等市出现供水紧张。截至 12 月底，广东、福建两省供水受影响人口 192 万人，山丘区有 10 万群众因旱发生饮水困难。

广东汕头市龙溪二级水库水位下降（4 月 23 日）
Shrinking Longxi II reservoir, Shantou City, Guangdong Province (April 23)

Droughts frequented the southeast coastal areas, with certain localities gripped by prolonged droughts. Because the typhoons that affected the southeast coastal areas in 2020 were fewer and weaker than normal, precipitation also fell short. As a result, traditionally wet provinces like Zhejiang, Fujian, and Guangdong suffered from severe droughts stretching from autumn and winter in 2020 till spring in 2021. When the flood season kicked in, things improved in vast areas. But part of eastern Guangdong and southern Fujian remained in drought due to insufficient precipitation and river inflow, and consequently under-replenishment in the source water reservoirs. By autumn, droughts returned to eastern Guangdong and part of Fujian and showed no sign of relaxing till the next spring. In particular, the Dongjiang and the Hanjiang River basins in Guangdong suffered from the worst droughts in 60 years. In some cities/counties, the droughts that started in October 2020 had not go away even in December 2021, lasting for more than 15 months.

Droughts strained the urban water supply, with localized drinking water access cut-offs. Droughts strained the water supply in the economically developed and densely populated southeast coastal area. Early in 2021, parts of Zhejiang, Guangdong, and Fujian began to experience water supply stresses, and had to resort to water rationing by time, by quota, or by lowering the water supply pressure. During the driest days in early February, 2.33 million people experienced disrupted water supplies and 330,000 residents in the hilly areas experienced difficulties accessing drinking water. By September, as precipitation fell persistently less than normal, the drought conditions in the southeast coastal area took a turn for the worse throughout autumn and winter. Shantou, Jieyang, Meizhou, Heyuan, Qingyuan, and Dongguan in Guangdong Province, and Zhangzhou, Longyan and Sanming in Fujian Province endured water supply stresses. By the end of December, 1.92 million people in Guangdong and Fujian provinces had experienced disrupted water supplies, and 100,000 residents in the hilly areas experienced difficulties accessing drinking water.

夏伏旱正值作物生长关键期，对农业生产造成一定影响。7—8 月正值玉米抽雄吐丝、棉花开花、中稻分蘖孕穗、晚稻栽插的关键时节，8 月中旬旱情高峰时，北方地区及南方局部地区耕地受旱面积达 2837.33 千公顷，其中内蒙古、陕西、甘肃、宁夏 4 省（自治区）耕地受旱面积 2635.33 千公顷，占全国耕地受旱面积的 90% 以上，对农业生产造成一定影响。

4.2 主要干旱过程

2021 年，全国旱情以阶段性为主，先后经历了南方地区冬春连旱、北方地区和西南局部夏伏旱、华南地区秋冬春连旱 3 个主要过程。

4.2.1 南方地区冬春连旱

2020 年 10 月至 2021 年 3 月，江南、华南大部、西南南部等地降水量较常年同期偏少 4 ~ 7 成，其中浙江、广东等省偏少 6 成以上，气象干旱严重；南方地区水库蓄水不均衡情况突出，浙江宁波、温州、绍兴、舟山等地水库蓄水偏少 3 成，广东韩江流域水库蓄水偏少 2 成，广西蓄水偏少 1 成，部分作为主要供水水源的中小型水库水位接近或低于死水位。受其影响，浙江、福建、广东、广西、云南等省（自治区）出现不同程度的旱情，部分城镇和农村出现供水紧张状况。2 月上旬旱情高峰时，南方地区耕地受旱面积 500.67 千公顷，有 33 万人因旱饮水困难，233 万人正常供水受到影响。入汛以后，南方地区出现多次较强降水过程，加之旱区修建的抗旱应急水源工程发挥作用，南方大部旱情基本解除，广东局部地区旱情长时间持续。

The summer drought coincided with critical crop growth periods, thereby impacting agricultural production. July and August are a critical period for maze tasseling and silking, cotton flowering, semilate rice tillering and panicle booting, as well as late-season rice planting. At the peak of drought in mid-August, 2,837,330 hectares of cropland were affected in the north and parts of the south. In particular, Inner Mongolia, Shaanxi, Gansu and Ningxia provinces/autonomous regions claimed over 90% of the drought-stricken cropland, totaling 2,635,330 hectares. Agricultural production was partly affected.

4.2 Major Drought Processes

Droughts in 2021 happened in rather distinct stages, including the winter-spring drought in Southern China, the summer drought in Northern China and parts of Southwestern China, and the autumn-winter-spring drought in South China.

4.2.1 Winter-spring drought in Southern China

From October 2020 to March 2021, precipitation in Jiangnan (areas south of the middle-lower Yangtze), the vast of South China and the southern Southwest China was 40%-70% less than normal. In particular, Zhejiang and Guangdong provinces suffered from severe meteorological droughts, as their local precipitation was 60% or even less than normal. Reservoir storage presented a mixed picture: reservoirs in Ningbo, Wenzhou, Shaoxing, and Zhoushan in Zhejiang Province held 30% less storage than normal; those in the Hanjiang River basin in Guangdong stored 20% less; those in Guangxi stored 10% less and some small and medium-sized source water reservoirs even retreated to or below the dead storage level. As a result, Zhejiang, Fujian, Guangdong, Guangxi, and Yunnan provinces/autonomous regions suffered from various degrees of drought, with some cities, towns, and villages experiencing disrupted water supplies. At the peak of drought in early February, 500,670 hectares of cropland were affected in southern China, 330,000 people experienced difficulties accessing drinking water, and 2.33 million people had their water supplies affected. When the flood season kicked in, because several strong precipitation processes occurred in the southern region and the emergency source water projects built in the drought-afflicted regions started to play a role, droughts in the vast southern areas were subdued. However, parts of Guangdong continued to suffer.

4.2.2 北方地区和西南局部夏伏旱

2021 年 6—8 月，华北西部、西北大部、江南中部西部及四川中部等地降水量较常年同期偏少 3 ~ 6 成，华北、西北、西南等地土壤中度以上缺墒，内蒙古、黑龙江、吉林、辽宁、河北、山西、陕西、甘肃、青海、湖南、四川、重庆、贵州等省（自治区、直辖市）旱情露头并迅速发展。8 月中旬旱情高峰期时，耕地受旱面积 2837.33 千公顷，有 45 万农村群众、89 万头大牲畜因旱饮水困难，33 万城镇居民供水受到影响。其中，内蒙古、陕西、甘肃、宁夏 4 省（自治区）旱情较为严重，耕地受旱面积 2635.33 千公顷，有 17 万农村群众、83 万头大牲畜因旱饮水困难。8 月下旬至 10 月初，旱区大部出现较强降水过程，部分地区土壤墒情得到明显改善，库塘蓄水得到有效补充，9 月底旱区大部旱情解除。

4.2.3 华南地区秋冬春连旱

受 2020 年冬至 2021 年春降水偏少影响，珠江流域骨干水库蓄水严重不足。2021 年 6—8 月，珠江流域“当汛不汛”，西江、北江、东江和韩江来水量偏少 3 ~ 7 成，其中东江、韩江来水量偏少 7 成，为 1956 年以来同期最枯，骨干水库汛末总有效蓄水率不足 20%。9 月，广东、福建、广西等省（自治区）出现不同程度旱情。11 月后，旱情快速发展，广东东江和韩江流域遭遇 60 年来最严重干旱；同时，降水偏少、江河来水偏枯还加剧了珠江三角洲咸潮上溯，出现了“秋冬春连旱、旱上加咸”的不利局面。截至 12 月底，3 省（自治区）耕地受旱面积 55.33 千公顷，10 万农村群众因旱饮水困难，192 万城镇居民供水受到影响，其中广东东部和福建局部旱情尤为严重，汕头、梅州、东莞、漳州等地多个城镇出现供水紧张状况。部分地区旱情影响持续到 2022 年春季。

4.2.2 Summer drought in Northern China and parts of Southwestern China

From June to August 2021, the western part of North China, most of Northwest China, the central and western parts of Jiangnan (areas south of the middle-lower Yangtze) and the central Sichuan Province 30%-60% drier than normal. North China, Northwest China and Southwest China suffered from low or severely low soil moisture. Drought emerged and developed quickly in Inner Mongolia, Heilongjiang, Jilin, Liaoning, Hebei, Shanxi, Shaanxi, Gansu, Qinghai, Hunan, Sichuan, Chongqing, and Guizhou provinces/autonomous regions/ municipalities. At the peak of drought in mid-August, 2,837,330 hectares of cropland were affected, 450,000 villagers and 890,000 head of bigger-sized livestock had difficulties accessing drinking water, and 330,000 urban residents had their water supplies affected. Inner Mongolia, Shaanxi, Gansu and Ningxia provinces/autonomous regions took the hardest hit: 2,635,330 hectares of cropland were drought-afflicted, and 170,000 villagers and 830,000 head of bigger-sized livestock experienced difficulties accessing drinking water. From late August to early October, moderate to heavy rainfall occurred in most of the drought-afflicted regions, notably improving the soil moisture in certain areas and effectively replenishing the reservoirs. By the end of September, droughts in the vast areas were subdued.

4.2.3 Autumn-winter-spring drought in South China

Because precipitation was less than normal in the Pearl River basin throughout the winter in 2020 and the spring in 2021, critical reservoirs in this basin were severely under-stored. From June to August 2021, which was the usual flood period for the Pearl basin, the river inflow to its tributaries—Xijiang, Beijiang, Dongjiang, and Hanjiang—were 30%-70% leaner than normal. In particular, Dongjiang and Hanjiang received only 30% of their normal inflows, marking a new post-1956 low of the same period. By the end of the flood season, the overall effective storage ratio in the critical reservoirs was less than 20%. In September, drought conditions of varying degrees began to emerge in Guangdong, Fujian, and Guangxi provinces/autonomous regions and developed rapidly since November. Dongjiang and Hanjiang river basins in Guangdong endured the worst drought seen in the past six decades. In addition, the less-than-normal precipitation and river inflow intensified the saltwater intrusion along the Pearl River Delta, resulting in a double-kill of persistent drought and salinity increase. By the end of December, 55,330 hectares of cropland were affected by drought in Guangdong, Fujian and Jiangxi, 100,000 villagers experienced difficulties accessing drinking water, and 1.92 million urban residents had their water supplies affected. Eastern Guangdong and parts of Fujian took the hardest hit: cities and towns like Shantou, Meizhou, Dongguan, and Zhangzhou endured disruptions in their water supplies. The impacts of drought even persisted through the spring of 2022 in some localities.

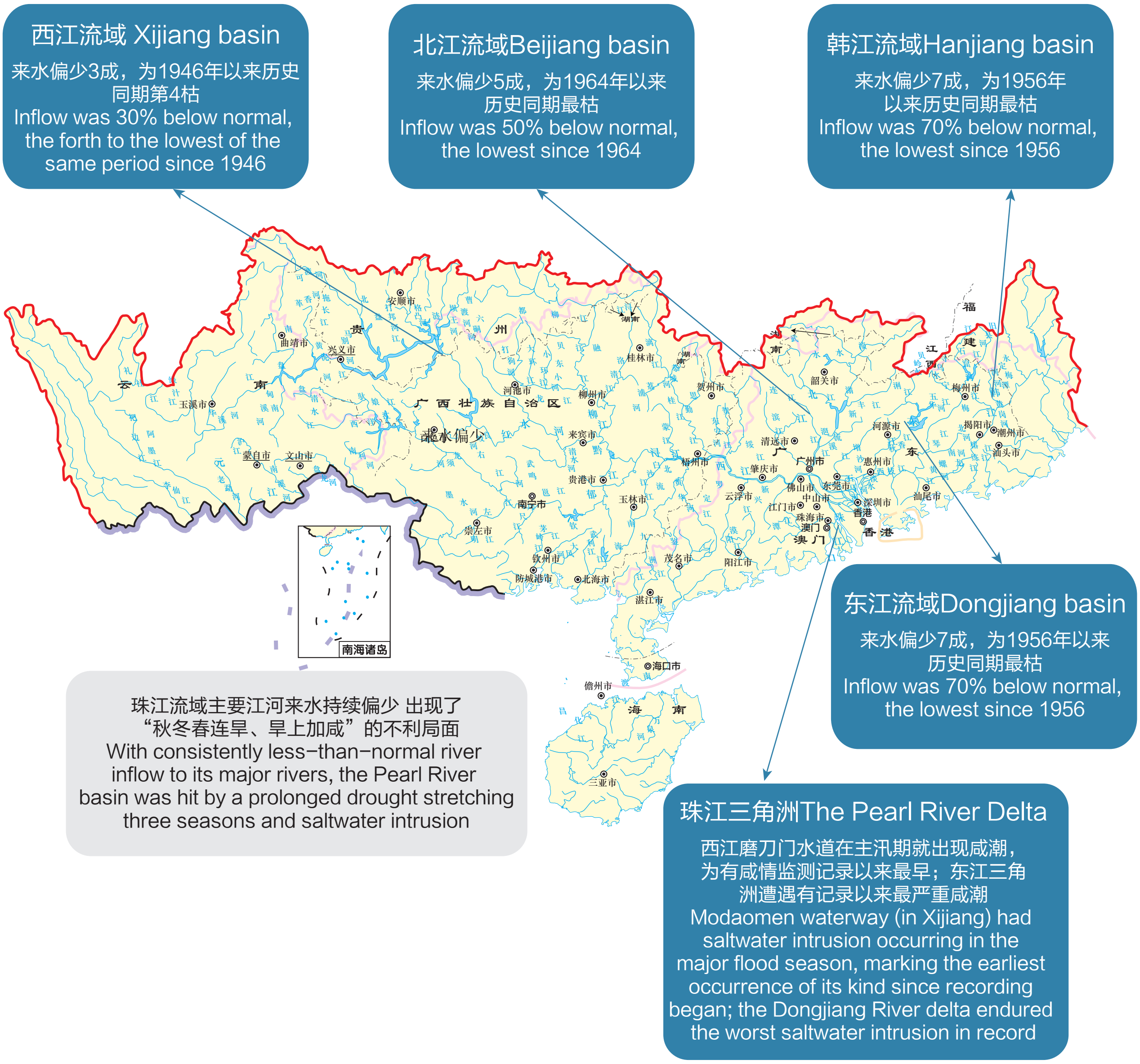


图 4-1　珠江流域来水概况

Figure 4-1　Inflows to the Pearl River basin

4.3 干旱灾情

2021 年，受降水偏少、江河来水偏枯和水利工程蓄水不足等因素影响，全国 26 省（自治区、直辖市）发生干旱灾害（江苏省出现旱情，未发生旱灾），灾情总体偏轻。全国作物因旱受灾面积 4447.80 千公顷，比前 10 年平均值下降 57.0%；成灾面积 2276.74 千公顷，绝收面积 561.16 千公顷；因旱粮食损失 49.28 亿公斤，比前 10 年平均值下降 71.7%；经济作物损失 54.90 亿元；546.35 万人发生因旱饮水困难，比前 10 年平均值下降 54.5%；250.63 万头大牲畜发生因旱饮水困难，比前 10 年平均值下降 68.4%。其中，作物因旱受灾面积、因旱饮水困难大牲畜数量、因旱粮食损失均为近 10 年最低。

4.3 Disasters and Losses

In 2021, less-than-normal precipitation and river inflow, as well as insufficient storage in water conservancy projects were the main drivers of the drought disasters that occurred in 26 provinces/autonomous regions/municipalities (Drought conditions occurred in Jiangsu Province but did not develop into disasters). The drought losses were moderate in general. Drought affected 4,447,800 hectares of cropland, 57.0% less than the preceding decadal average; Drought damaged 2,276,740 hectares of cropland, among which 561,160 hectares suffered from crop failure; The grain yield loss attributed to drought was 4.928 billion kg, down by 71.7% from the preceding decadal average; The loss of cash crops amounted to 5.49 billion RMB; A total of 5.4635 million people experienced difficulties accessing drinking water due to drought, 54.5% less than the preceding decadal average; A total of 2.5063 million bigger-sized livestock experienced difficulties accessing drinking water due to drought, 68.4% less than the preceding decadal average. It is noted that the cropland area affected by drought, the number of bigger-sized livestock experiencing difficulties accessing drinking water by drought, and the grain yield loss by drought marked their lowest in the past decade.

表 4-1　2021 年作物因旱受灾面积、成灾面积、绝收面积情况统计表（单位：千公顷）
Table 4-1　Cropland area affected, damaged, and failed by drought (in 1,000 hectares)

地区 Province	作物因旱受灾面积 Cropland area affected by drought	作物因旱成灾面积 Cropland area damaged by drought	作物因旱绝收面积 Cropland area failed by drought
全国 Nationwide	4447.80	2276.74	561.16
北京 Beijing			
天津 Tianjin	2.78	2.74	0.04
河北 Hebei	87.81	24.34	
山西 Shanxi	244.72	157.28	17.67
内蒙古 Inner Mongolia	899.07	364.52	39.21
辽宁 Liaoning	8.11	5.66	0.22
吉林 Jilin	3.60	3.60	
黑龙江 Heilongjiang	480.77	199.77	36.32
上海 Shanghai			
江苏 Jiangsu			
浙江 Zhejiang	10.25	2.41	0.35
安徽 Anhui			
福建 Fujian	40.80	17.85	1.17
江西 Jiangxi	329.00	111.30	12.00
山东 Shandong	0.04	0.04	
河南 Henan	40.84	10.16	0.65
湖北 Hubei	88.55	54.76	0.65
湖南 Hunan	80.89	49.88	9.53
广东 Guangdong	94.72	48.18	6.73
广西 Guangxi	214.69	117.81	30.12
海南 Hainan	4.04	0.74	0.08
重庆 Chongqing	56.45	37.66	5.27
四川 Sichuan	25.25	2.79	1.83
贵州 Guizhou	3.49	2.62	0.14
云南 Yunnan	311.26	166.10	18.41
西藏 Tibet			
陕西 Shaanxi	564.32	331.60	137.84
甘肃 Gansu	391.38	275.03	82.59
青海 Qinghai	33.04	24.80	0.87
宁夏 Ningxia	410.88	252.04	158.84
新疆 Xinjiang	21.05	13.06	0.63

注：空白表示无灾情。
Note: Spaces in blank denote no such losses by drought.

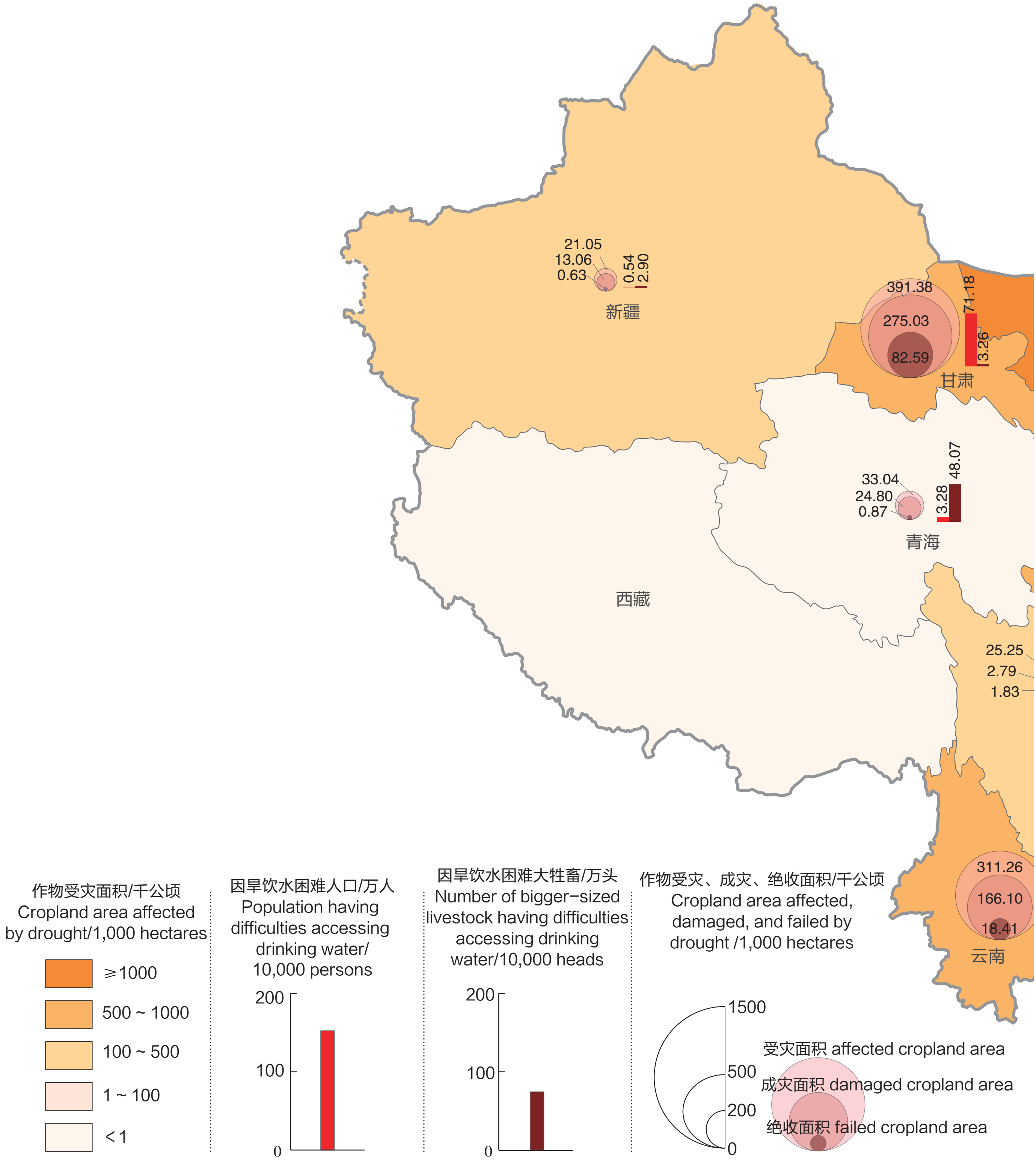
表 4–2　2021 年农村因旱饮水困难情况统计表
Table 4–2　Difficulties accessing drinking water attributed to drought in rural areas

地区 Province	因旱饮水困难人口 / 万人 Population having difficulties accessing drinking water /10,000 persons	因旱饮水困难大牲畜 / 万头 Number of bigger–sized livestock having difficulties accessing drinking water/10,000 heads	地区 Province	因旱饮水困难人口 / 万人 Population having difficulties accessing drinking water /10,000 persons	因旱饮水困难大牲畜 / 万头 Number of bigger–sized livestock having difficulties accessing drinking water/10,000 heads
全国 Nationwide	546.35	250.63	河南 Henan		
北京 Beijing			湖北 Hubei	11.18	2.06
天津 Tianjin			湖南 Hunan	6.42	2.33
河北 Hebei			广东 Guangdong	123.90	5.62
山西 Shanxi	17.59	2.95	广西 Guangxi	9.43	0.14
内蒙古 Inner Mongolia	14.80	82.12	海南 Hainan	1.81	
辽宁 Liaoning	0.19	0.05	重庆 Chongqing	16.00	6.50
吉林 Jilin		2.35	四川 Sichuan	2.82	4.15
黑龙江 Heilongjiang	2.65	0.25	贵州 Guizhou	6.06	0.19
上海 Shanghai			云南 Yunnan	184.12	66.28
江苏 Jiangsu			西藏 Tibet		
浙江 Zhejiang	10.88	0.70	陕西 Shaanxi	13.30	18.96
安徽 Anhui			甘肃 Gansu	71.18	3.26
福建 Fujian	47.45	1.75	青海 Qinghai	3.28	48.07
江西 Jiangxi	2.76		宁夏 Ningxia		
山东 Shandong			新疆 Xinjiang	0.54	2.90

注：空白表示无灾情。
Note: Spaces in blank denote no such losses by drought.

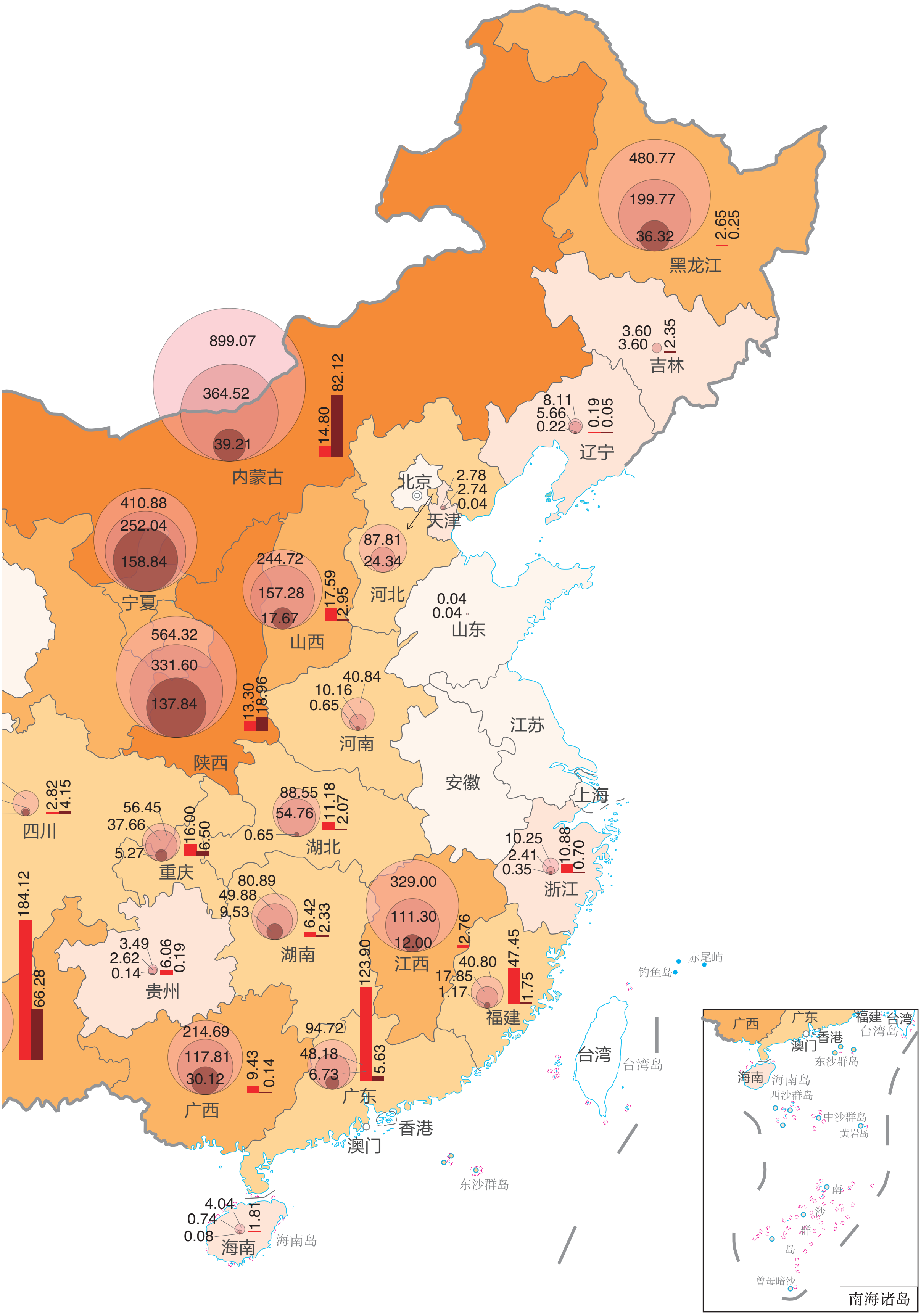
图 4-2　2021 年全国干旱灾害分布图

Figure 4-2　Overview of drought disasters nationwide in 2021



注： 香港特别行政区、澳门特别行政区、台湾地区资料暂缺。

Note: Data of Hong Kong SAR, Macao SAR, and Taiwan are currently unavailable.


黑龙江
480.77
199.77
36.32
2.65
0.25
吉林
3.60
3.60
2.35
辽宁
8.11
5.66
0.22
0.19
0.05
内蒙古
899.07
364.52
39.21
14.80
82.12
北京
天津
2.78
2.74
0.04
河北
87.81
24.34
宁夏
410.88
252.04
158.84
山西
244.72
157.28
17.67
17.59
2.95
山东
0.04
0.04
陕西
564.32
331.60
137.84
13.30
18.96
河南
40.84
10.16
0.65
江苏
安徽
上海
四川
2.82
14.15
重庆
56.45
37.66
5.27
16.00
6.50
湖北
88.55
54.76
0.65
11.18
2.07
浙江
10.25
2.41
0.35
10.88
0.70
湖南
80.89
49.88
9.53
6.42
2.33
江西
329.00
111.30
12.00
2.76
184.12
66.28
贵州
3.49
2.62
0.14
6.06
0.19
福建
40.80
17.85
1.17
47.45
1.75
广西
214.69
117.81
30.12
9.43
0.14
广东
94.72
48.18
6.73
123.90
5.63
香港
澳门
海南
4.04
0.74
0.08
1.81
海南岛
台湾
台湾岛
钓鱼岛
赤尾屿
东沙群岛
南海诸岛
广西
广东
福建
台湾
香港
澳门
台湾岛
东沙群岛
海南
海南岛
西沙群岛
中沙群岛
黄岩岛
南
沙
群
岛
曾母暗沙

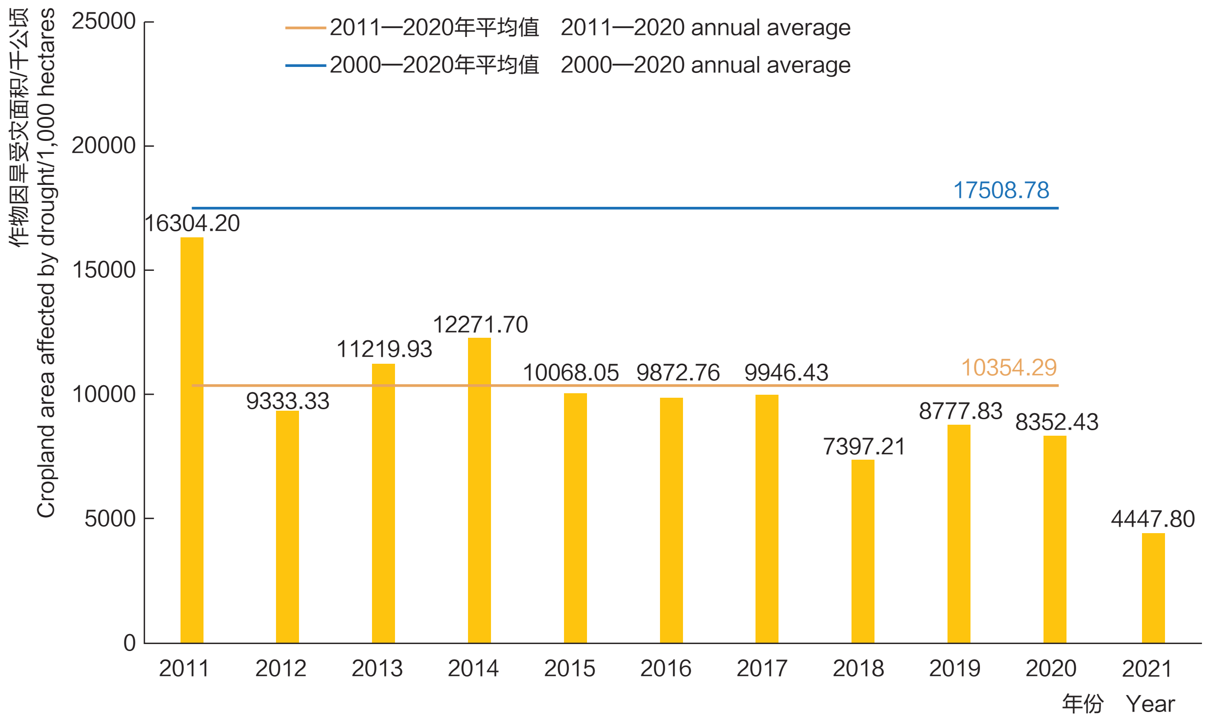


图 4-3　2011—2021 年全国作物因旱受灾面积统计
Figure 4-3　Cropland area affected by drought 2011—2021

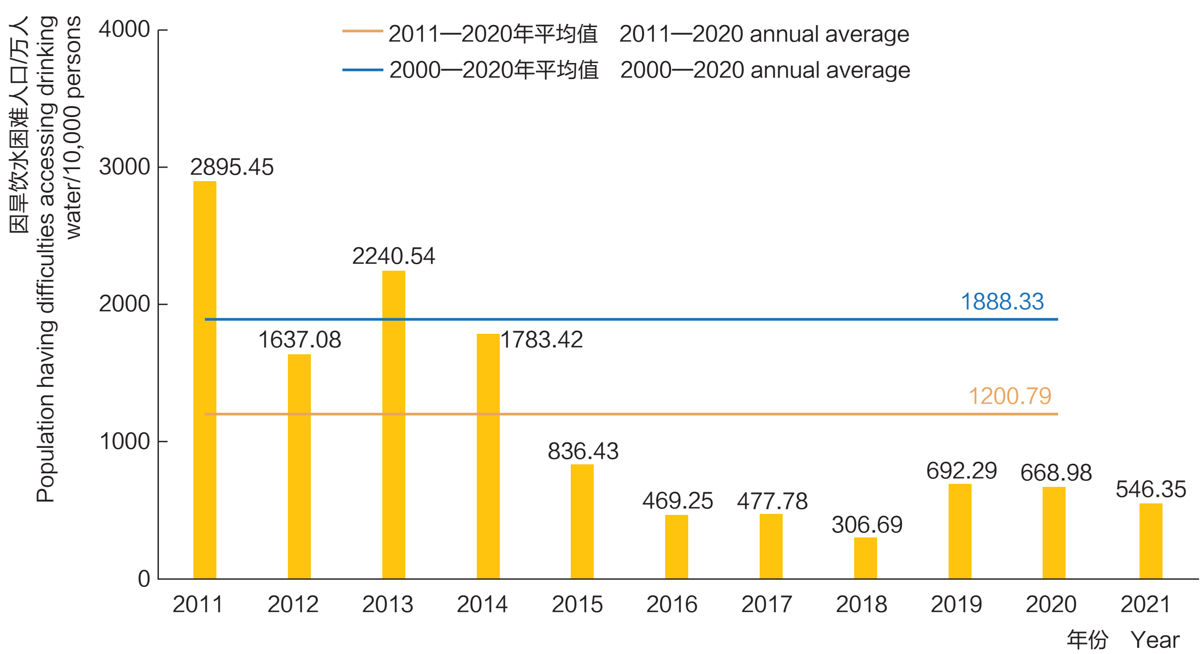


图 4-4　2011—2021 年全国因旱饮水困难人口统计
Figure 4-4　Population having difficulties accessing drinking water 2011—2021

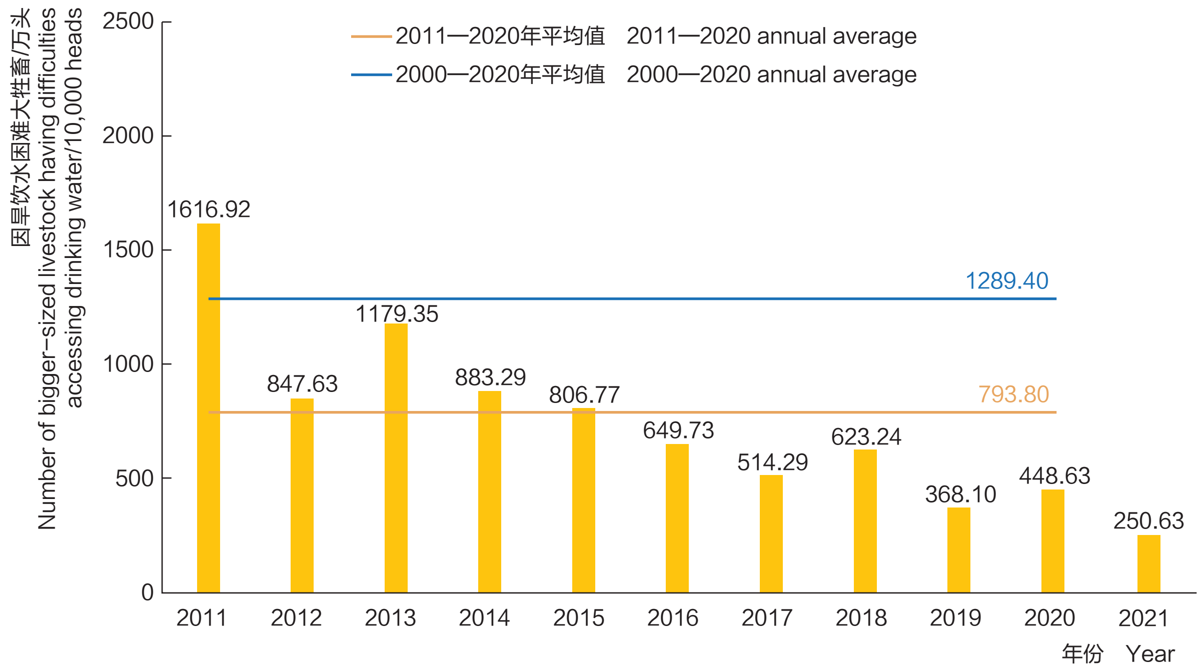


图 4-5　2011—2021 年全国因旱饮水困难大牲畜统计

Figure 4-5　Number of bigger-sized livestock having difficulties accessing drinking water 2011—2021

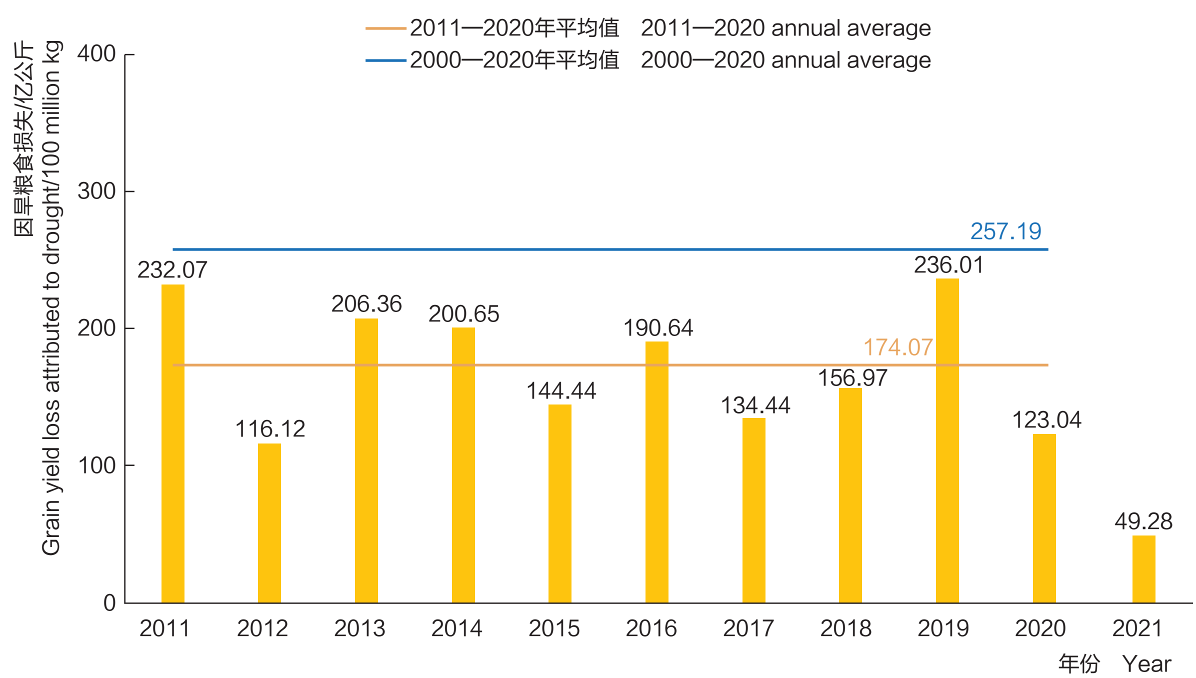


图 4-6　2011—2021 年全国因旱粮食损失统计

Figure 4-6　Grain yield loss attributed to drought 2011—2021

4.4 防御工作

4.4.1 部署安排

水利部部长李国英多次召开专题会商会，要求始终把保障群众饮水安全放在首位，坚持流域区域统筹、开源节流并重、短期长期兼顾，做到“预”字当先、“实”字托底，实施抗旱“四预”机制，筑牢供水保障“三道防线”，确保供水安全。分管部领导等多次会商部署抗旱保供水工作，作出具体工作安排。水利部派出 14 个工作组赴广东、云南、浙江、福建、广西、四川等省（自治区）协助指导抗旱工作；先后发出 6 个通知对保障群众饮水安全、做好春灌工作提出明确要求；召开全国抗旱工作业务培训班，对省级水利部门从事抗旱工作人员进行培训，部署抗旱工作。

4.4.2 方案编制

1 月，下发《水利部办公厅关于加强旱情排查和编制城乡群众生活供水保障方案的通知》，组织浙江、福建、江西、湖南、广东、广西、云南 7 省（自治区）立足 2021 年汛前无有效降水的最不利情况，编制城乡群众生活供水保障方案，因地制宜确保群众用水安全；组织珠江委、广东省水利厅针对枯水期供水需求，编制西江、韩江、东江枯水期水资源联合调度方案和广东省抗旱保供水预案，进一步加强流域骨干工程调度，全力保障香港、澳门和广州、深圳、珠海、东莞、汕头、揭阳、梅州等重要城市供水安全；积极推动各流域管理机构和省级水行政主管部门根据《水利部办公厅关于印发应急水量调度预案编制指南（试行）的通知》要求编制应急水量调度预案。黄委根据无定河流域取用水、旱情形势分析及骨干水利工程情况，编制《无定河应急水量调度预案》。河南省针对可能发生的干旱缺水、生态破坏以及其他需要启动应急水量调度的事件，制定《河南省水利厅应急水量调度预案》。

4.4 Prevention and Control

4.4.1 Arrangements

At the multiple consultation meetings he convened, Minister Li Guoying of MWR required that utmost priority be put on securing drinking water supplies. Efforts must be made to coordinate different river basins and regions, save water use and increase source water, and address both near-term and longer-term issues. Forecasting, early-warning, exercising, and contingency planning (the four preventive pillars) should be followed through, and the “three safety nets” for water supply, i.e. local, nearby, and long-distance source water, must be made available. Leaders in charge made specific arrangements through multiple consultations. The Ministry sent 14 working groups to Guangdong, Yunnan, Zhejiang, Fujian, Guangxi, and Sichuan provinces (autonomous regions) to help guide drought relief. Six notices were issued urging for securing drinking water supplies and ensuring springtime irrigation. The Ministry also held national training courses for front line officials in provincial water resources departments in order to guide their work.

4.4.2 Contingency planning

In January, the General Office of MWR issued the *Notice on Strengthening Drought Investigation and Drafting the Water Supply Security Plan for Urban and Rural Residents*. Zhejiang, Fujian, Jiangxi, Hunan, Guangdong, Guangxi, Yunan provinces/autonomous regions followed up to draft their plans based on the worst scenario of no effective precipitation before the 2021 flood season in order to ensure water supply security in congruent with local conditions. The Ministry also asked the Pearl River Commission and the Water Resources Department of Guangdong Province to formulate joint water resources scheduling plan for Xijiang, Hanjiang, and Dongjiang rivers and a provincial drought relief and water supply security plan to cope with water demand in the low-water period. It was urged that the scheduling of critical water conservancy projects within the watersheds be strengthened so as to secure the water supplies to Hong Kong, Macao, Guangzhou, Shenzhen, Zhuhai, Dongguan, Shantou, Jieyang, Meizhou and other major cities. The Ministry also pushed the preparation of emergency water dispatch plans by all river basin authorities and provincial water administrative agencies in accordance with the *Notice of the General Office of the Ministry of Water Resources on Releasing the Guidelines (trial) for Drafting Emergency Water Dispatch Plans*. The Yellow River Commission prepared the *Wuding River Emergency Water Dispatch Plan* based on the analyses of water withdrawal and consumption, drought conditions, and the status of critical water conservancy projects in the basin. Henan Province also formulated the *Emergency Water Dispatch Plan of the Water Resources Department* of *Henan Province* in view of possible emergencies such as drought, water shortage, and ecological damage.

4.4.3 水量调度

坚持“系统、统筹、科学、安全”的原则，汛期加强水量精细调度，合理配置水资源，为抗旱提供水源保障，汛末开展蓄水调度，保障下游供水。长江委组织实施长江流域控制性水库群枯水期补水调度和汛前消落调度，2020 年底至 2021 年汛前累计向下游补水 595 亿立方米；汛前三峡水库累计补水 221 亿立方米，秋汛之后完成 175 米满蓄任务，为下一阶段枯水期用水提供水量保障；丹江口水库 2021 年度实际向北方调水 90.54 亿立方米，供水总量和生态补水量均创历史新高，并首次实现 170 米满蓄目标。黄委调度黄河干流龙羊峡、刘家峡、万家寨、三门峡、小浪底 5 大水库，汛期增蓄水量 100.77 亿立方米，非汛期向下游补水 126.53 亿立方米，为抗旱供水提供了水源；全年度黄河干流供水 195.39 亿立方米。珠江委实施 2020—2021 年珠江枯水期水量调度工作，累计向澳门和珠海供水 1.41 亿立方米，其中向澳门供水 3960 万立方米，连续 17 年保障澳门、珠海等地供水安全；针对 2021 年秋冬季珠江流域河道来水持续偏少、骨干水库蓄水不足情况，统筹防洪、供水、发电、航运、生态等多方需求，提前启动 2021—2022 年西江枯水期水量调度，在后汛期抓好蓄水补库，为保障澳门、珠海等地供水储备了宝贵水源。松辽委调度察尔森水库开展抗旱应急补水，累计调水 8000 万立方米，改善了向海国家自然保护区、牛心套湿地公园生态环境，保障了白城市农业生产春灌用水需求。太湖局科学实施 4 次引江济太调水，首度确立 II 类水入湖目标，累计调引长江水 14.4 亿立方米，入太湖 7.2 亿立方米；3 次实施太浦河闸泵调度，累计供水 2134 万立方米。

4.4.3 Water dispatch

The Ministry implemented systemic, coordinated, scientific, and safe scheduling of water resources during and post the flood season to secure water resources for drought relief and water supplies downstream. The Changjiang Commission commanded the watershed controlling reservoirs to release water during low-water periods and conduct reservoir draw-down prior to the flood season. As a result, these reservoirs released 59.5 billion m^3 of water from the end of 2020 to the onset of flood season in 2021. In particular, the Three Gorges Reservoir released 22.1 billion m^3 of water prior to the flood season and was stored to its full capacity at 175m-level post the autumn flood season, hence securing water for future low-water periods. The Danjiangkou Reservoir transferred 9.054 billion m^3 of water to the northern regions in 2021, setting new records in both total water diversion volume and ecological water replenishment; also, the reservoir achieved full storage capacity at 170m-level for the first time. The Yellow River Commission commanded Longyangxia, Liujiaxia, Wanjiazhai, Sanmenxia and Xiaolangdi—the five major reservoirs on the main-stem Yellow River—to take in additionally 10.077 billion m^3 of floodwater and then supply to the downstream 12.653 billion m^3 after the flood season ended, hence securing water supply at times of drought. In total, the main-stem Yellow River supplied 19.539 billion m^3 of water throughout the year. The Pearl River Commission conducted water dispatch during the 2020-2021 low-water period and supplied 141 million m^3 of water to Zhuhai and Macao, the latter of which received 39.6 million m^3. It was the 17th year in a row that water from the Pearl River had been feeding the pipelines in these cities. As the Pearl River basin received persistently lower-than-normal river inflow and the critical reservoirs were not replenished sufficiently during autumn and winter in 2021, the Commission coordinated the multiple water demands such as flood control, water supply, power generation, navigation, and ecological flow, and initiated Xijiang River water dispatch during the 2021-2022 low-water period ahead of the usual time. Reservoirs were replenished timely near the end of the flood season, thereby securing water supply to cities like Macao and Zhuhai. The Songliao Commission commanded emergency water dispatch totaling 80 million m^3 from Chaersen Reservoir to conserve the ecological soundness in Xianghai National Nature Reserve and Niuxintaobao Wetland Park and guarantee spring irrigation in Baicheng city. The Taihu Authority diverted water from the Yangtze to the Taihu Lake four times and for the first time introduced a class II water quality target for water that enters the Lake. A total of 1.44 billion m^3 of water was diverted from the Yangtze and 720 million m^3 flowed into the Taihu. The Taihu Basin Authority also put into operation the Taipu River gates and pump complex three times to transfer 21.34 million m^3 of water.

案例 9 应对华南地区秋冬春连旱

2021 年，珠江流域降雨偏少 3 ~ 4 成，江河来水持续偏枯，其中西江偏少 3 成、北江偏少 5 成、东江和韩江偏少近 7 成，骨干水库有效蓄水率一直偏低，特别是东江、韩江流域骨干水库蓄水严重不足。受其影响，珠江流域多地秋季出现旱情，加上珠江口咸潮活动明显偏强，旱情呈现“秋冬春连旱、旱上加咸”态势，其中东江、韩江流域遭遇了 60 年来最严重旱情，广东东部和福建局部旱情尤为严重。

水利部李国英部长多次视频连线广东和福建省人民政府、水利厅及基层水利工程管理单位，珠江委及大藤峡水利枢纽管理部门等，会商研判旱情趋势，部署应急抗旱调水和压咸补淡等工作，要求强化“四预”措施，筑牢当地、近地、远地供水保障“三道防线”。

珠江委完善预报、预警、预演、预案机制，充分利用抗旱“四预”平台，密切监视雨情、水情、工情、咸（潮）情，及时发布东江、韩江干旱黄色预警和西江、北江干旱蓝色预警，模拟预演水情、咸（潮）情、工情动态，制定枯水期应急水量调度方案，启动珠江防总抗旱Ⅳ级应急响应。调度骨干水工程，逐流域、逐供水区研判供水保障形势，结合流域工程体系和蓄水状况，按照当地、近地、远地梯次构筑了西江、东江、韩江抗旱保供水“三道防线”。西江以珠海等本地水库为“第一道防线”，中下游大藤峡水利枢纽为“第二道防线”，中上游龙滩、百色等骨干水库为“第三道防线”；东江以深圳等本地水库为“第一道防线”，中下游东江（剑潭）水利枢纽为“第二道防线”，中上游新丰江、枫树坝、白盆珠等水库群为“第三道防线”；韩江以潮州水利枢纽为“第一道防线”，中游高陂水利枢纽为“第二道防线”，福建棉花滩和广东长潭、益塘、合水等水库群为“第三道防线”。珠江委深入一线指导“第一道防线”加强蓄水补库和供水调配；滚动调整“第二道防线”“第三道防线”出库流量，多方案预演压咸时机和补充水量。在水利部的统一部署下，先后 3 次启动压咸补淡应急调度，有效压制河口咸潮，其中西北江磨刀门水道咸界最多下移约 23 公里，东江三角洲北干流、南支流咸界最多下移约 6 公里和 8 公里，最大程度减轻了咸潮对主要取水口的影响，有效保障了粤港澳大湾区供水安全。

广东、福建等省提前修订完善应急抗旱预案，及时启动抗旱应急响应，强化水工程运行管理，严格执行调度指令，加强应急补水期间重要断面水质监测和沿程取水口监管，抓住时机抢蓄淡水，保证了应急补水调度取得最大成效。同时，综合采取建设抗旱应急供水工程、加强节约用水、限制高耗水行业用水等措施，全力保障城乡供水安全。

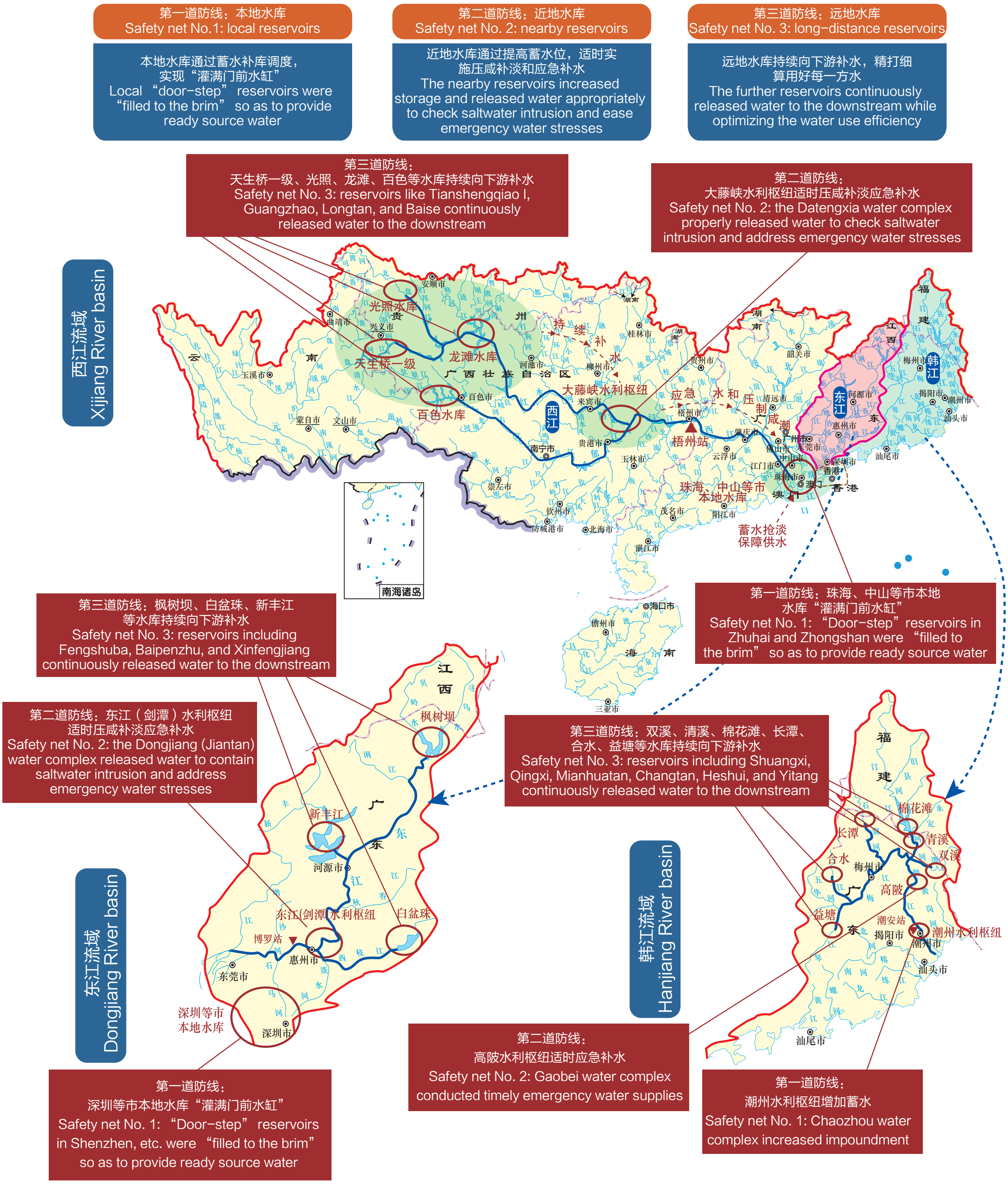


图 4–7 珠江流域供水保障“三道防线”

Figure 4–7 The “three safety nets” of water supply in the Pearl River basin

Case 9 Responses to the autumn–winter–spring drought in South China

In 2021, rainfall in the Pearl River basin fell 30%-40% below normal and river inflow was persistently leaner-than-normal. Xijiang River received 30% less inflow than normal, Beijiang River received 50% less, and Dongjiang River and Hanjiang River received almost 70% less. The effective storage ratio of critical reservoirs was low, with reservoirs in Dongjiang and Hanjiang watersheds were severely under-stored. Under such circumstances, multiple places in the Pearl basin were gripped by drought since autumn, and saltwater intrusion along the Pearl River estuary was notably stronger than normal. This double kill of stretching drought and salinity increase induced the worst drought that ever gripped the Dongjiang and the Hanjiang river basins in 60 years. Eastern Guangdong and parts of Fujian were the most severely affected.

Reaching out to and consulting with Guangdong and Fujian provincial governments, water resources departments, local water projects management agencies, the Pearl River Commission and the Datengxia Water Complex Authority, Minister Li Guoying of MWR commanded emergency water diversion to combat drought and check saltwater intrusion. He urged to shore up forecasting, early-warning, exercising, and contingency planning for drought disaster prevention, and to ensure local, nearby, and long-distance source water allocation.

The Pearl River Commission improved and fully tapped into the mechanism of forecasting, early warning, exercising, and contingency planning to closely monitor rainfall, water regime, water projects and saltwater intrusion. A yellow warning of drought for Dongjiang and Hanjiang Rivers and a blue warning of drought for Xijiang and Beijiang Rivers were issued promptly, low-water period emergency water dispatch plans were drafted in accordance with the dynamic simulations, and a level-IV emergency response against drought was launched by the Pearl River Flood Control and Drought Relief Headquarters.

Upon analyses of the drought conditions and water stresses by each watershed and by each water receiving region, as well as the water projects and reservoir storage dynamics, the Commission regulated the critical water projects in the Xijiang, Dongjiang, and Hanjiang River basins to make available local, nearby, and long-distance source water supplies.

For Xijiang River, local reservoirs such as those in Zhuhai city were the “first safety net”, the Datengxia Water Complex in the mid-lower reaches was the “second safety net”, and the backbone reservoirs such as Longtan and Baise in the mid-upper reaches were the “third safety net”. For Dongjiang River, local reservoirs such as those in Shenzhen city were the “first safety net”, the Dongjiang (Jiantan) Water Complex in the mid-lower reaches was the "second safety net", and reservoirs in the mid-upper reaches including Xinfengjiang, Fengshuba, and Baipenzhu were the "third safety net". For Hanjiang River, the Chaozhou Water Complex was the "first safety net", Gaobei Water Complex in the middle reaches was the "second safety net", and the reservoir group including Mianhuatan in Fujian Province and Changtan, Yitang and Heshui in Guangdong Province were the "third safety net". With regard to the first safety net, focuses were laid on storing up the reservoirs and allocating the water; with regard to the second and the third safety nets, reservoir outflows were flexibly adjusted and the timing and the quantity of freshwater release to check saltwater intrusion were rehearsed under multiple scenarios. Following the command from MWR, the Commission conducted emergency water dispatch three times to effectively contain the saline intrusion at the estuary. As a result, the freshwater/saltwater interface at Modaomen (the sea-bound waterway of Xijiang River) retreated for up to 23 km, while the interfaces at the northern mainstream and the southern tributary of Dongjiang River delta retreated for up to 6 km and 8 km, respectively. Such measures effectively protected the major source water intakes and secured the water supplies to the Guangdong-Hong Kong-Macao Greater Bay Area.

Provinces including Guangdong and Fujian revised and improved their drought relief contingency plans in advance, timely launched emergency responses against drought, strengthened the operation and management of water projects, strictly implemented the water dispatch instructions, strengthened the monitoring of water quality in important cross sections during the emergency replenishment period and the supervision of water intakes along the replenishment route. The provinces lost no time to store fresh water whenever the circumstances allowed, and ensured that the emergency water replenishment dispatch achieved maximum results. At the same time, comprehensive measures such as constructing drought relief emergency water supply projects, strengthening water conservation, and restricting water use in high-water-consuming industries were adopted to ensure the safety of urban and rural water supply.

4.4.4 应急响应

为做好抗旱工作，相关流域和旱区各地及时启动应急响应，全力应对旱情。珠江委启动干旱灾害防御Ⅳ级应急响应，发布西江、北江干旱蓝色预警和东江、韩江干旱黄色预警，提醒相关地区做好干旱应对工作。广东省启动水利抗旱Ⅳ级应急响应，多个受旱城市发出节水倡议，呼吁全民、全行业、全社会珍惜水、爱护水、节约水，营造全民支持抗旱的良好氛围。陕西省启动陕北地区和渭北片区水旱灾害防御Ⅳ级应急响应，要求各级水利部门密切关注旱情发展动态，充分利用抗旱水源和设施设备，科学调度水工程，努力保障群众生活、生产用水和粮食安全。

4.4.5 基础工作

水利部积极落实抗旱“四预”机制，推进开展旱情监测预警综合平台建设、江河湖库旱警水位（流量）确定等基础工作。召开专题会议研究部署旱情监测预警综合平台建设工作；加快完成旱情监测预警综合平台的前期设计，支撑在全国范围内实现农作物、林木、牧草、重点湖泊湿地生态的旱情综合监测评估。在东北、华北、长江中下游的 7 省 16 个水文测站开展江河湖库旱警水位（流量）确定研究，派出工作组对试点成果进行调研评估；对现有干旱预警指标确定工作中的成熟经验和江河湖库旱警水位（流量）计算方法进行总结归纳，汇编完成《江河湖库旱警水位（流量）计算方法案例》，解决江河湖库旱警水位（流量）确定工作中的技术难题，促进抗旱预案更加有针对性和可操作性，助力提高旱情监测预报预警能力。

4.4.4 Emergency responses

Swift emergency responses against drought were launched in the affected river basins and jurisdictions. The Pearl River Commission launched level-IV emergency response against drought, issued a blue warning of drought for Xijiang and Beijiang Rivers and a yellow warning of drought for Dongjiang and Hanjiang Rivers, and urged relevant regions to prepare for drought. Guangdong Province launched level-IV emergency response against drought, and many drought-stricken cities launched water-saving initiatives that called for society-wide water conservation. Shaanxi Province launched level-IV emergency response for flood and drought disaster prevention in its Shanbei and Weibei regions. Local water resources departments were required to track the development of drought, fully and scientifically tap into their drought-relief water sources, facilities, and water projects to sustain water supplies to households, industry, and agriculture.

4.4.5 Foundational work

Shoring up the four preventive pillars of drought prevention, MWR strengthened foundational work such as developing drought monitoring and early warning platforms and determining drought-alert levels (flows) in rivers, lakes, and reservoirs. Focal working meetings were organized and the preliminary design of the platforms was finished in the swiftest possible manner. The platforms had been supporting nation-wide comprehensive drought monitoring and assessment covering cropland, forests, pastures and grassland, and key lake and wetland ecosystems. The determination of drought-alert levels (flows) was carried out at 16 hydrologic stations in seven provinces in Northeast China, North China and the middle and lower reaches of the Yangtze. Upon investigation and evaluation of such pilot work, MWR commissioned a review of the prevailing practices and proven methods, and produced *Case Studies on Calculation Methods of Drought-Alert Levels (Flows) In Rivers, Lakes, and Reservoirs*. This document helped address the technical barriers in determining the threshold levels (flows) triggering a drought alert, strengthened the precision and the operability of drought relief contingency plans, and contributed to stronger drought monitoring, forecasting, and early-warning capacities.

4.4.6 抗旱投入

为保障城乡居民用水安全和粮食丰收，尽可能减小旱灾影响和损失，中央和地方各级政府多措并举，千方百计增加抗旱投入。水利部商财政部分 3 批次安排中央水利救灾资金 6.5 亿元，支持受旱省份做好抗旱工作。受旱地区也加大投入力度，充分调动群众抗旱积极性。山西省累计投入抗旱资金 10141 万元，其中，省级财政抗旱补助资金 800 万元，市（县）财政投入 734 万元，群众自筹资金 8607 万元。黑龙江省启用机电井 1.78 万眼、泵站 459 处，投入机动抗旱设备 3.06 万台（套），出动机动运水车辆 0.98 万辆，累计完成抗旱浇灌 53.98 千公顷。广东省各地累计派出工作组 1861 个 4979 人次，投入资金 14 亿元，保障供水安全。云南省财政拨出专款 1.5 亿元支持旱情较重州（市）、县（市、区）做好抗旱保供水工作。陕西省分批次下达省级抗旱资金 2100 万元。甘肃省下达省级水利救灾抗旱资金 1000 万元支持旱情较重地区开展供水保障工作。宁夏回族自治区及时下达资金 1.14 亿元，维修养护农村供水工程 95 处、农业灌溉引水渠道 1600 多公里、水工建筑物 6600 多座，检修保养泵站机电设备设施 54 座。

4.5 防御成效

在党中央、国务院的领导下，水利部坚持防汛和抗旱工作两手抓，旱区各级党委、政府落实责任，抓各级联动、抓精准调度、抓保障有力，组织干部群众积极防御，最大程度减少旱灾损失，确保了旱区群众的饮水安全，保障了粮食丰收，维护了旱区经济社会可持续发展。2021 年全国投入抗旱劳力 604.56 万人，开动机电井 119.01 万眼、泵站 2.9 万处、机动抗旱设备 636.91 万台（套），出动各类机动运水车辆 904.76 万辆，全年累计投入抗旱资金 29.90 亿元，全年累计解决临时饮水困难人口 535 万人，完成抗旱浇地面积 3997.62 千公顷，抗旱挽回粮食损失 56.32 亿公斤、经济作物损失 50.48 亿元。

4.4.6 Financial and in-kind input for drought relief

The central and local governments went all out to mobilize funding and resources in a bid to secure public water supplies, support agricultural irrigation, and minimize the impacts and losses from drought. MWR, in consultation with the Ministry of Finance, allocated three installments of central water disaster relief fund, totaling 650 million RMB, to the drought-stricken provinces. The affected regions also increased input and encouraged the society to play a part. Shanxi Province spent a total of 101.41 million RMB on drought relief, including 8.00 million RMB from the provincial fiscal coffers, 7.34 million RMB from local finance and 86.07 million RMB raised by the public. Heilongjiang Province put into operation 17,800 electromechanical wells and 459 pumping stations, commissioned 30,600 sets of mobile drought mitigation equipment and 9,800 water tankers to irrigate 53,980 hectares of affected cropland. Guangdong Province dispatched 1,861 water supply working groups that involved 4,979 person-times and invested 1.4 billion RMB in this regard. Yunnan Province earmarked 150 million RMB to support the most drought-stricken localities. Shaanxi Province cumulatively allocated 21 million RMB for drought relief from its provincial finance. Gansu Province allocated 10 million RMB in the form of provincial water disaster relief fund to support water supplies in areas that are worst hit by drought. The Ningxia Hui Autonomous Region allocated 114 million RMB to repair and service 95 rural water supply projects, more than 1,600 km of irrigation diversion channels, over 6,600 hydraulic structures, and the electromechanical facilities in 54 pumping stations.

4.5 Effectiveness of Drought Disaster Prevention

Under the leadership of the CPC Central Committee and the State Council, MWR laid an equal focus on drought disaster prevention as on flood control and management. Local governments also solidly assumed their responsibilities. They strengthened collaboration and coordination, improved precise commanding and scheduling, secured effective support, and mobilized the society to help fight drought. Losses were contained, drinking water supplies were maintained, agricultural production was saved, and the local socio-economic development was sustained. In 2021, a total of 6.0456 million people participated in drought relief work, 1.1901 million electromechanical wells, 29,000 pumping stations, 6.3691 million sets of mobile drought mitigation equipment, and 9.0476 million water tankers were put in use. A total of 2.99 billion RMB was invested in drought relief for the whole year. Water was supplied to 5.35 million people with temporary difficulties accessing drinking water. A total of 3,997,620 hectares of affected cropland were saved with emergency irrigation. As a result, 5.632 billion kg of grain yield and cash crops worth of 5.048 billion RMB were recovered.

4.5.1 有效保障群众用水安全

旱区各地按照“先生活、后生产”的原则，把确保群众生活用水放在抗旱工作的首位。浙江省实施省内跨流域引供水，省内主要城镇未出现饮水困难情况。广东省紧急实施应急抗旱供水工程，基本建成韩江、榕江、练江水系连通工程，韩江鹿湖隧洞提前通水，日供水量 15 万立方米；2021 年 6 月开始实施的农村集中供水全覆盖攻坚行动，建设供水设施 4678 宗，基本实现 525 万农村居民集中供水全覆盖，实际受益人口超过 700 万人。云南省 2021 年累计开工兴建抗旱保供水工程 567 项，工程受益人口 255.05 万人，有效保证了城乡集镇供水安全。

4.5.1 Securing drinking water supplies

"Drink before production" was followed when it came to prioritizing the water uses at times of drought. Zhejiang Province conducted water diversion across different catchments within the province to ensure that no drinking water cut-off happened in major cities and towns. Guangdong Province implemented emergency water supply projects: the Hanjiang-Rongjiang-Lianjiang River connectivity system was completed in vast parts, and the Luhu diversion tunnel of Hanjiang River was commissioned ahead of schedule, supplying 150,000 m^3 of water daily. The province started a centralized water supply campaign in rural areas since June 2021 and since then, 4,678 water supply facilities were constructed; roughly all the rural residents, totaling 5.25 million, had access to centralized water supplies; and the factual beneficiaries went beyond 7 million. Yunnan Province launched 567 drought relief and water supply projects in 2021, benefiting 2.5505 million people and securing water supplies to both urban and rural areas.

广东广州市刘屋洲应急供水工程（2021 年 12 月）
Liuwuzhou emergency water supply project in Guangzhou city, Guangdong Province (December, 2021)

4.5.2 有效保障农业灌溉

受旱地区水利部门科学制定灌溉方案，通过蓄水、调水、补水等措施，全力保障农业灌溉，为维护国家粮食安全提供了强有力支撑。山西省发挥水利工程的抗旱能力，2020 年冬浇和 2021 年春浇、夏浇共完成抗旱灌溉面积 295.11 千公顷。内蒙古自治区努力增加工程蓄水，优化调度水利工程，累计完成抗旱浇灌面积 3936 千公顷，挽回粮食损失 8.5 亿公斤。陕西省发挥 12 个大中型灌区的抗旱主力军作用，完成抗旱灌溉面积 613.33 千公顷，在旱区常规供水水源不足的情况下发挥已建成抗旱应急水源工程效益，挽回粮食损失 10.14 亿公斤。甘肃省在优先保障人畜饮水安全情况下，尽可能保障灌区作物适时适量灌溉，累计补水补灌 32 千公顷次。

4.5.3 有效保障水生态环境安全

长江委针对年初汉江中下游“水华”现象，调度丹江口水库向汉江中下游紧急增加下泄水量 0.93 亿立方米，并联合调度兴隆水利枢纽、引江济汉等工程，同时要求湖北省环境部门和汉江中下游沿岸相关地区做好限排控污、水环境应急监测，采取综合应对措施，保障了武汉、仙桃等城市水生态安全；两次组织实施丹江口—王甫洲区间生态调度试验，有效抑制伊乐藻等水生植物过度生长，改善了汉江中下游水生态环境；汛前消落期间开展 9 次生态调度试验，其中三峡水库生态调度试验期间宜都江段产漂流性卵鱼类总产卵量超过 124 亿粒、“四大家鱼”产卵量约 84 亿粒，产卵规模创历年之最。太湖局科学实施 4 次引江济太调水，首度确立 II 类水入湖目标，累计调引长江水 14.4 亿立方米，入太湖 7.2 亿立方米；3 次实施太浦河闸泵调度，太浦河水源地连续 4 年未发生水质异常。松辽委组织协调察尔森水库开展抗旱应急补水工作，累计调水量 8000 万立方米，有效缓解了吉林白城市旱情，沿途地下水得到充分补给，白城市境内的向海国家自然保护区、牛心套保湿地公园生态环境得到明显改善，取得了较好的社会效益和生态效益。

4.5.2 Ensuring agricultural irrigation

Water resources departments in the affected areas worked out scientific irrigation schemes and made every effort to meet agricultural water use through water storage, diversion and replenishment, thus effectively safeguarding national food security. Shanxi Province made use of water conservancy projects to irrigate 295,110 hectares of drought affected cropland during the winter in 2020 and the spring and the summer in 2021. The Inner Mongolia Autonomous Region managed to increase reservoir storage and optimize the operation of water conservancy projects to irrigate 3,936,000 hectares of drought affected cropland. A grain yield totaling 850 million kg was hence recovered. Shaanxi Province tapped into the 12 large and medium-sized irrigation districts and irrigated 613,330 hectares of drought affected cropland. When the regular water sources were lean, Shaanxi Province put into use emergency source water projects and successfully recovered 1.014 billion kg of grain yield. While giving priority to ensuring drinking water supplies to people and their livestock, Gansu Province managed to conduct timely and sufficient irrigation in its irrigation districts; 32,000 hectares of drought-threatened crops got irrigated cumulatively.

4.5.3 Water ecological health

An algal bloom broke out in the mid-lower reaches of Hanjiang River in early 2021. The Changjiang Commission increased the outflow from Danjiangkou reservoir by 93 million m^3 to the mid-lower reaches, and commanded joint scheduling of Xinglong water complex and Yangtze-Hanjiang water diversion project. In addition, the Commission urged the Hubei provincial environment protection departments and regions along the mid-lower reaches to strengthen river-bound pollution discharge control and emergency water environment monitoring. This portfolio of measures helped protect the water ecological health in cities like Wuhan and Xiantao. The Commission also commanded ecological flow regulation experiments twice in the Danjiangkou-Wangfuzhou River reach and effectively inhibited the excessive growth of aquatic plants such as Elodea and improved the water ecological environment in the mid-lower reaches of Hanjiang. Nine ecological flow regulation experiments were conducted during reservoir draw-downs in the lead-up to the flood season. During the experiment conducted in the Three Gorges reservoir area, the Yidujiang River reach registered over 12.4 billion eggs spawned by fish that produce drifting eggs and about 8.4 billion eggs spawned by the so-called “four most popular domesticated fish”, the latter of which set a new record high in years. The Taihu Authority diverted water from the Yangtze to the Taihu Lake for four times and for the first time set a class II water quality target for water that enters the Lake. A total of 1.44 billion m^3 of water were diverted from the Yangtze and 720 million m^3 flowed into the Taihu Lake. The Taipu River gates and pumps complex were operated three times and no water quality abnormalities ever occurred in the source water area of Taipu River for four consecutive years. The Songliao Commission coordinated Chaersen reservoir for emergency drought relief and achieved positive social and ecological benefits. Cumulatively 80 million m^3 of water were released. The drought conditions in Baicheng city in Jilin Province were effectively dissipated, the groundwater aquifers along the diversion pathway were sufficiently replenished, and both Xianghai National Nature Reserve and Niuxintaobao Wetland Park saw their ecological environment notably improved.

5 基础工作

FOUNDATIONAL WORK

5.1 规章制度

水利部组织制定并印发了《大中型水库汛期调度运用规定（试行）》《山洪灾害动态预警指标分析技术要求》《危险区动态管理清单编制指南》。长江委组织编制、修订了《长江水情预警发布管理办法》《长江委水旱灾害防御值班工作管理规定》《委管水库防汛物资储备管理办法》。地方各级水利部门按照水利部的统一部署，编制、修订、印发水旱灾害防御、水库调度运用等相关规章制度，进一步规范工作程序。

5.1 Rules and Regulations

MWR commissioned the preparation and circulation of *Regulations on the Dispatch and Operation of Large and Medium Reservoirs in Flood Season (Trial)*, *Technical Requirements for Dynamic Analysis of Flash Floods Early Warning Indicators* and *Guidelines for Dynamic Management Listing of Danger Zones.* The Changjiang Commission drafted and/or amended the *Regulations on Yangtze Water Regime Early-Warning Release*, the *Commission Regulations on Duty Standing for Flood and Drought Disaster Prevention*, and the *Management Regulations on Flood Control Supplies for Commission Reservoirs*. The local water resources departments and authorities followed up to formulate and/or upgrade rules, regulations, and working mechanism for flood and drought disaster prevention, and reservoir regulation and operation, etc.

5.2 方案预案

水利部批复了《2021年长江流域水工程联合调度运用计划》《丹江口水库优化调度方案（2021年度）》《2021年雄安新区起步区安全度汛方案》；编制印发了《水库防洪调度和汛限水位执行监督检查工作方案》《山洪灾害防御监督检查工作方案》。长江委印发了《长江流域水旱灾害防御补短板工作方案》，会同相关地方水行政管理部门审查批复了纳入联合调度的47座控制性水库汛期调度运用计划，修订了长江和嘉陵江、乌江、汉江、水阳江、滁河等省际河流超标准洪水防御预案，修编了长江超标准洪水防御“作战图”。黄委编制了《无定河水量应急调度预案》，修订完善了《2021年黄河中下游洪水调度方案》《2021年龙羊峡、刘家峡水库联合防洪调度方案》《国家重要水文站年度测洪及报汛方案》，编制印发了《2021年汛前黄河调水调沙预案》，审查批复了黄河干支流11座骨干水库汛期调度运用计划。淮委制定了《2021年淮河流域汛前检查工作方案》，编制了《淮河流域防洪“四预”试点技术方案》，修订完善了淮河流域主要河道、大型水库汛期调度运用计划，修编了淮河、洪汝河、沙颍河、沂河、沭河超标准洪水防御预案和淮河、沂河、沭河“作战图”，完善了王家坝、正阳关及吴家渡洪水预报方案。海委编制了《2021年雄安新区起步区安全度汛方案》以及15个报汛站超标准洪水应对预案，全面修编了滦河、北三河、永定河、大清河、子牙河、漳卫河超标准洪水防御预案及“作战图”。珠江委编制了《西江、韩江、东江枯水期水资源联合调度方案》《大藤峡、粤港澳大湾区防洪保障方案》《珠江枯水期水量调度方案》《韩江枯水期水量调度方案》以及珠江超标准洪水防御“作战图”，修订了《流域超标洪水防御方案》，批复了13座流域重点及省界水库汛期调度运用计划。松辽委修订完善了松花江、辽河超标准洪水防御预案，组织修订了《尼尔基水库防洪调度方案》《察尔森水库洪水调度方案》，批复了尼尔基、察尔森、丰满、白山4座骨干水库2021年汛期调度运用计划。太湖局修订印发了《太湖流域管理局水旱灾害防御应急预案》，编制了《太湖超标准洪水防御预案》《防御“烟花”台风暴雨洪水方案》《2021年春季引江济太应急调水方案》及超标准洪水防御“作战图”。地方各级水利部门结合本地实际，加强防汛抗旱预案、超标准洪水防御、应急调水等方案预案的制定与实施，不断提升水旱灾害防御能力，有力防范应对水旱灾害，保障防洪和供水安全。

5.2 Contingency Planning

MWR approved the *2021 Joint Scheduling and Operation Plan for Water Projects in the Yangtze River Basin*, the *2021 Upgraded Scheduling Plan for Danjiangkou Reservoir*, and the *2021 Flood Safety Plan for the Start-up Zone of Xiong'an New Area*. The Ministry also formulated and issued the *Enforcement Work Plan for Flood Control Operation and Keeping Reservoirs Under Flood Control Level* and the *Work Plan for Supervision and Inspection of Flash Flood Prevention*. The Changjiang Commission issued the *Yangtze River Basin Flood and Drought Disaster Prevention Strengthening Work Plan*. It worked with relevant local water administrative agencies to examine and approve the flood season joint scheduling and operation plans of 47 controlling reservoirs, revised the contingency plans for coping with floods breaking maximum designed protection in the Yangtze, the Jialing, the Wujiang, the Shuiyang, the Chuhe, and other trans-provincial rivers, and mapped out detailed actions to be taken. The Yellow River Commission formulated the *Contingency Plan for Wuding River Emergency Water Dispatch*, amended the *2021 Floodwater Regulation Plan for the Middle and Lower Reaches of the Yellow River*, the *2021 Joint Flood Control Plan for Longyangxia and Liujiaxia Reservoirs*, the *Annual Flood Measurement and Report Plan for Major National Hydrologic Stations*, and formulated the *2021 Pre-flood Flow and Sediment Regulation Plan for Yellow River*. It also examined and approved the flood season scheduling and operation plans of 11 critical reservoirs in the main-stem and tributaries of the Yellow River. The Huaihe Commission formulated the *2021 Huaihe River Basin Pre-Flood Inspection Plan*, compiled the *Technology Plan for Piloting Four Preemptive Pillars of Flood Control in Huaihe River Basin*, improved the flood season operation plans for main waterways and large reservoirs within the basin, revised the contingency plans for coping with floods breaking maximum designed protection in the Huaihe, the Hongru, the Shaying, the Yihe, and the Shuhe Rivers as well as detailed action maps for the Huaihe, the Yihe and the Shuhe. The Commission also upgraded the schemes of flood forecasting at Wangjiaba, Zhengyangguan, and Wujiadu hydrologic stations. The Haihe Commission formulated the *2021 Flood Safety Plan for the Start-up Area of Xiong'an New Are*a and the contingency plans for coping with floods breaking maximum designed protection at 15 flood reporting stations, and thoroughly revised the relevant plans and actions maps for the Luanhe, the Beisan, the Yongding, the Daqing, the Ziya and the Zhangwei Rivers.

The Pearl River Commission compiled the *Joint Water Resources Scheduling Plan for Xijiang, Hanjiang, and Dongjiang Rivers*, the *Flood Safety Plan for Datengxia Water Complex and the Greater Bay Area*, the *Water Dispatch Plan for the Pearl River in Low-Water Period*, the *Water Dispatch Plan for the Hanjiang River in Low-Water Period,* and the action map for coping with floods breaking maximum designed protection in the Pearl River. It also revised the *Basin-wide Contingency Plan of Coping with Floods Breaking Maximum Designed Protection* and approved the flood season scheduling and operation plans for 13 major and/or trans-provincial reservoirs. The Songliao Commission upgraded the contingency plans for coping with ultra-standard floods in the Songhua and Liaohe Rivers, commissioned revision of the *Nierji Reservoir Floodwater Regulation Plan* and the *Chaersen Reservoir Floodwater Regulation Plan*, and approved the 2021 flood season scheduling and operation plans for the four critical reservoirs—Nierji, Chaersen, Fengman and Baishan. The Taihu Authority revised and issued its in-house *Flood and Drought Disaster Prevention Contingency Plan,* and formulated the *Contingency Plan for Ultra-Standard Floods in the Taihu Lake*, the *Contingency Plan Against Rainstorms Caused by Typhoon "In-Fa"*, the *Emergency Water Diversion Plan of Yangtze-Taihu Water Diversion Project during 2021 Springtime*, and detailed action maps against ultra-standard floods. Local water resources departments also strengthened the formulation and implementation of locally fitting flood control and drought relief plans, ultra-standard flood control plans, and emergency water diversion plans. The flood and drought disaster prevention capabilities have been improved, thereby effectively coping with flood and drought disasters and securing water supplies when disasters stroke.

5.3 信息发布

水利部组织参与新闻发布会，召开水旱灾害防御工作通气会，发布新闻通稿 114 篇，向社会及时发布实时汛情旱情和防御工作动态，人民日报、新华社、中央广播电视总台等中央主流媒体及网络新媒体广泛采用，累计发布报道 500 余篇（条），累计转载量超 4.3 万余篇（条）。防汛关键期，中央广播电视总台央视记者驻守水利部 27 天，累计在《新闻联播》《朝闻天下》《新闻直播间》等多个栏目发布报道 242 条（次）。水利部网站及时发布汛情、旱情和防御工作动态，水利部官方微信“中国水利”、官方微博“水利部发布”等政务新媒体平台累计发布信息 750 余篇，点击量超过 3400 万次，“中国水事”“中国防汛抗旱”等新媒体平台通过图文、视频等多种形式发布水旱灾害防御信息。水利部水旱灾害防御司、信息中心、防洪抗旱减灾工程技术研究中心及相关流域机构专家接受媒体采访 50 多人次，组织开展“防汛备汛行”“秋汛防御一线直击”主题采访活动。及时发布江河洪水及橙色和红色山洪灾害气象预警信息，提醒相关地区做好防范工作。制作公益宣传片《关注山洪预警及时转移避险》，在中央广播电视总台央视相关频道、主流网络媒体和商业网站滚动播出；推出《应知道的“汛期”常识》等多篇水旱灾害防御相关科普图文。举办 2021 年水利防汛图片展，并在各流域管理机构进行了巡展。各流域机构通过主流媒体以及官网、微信公众号等多种媒体渠道发布雨水汛情、水旱灾害防御工作动态、防灾减灾知识等信息共计 800 余篇（条），确保水旱灾害防御信息报道及时、准确、透明。

5.3 Information Dissemination

MWR produced 114 press releases from the press conferences and media briefings it either organized or participated to get the society up to date on floods and droughts as well as what had been done to cope with these hazards. These communications were widely picked up by state media like People's Daily, Xinhua News Agency, and China Media Group as well as social media, whom went on to produce over 500 reports (articles). These news got 43,000 forwards. In the period that flood control pressures were the gravest, reporters from China Central Television (CCTV) worked at MWR for 27 days and produced a total of 242 news that were aired on CCTV programs such as "News Broadcast (Xinwen Lianbo)", "Morning News (Zhaowen Tianxia)", and "Live Newsroom (Xinwen Zhibojian)".

The Ministry also released updates via its official website and both in-house and affiliated social media channels. For example, on its official WeChat and Weibo handles—"China Water" and "Message from MWR", respectively—the Ministry released over 750 posts winning over 34 million click views; other affiliated WeChat handles such as "China Water Affairs" (a video channel) and "China Flood & Drought Management" were also producing related audio-visual content. Experts from the Department of Flood and Drought Disaster Prevention, Water Resources Information Center, Research Center on Flood and Drought Disaster Reduction of the Ministry and relevant river basin authorities accepted media interviews for over 50 person-times. Themed interviews featuring "Preparedness for floods"and "Get to the backstage of fighting the autumn floods". The Ministry released meteorological early warning information on river floods and issued orange and red alerts of flash floods, and advised relevant areas on getting prepared. The Ministry also produced its own educative content, including a short film titled *"What do flash flood alerts tell you?"* and articles like *"Things you must know when floods are in session"*. The educative film was rolled continuously on CCTV channels, popular social media and commercial websites. The Ministry also organized a tour photo exhibition featuring the fight against floods in 2021 among its affiliated river basin commissions, who had staged their own information dissemination campaigns, culminating in over 800 pieces of news, to make sure that the public were timely, accurately, and honestly informed.

附录
APPENDICES

1950—2021 年全国水旱灾情统计

STATISTICS OF FLOOD AND DROUGHT DISASTERS IN CHINA 1950—2021

附表 1　1950—2021 年全国洪涝灾情统计表
Appendix 1　Flood disasters and losses 1950—2021

年份 Year	农作物受灾面积 / 千公顷 Affected cropland area /1,000 hectares	农作物成灾面积 / 千公顷 Damaged cropland area/1,000 hectares	因灾死亡人口 / 人 Deaths/ person	因灾失踪人口 / 人 Missing persons/ person	倒塌房屋 / 万间 Collapsed dwellings/ 10,000 rooms	直接经济损失 / 亿元 Direct economic loss/100 million RMB
1950	6559.00	4710.00	1982	—	130.50	—
1951	4173.00	1476.00	7819	—	31.80	—
1952	2794.00	1547.00	4162	—	14.50	—
1953	7187.00	3285.00	3308	—	322.00	—
1954	16131.00	11305.00	42447	—	900.90	—
1955	5247.00	3067.00	2718	—	49.20	—
1956	14377.00	10905.00	10676	—	465.90	—
1957	8083.00	6032.00	4415	—	371.20	—
1958	4279.00	1441.00	3642	—	77.10	—
1959	4813.00	1817.00	4540	—	42.10	—
1960	10155.00	4975.00	6033	—	74.70	—
1961	8910.00	5356.00	5074	—	146.30	—
1962	9810.00	6318.00	4350	—	247.70	—
1963	14071.00	10479.00	10441	—	1435.30	—
1964	14933.00	10038.00	4288	—	246.50	—
1965	5587.00	2813.00	1906	—	95.60	—
1966	2508.00	950.00	1901	—	26.80	—
1967	2599.00	1407.00	1095	—	10.80	—
1968	2670.00	1659.00	1159	—	63.00	—
1969	5443.00	3265.00	4667	—	164.60	—
1970	3129.00	1234.00	2444	—	25.20	—
1971	3989.00	1481.00	2323	—	30.20	—
1972	4083.00	1259.00	1910	—	22.80	—
1973	6235.00	2577.00	3413	—	72.30	—

续表 Continued

年份 Year	农作物受灾面积 / 千公顷 Affected cropland area /1,000 hectares	农作物成灾面积 / 千公顷 Damaged cropland area/1,000 hectares	因灾死亡人口 / 人 Deaths/ person	因灾失踪人口 / 人 Missing persons/ person	倒塌房屋 / 万间 Collapsed dwellings/ 10,000 rooms	直接经济损失 / 亿元 Direct economic loss/100 million RMB
1974	6431.00	2737.00	1849	—	120.00	—
1975	6817.00	3467.00	29653	—	754.30	—
1976	4197.00	1329.00	1817	—	81.90	—
1977	9095.00	4989.00	3163	—	50.60	—
1978	2820.00	924.00	1796	—	28.00	—
1979	6775.00	2870.00	3446	—	48.80	—
1980	9146.00	5025.00	3705	—	138.30	—
1981	8625.00	3973.00	5832	—	155.10	—
1982	8361.00	4463.00	5323	—	341.50	—
1983	12162.00	5747.00	7238	—	218.90	—
1984	10632.00	5361.00	3941	—	112.10	—
1985	14197.00	8949.00	3578	—	142.00	—
1986	9155.00	5601.00	2761	—	150.90	—
1987	8686.00	4104.00	3749	—	92.10	—
1988	11949.00	6128.00	4094	—	91.00	—
1989	11328.00	5917.00	3270	—	100.10	—
1990	11804.00	5605.00	3589	—	96.60	239.00
1991	24596.00	14614.00	5113	—	497.90	779.08
1992	9423.30	4464.00	3012	—	98.95	412.77
1993	16387.30	8610.40	3499	—	148.91	641.74
1994	18858.90	11489.50	5340	—	349.37	1796.60
1995	14366.70	8000.80	3852	—	245.58	1653.30
1996	20388.10	11823.30	5840	—	547.70	2208.36
1997	13134.80	6514.60	2799	—	101.06	930.11
1998	22291.80	13785.00	4150	—	685.03	2550.90

续表 Continued

年份 Year	农作物受灾面积 / 千公顷 Affected cropland area /1,000 hectares	农作物成灾面积 / 千公顷 Damaged cropland area/1,000 hectares	因灾死亡人口 / 人 Deaths/ person	因灾失踪人口 / 人 Missing persons/ person	倒塌房屋 / 万间 Collapsed dwellings/ 10,000 rooms	直接经济损失 / 亿元 Direct economic loss/100 million RMB
1999	9605.20	5389.12	1896	—	160.50	930.23
2000	9045.01	5396.03	1942	—	112.61	711.63
2001	7137.78	4253.39	1605	—	63.49	623.03
2002	12384.21	7439.01	1819	—	146.23	838.00
2003	20365.70	12999.80	1551	—	245.42	1300.51
2004	7781.90	4017.10	1282	—	93.31	713.51
2005	14967.48	8216.68	1660	—	153.29	1662.20
2006	10521.86	5592.42	2276	—	105.82	1332.62
2007	12548.92	5969.02	1230	—	102.97	1123.30
2008	8867.82	4537.58	633	232	44.70	955.44
2009	8748.16	3795.79	538	110	55.59	845.96
2010	17866.69	8727.89	3222	1003	227.10	3745.43
2011	7191.50	3393.02	519	121	69.30	1301.27
2012	11218.09	5871.41	673	159	58.60	2675.32
2013	11777.53	6540.81	775	374	53.36	3155.74
2014	5919.43	2829.99	486	91	25.99	1573.55
2015	6132.08	3053.84	319	81	15.23	1660.75
2016	9443.26	5063.49	686	207	42.77	3643.26
2017	5196.47	2781.19	316	39	13.78	2142.53
2018	6426.98	3131.16	187	32	8.51	1615.47
2019	6680.40	—	573	85	10.30	1922.7
2020	7190.00	—	230	49	9.0	2669.8
2021	4760.43	—	512	78	15.20	2458.92

注：2019—2021 年数据来源于应急管理部；“—” 表示没有统计数据；因灾失踪人口从 2008 年开始作为指标统计。

Note: Data during 2019—2021 are from the Ministry of Emergency Management; “—” means statistics don’t exist; missing persons attributed to disasters was determined as a statistical indicator since 2008.

附表 2　2000—2021 年中小河流和山洪灾害死亡与失踪人口统计表
Appendix 2　Deaths and missing persons attributed to river floods (in small and medium sized rivers) and flash floods 2000—2021

年份 Year	因灾死亡人口 / 人 Deaths/person	因灾失踪人口 / 人 Missing persons/ person	年份 Year	因灾死亡人口 / 人 Deaths/person	因灾失踪人口 / 人 Missing persons/ person
2000	1102	—	2011	413	—
2001	788	—	2012	473	—
2002	924	—	2013	560	—
2003	1307	—	2014	340	—
2004	998	—	2015	226	50
2005	1400	—	2016	481	129
2006	1612	—	2017	207	16
2007	1069	—	2018	129	32
2008	508	—	2019	347	—
2009	430	—	2020	95	62
2010	2824	—	2021	171	67

注：“—” 表示没有统计数据。
Note: “—” means statistics don’t exist.

附表 3 1950—2021 年全国干旱灾情统计表
Appendix 3 Drought disasters and losses 1950—2021

年份 Year	作物受灾面积 / 千公顷 Affected cropland area/1,000 hectares	作物成灾面积 / 千公顷 Damaged cropland area/1,000 hectares	作物绝收面积 / 千公顷 Area of crop failure/1,000 hectares	因旱粮食损失 / 亿公斤 Crop losses/100 million kg	因旱饮水困难人口 / 万人 People with drinking water difficulties/10,000 persons	因旱饮水困难大牲畜 / 万头 Number of bigger-sized livestock having difficulties accessing drinking water/10,000 heads	直接经济损失 / 亿元 Direct economic loss/100 million RMB
1950	2398.00	589.00	—	19.00	—	—	—
1951	7829.00	2299.00	—	36.88	—	—	—
1952	4236.00	2565.00	—	20.21	—	—	—
1953	8616.00	1341.00	—	54.47	—	—	—
1954	2988.00	560.00	—	23.44	—	—	—
1955	13433.00	4024.00	—	30.75	—	—	—
1956	3127.00	2051.00	—	28.60	—	—	—
1957	17205.00	7400.00	—	62.22	—	—	—
1958	22361.00	5031.00	—	51.28	—	—	—
1959	33807.00	11173.00	—	108.05	—	—	—
1960	38125.00	16177.00	—	112.79	—	—	—
1961	37847.00	18654.00	—	132.29	—	—	—
1962	20808.00	8691.00	—	89.43	—	—	—
1963	16865.00	9021.00	—	96.67	—	—	—
1964	4219.00	1423.00	—	43.78	—	—	—
1965	13631.00	8107.00	—	64.65	—	—	—
1966	20015.00	8106.00	—	112.15	—	—	—
1967	6764.00	3065.00	—	31.83	—	—	—
1968	13294.00	7929.00	—	93.92	—	—	—
1969	7624.00	3442.00	—	47.25	—	—	—
1970	5723.00	1931.00	—	41.50	—	—	—
1971	25049.00	5319.00	—	58.12	—	—	—
1972	30699.00	13605.00	—	136.73	—	—	—

续表 Continued

年份 Year	作物受灾面积 / 千公顷 Affected cropland area/1,000 hectares	作物成灾面积 / 千公顷 Damaged cropland area/1,000 hectares	作物绝收面积 / 千公顷 Area of crop failure/1,000 hectares	因旱粮食损失 / 亿公斤 Crop losses/ 100 million kg	因旱饮水困难人口 / 万人 People with drinking water difficulties/ 10,000 persons	因旱饮水困难大牲畜 / 万头 Number of bigger–sized livestock having difficulties accessing drinking water/10,000 heads	直接经济损失 / 亿元 Direct economic loss/100 million RMB
1973	27202.00	3928.00	—	60.84	—	—	—
1974	25553.00	2296.00	—	43.23	—	—	—
1975	24832.00	5318.00	—	42.33	—	—	—
1976	27492.00	7849.00	—	85.75	—	—	—
1977	29852.00	7005.00	—	117.34	—	—	—
1978	40169.00	17969.00	—	200.46	—	—	—
1979	24646.00	9316.00	—	138.59	—	—	—
1980	26111.00	12485.00	—	145.39	—	—	—
1981	25693.00	12134.00	—	185.45	—	—	—
1982	20697.00	9972.00	—	198.45	—	—	—
1983	16089.00	7586.00	—	102.71	—	—	—
1984	15819.00	7015.00	—	106.61	—	—	—
1985	22989.00	10063.00	—	124.04	—	—	—
1986	31042.00	14765.00	—	254.34	—	—	—
1987	24920.00	13033.00	—	209.55	—	—	—
1988	32904.00	15303.00	—	311.69	—	—	—
1989	29358.00	15262.00	2423.33	283.62	—	—	—
1990	18174.67	7805.33	1503.33	128.17	—	—	—
1991	24914.00	10558.67	2108.67	118.00	4359.00	6252.00	—
1992	32980.00	17048.67	2549.33	209.72	7294.00	3515.00	—
1993	21098.00	8658.67	1672.67	111.80	3501.00	1981.00	—
1994	30282.00	17048.67	2526.00	233.60	5026.00	6012.00	—
1995	23455.33	10374.00	2121.33	230.00	1800.00	1360.00	—
1996	20150.67	6247.33	686.67	98.00	1227.00	1675.00	—

续表 Continued

年份 Year	作物受灾面积 / 千公顷 Affected cropland area/1,000 hectares	作物成灾面积 / 千公顷 Damaged cropland area/1,000 hectares	作物绝收面积 / 千公顷 Area of crop failure/1,000 hectares	因旱粮食损失 / 亿公斤 Crop losses/ 100 million kg	因旱饮水困难人口 / 万人 People with drinking water difficulties/ 10,000 persons	因旱饮水困难大牲畜 / 万头 Number of bigger–sized livestock having difficulties accessing drinking water/10,000 heads	直接经济损失 / 亿元 Direct economic loss/100 million RMB
1997	33514.00	20010.00	3958.00	476.00	1680.00	850.00	—
1998	14237.33	5068.00	949.33	127.00	1050.00	850.00	—
1999	30153.33	16614.00	3925.33	333.00	1920.00	1450.00	—
2000	40540.67	26783.33	8006.00	599.60	2770.00	1700.00	—
2001	38480.00	23702.00	6420.00	548.00	3300.00	2200.00	—
2002	22207.33	13247.33	2568.00	313.00	1918.00	1324.00	—
2003	24852.00	14470.00	2980.00	308.00	2441.00	1384.00	—
2004	17255.33	7950.67	1677.33	231.00	2340.00	1320.00	—
2005	16028.00	8479.33	1888.67	193.00	2313.00	1976.00	—
2006	20738.00	13411.33	2295.33	416.50	3578.23	2936.25	986.00
2007	29386.00	16170.00	3190.67	373.60	2756.00	2060.00	1093.70
2008	12136.80	6797.52	811.80	160.55	1145.70	699.00	545.70
2009	29258.80	13197.10	3268.80	348.49	1750.60	1099.40	1206.59
2010	13258.61	8986.47	2672.26	168.48	3334.52	2440.83	1509.18
2011	16304.20	6598.60	1505.40	232.07	2895.45	1616.92	1028.00
2012	9333.33	3508.53	373.80	116.12	1637.08	847.63	533.00
2013	11219.93	6971.17	1504.73	206.36	2240.54	1179.35	1274.51
2014	12271.70	5677.10	1484.70	200.65	1783.42	883.29	909.76
2015	10067.05	5577.04	1005.39	144.41	836.43	806.77	579.22
2016	9872.76	6130.85	1018.20	190.64	469.25	649.73	484.15
2017	9946.43	4490.02	752.71	134.44	477.78	514.29	437.88
2018	7397.21	3667.23	610.21	156.97	306.69	462.30	483.62
2019	8777.83	4179.99	724.51	236.01	692.29	368.10	—
2020	8352.43	4080.99	740.19	123.04	668.98	448.63	—
2021	4447.80	2276.74	561.16	49.28	546.35	250.63	—

注：“—” 表示没有统计数据。
Note: “—” means statistics don’t exist.