2022 GLOBAL NATURAL DISASTER ASSESSMENT REPORT

October 2023

Academy of Disaster Reduction and Emergency Management,
Ministry of Emergency Management - Ministry of Education

School of National Safety and Emergency Management, Beijing Normal University

National Disaster Reduction Center of China, Ministry of Emergency Management

International Federation of Red Cross and Red Crescent Societies

EXECUTIVE SUMMARY

Compared to the average over the last 30 years (1992-2021), the intensity of global natural disasters was generally lower in 2022, with 3% less in frequency, 38% fewer in deaths, 4% less in the affected population, and 53% more in direct economic losses. Global extreme temperatures in 2022 were in low frequency but were the deadliest events, causing 16,416 deaths. Floods were the most frequent, 14% more than the historical average (which means the average for 1992-2021, hereinafter the same), causing 8,049 deaths, 20% more than the historical average of flood-related deaths. The direct economic losses caused by storms were the most, at about USD 131 billion, 106% more than the historical average. Seismic activities increased but caused fewer deaths. The number of deaths from wildfires decreased, and the direct economic losses were 77% lower than the historical average. The occurrence of landslides decreased, resulting in 54% fewer deaths and 50% less affected population than the historical average. Regionally, Asia has seen the highest frequency of natural disasters in 2022, followed by Africa. Among all continents, Europe has had the largest number of deaths due to disasters, followed by Asia. North America has seen the highest economic losses due to disasters, followed by Asia. Compared with developed countries, developing countries were more severely affected by natural disasters, mostly by floods and storms.

The report finds that main natural disasters in China in 2022 included flood, drought, strong wind and hail, earthquake and geological disasters, while typhoon, cold wave, sand and dust storm, forest and grassland fires and marine disasters also occurred to varying degrees. In 2022, various natural disasters totally caused affected population of 112 million, death and missing toll of 554 people, and direct economic losses of CNY 238.65 billion in China.

The report analyzes the characteristics of global climate extremes from 2000 to 2022, and finds that the number of deaths was typically extreme in Asia, Europe and Africa, but with no significant fluctuation in the Americas and Oceania. At the same time, annual direct economic losses due to climate extremes were on the rise in Asia, America, Europe, Africa and Oceania.

The report also summarizes the characteristics of global climate and the major weather and climate events in 2022, coupled with an assessment of the risks of compound high temperature and drought disasters in China's Yangtze River basin in 2022. The report calls for global efforts to strengthen capacity building for risk assessment and early warning of high temperatures, droughts and other disasters, intensify research in compound disaster risks, and enhance the capabilities of data collection and sharing across multiple disciplines and departments.

The intensity of global natural disasters was generally lower in 2022

Frequency	Deaths	Affected population	Direct economic losses
↓3%	↓38%	↓4%	↑53%

Global extreme temperatures in 2022 were in low frequency but were the deadliest events, causing **16,416** deaths

Floods were the most frequent, more than the historical average **↑14%**

Deaths **8,049**

The direct economic losses caused by storms were the most, at about **131** billion USD

More than the historical average **↑106%**

Seismic activities increased but caused fewer deaths

The number of deaths from wildfires decreased, and the direct economic losses were **↓77%**

The occurrence of landslides decreased, resulting in fewer deaths **↓54%**

Less affected population than the historical average **↓50%**

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Top 50 natural disasters worldwide in terms of death toll and direct economic losses from 1991 to 2022

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General Report

Global natural disaster profile for 2022

1.1 Overview of global natural disasters in 2022

A total of 321 major natural disasters (excluding epidemic disasters) occurred worldwide in 2022, affecting 118 countries and regions. Among all these disasters, 163 were caused by floods, with the highest frequency, accounting for 50.78% of the total; 66 caused by storms (typhoons and hurricanes), accounting for 20.56%; 30 by earthquakes, accounting for 9.34%; 20 by droughts, accounting for 6.23%; 17 by landslides, accounting for 5.3%; 15 by wildfires disasters, accounting for 4.67%; 6 by extreme temperatures, accounting for 1.87%; and 4 by volcanic eruptions, accounting for 1.25% (Table 1 and Figure 1).

Table 1 Frequency and losses of natural disasters worldwide in 2022

Type of Disaster	Frequency (time)/%	Deaths (person)/%	Population affected (ten thousand)/%	Direct economic losses (USD 0.1 billion)/%
Flood	163/50.78	8,049/26.17	5,752.52/30.94	449.28/20.07
Storm	66/20.56	1,582/5.14	1,692.87/9.1	1,309.80/58.52
Earthquake	30/9.34	1,626/5.29	361.61/1.95	124.95/5.58
Drought	20/6.23	2,601/8.46	10,735.34/57.73	342.40/15.3
Landslide	17/5.3	403/1.3	11.50/0.06	0/0
Wildfire	15/4.67	76/0.25	23.77/0.13	10.76/0.48
Extreme temperature	6/1.87	16,416/53.37	8.17/0.04	0/0
Volcanic eruption	4/1.25	6/0.02	9.73/0.05	1.18/0.05
Total	321/100	30,759/100	18,595.51/100	2,238.37/100

(Note: The global natural disaster data come from the EM-DAT of the Université catholique de Louvain (UCLouvain), Belgium; and the time period is from January 1, 2022 to December 31, 2022, the same hereinafter.)

A total of 30,759 people were killed by natural disasters worldwide in 2022. Extreme temperatures caused the largest number of deaths, reaching 16,416 people and accounting for 53.37% of total deaths; followed by floods with 8,049 deaths, accounting for 26.17%; droughts with 2,601 deaths, accounting for 8.46%; earthquakes with 1,626 deaths, accounting for 5.29%; storms with 1,582 deaths, accounting for 5.14%; landslides with 403 deaths, accounting for 1.3%; wildfires with 76 deaths, accounting for 0.25%; and volcanic eruptions with 6 deaths, accounting for 0.02%.

A total of 185.9551 million people were affected by natural disasters globally in 2022, of whom 57.73% were affected by droughts, reaching 107.3534 million people, accounting for the largest proportion of the total; 30.94% by floods, reaching 57.5252 million people; 9.1% by storms, reaching 16.9287 million people, 1.95% by earthquakes, reaching 3.6161 million people; 0.13% by wildfires, reaching 237,700 people; 0.06% by landslides, reaching 115,000 people; 0.05% by volcanic eruptions, reaching 97,300 people; and 0.04% by extreme temperatures, reaching 81,700 people.

A total of USD 223.837 billion in direct economic losses were caused by natural disasters worldwide in 2022, of which 58.52% were caused by storms, reaching USD 130.98 billion, accounting for the most proportion of the total amount; 20.07% by floods, reaching USD 44.928 billion; 15.3% by droughts, reaching USD 34.24 billion; 5.58% by earthquakes, reaching USD 12.495 billion; 0.48% by wildfires, reaching 1.076 billion; and 0.05% by volcanic eruptions, reaching USD 118 million.

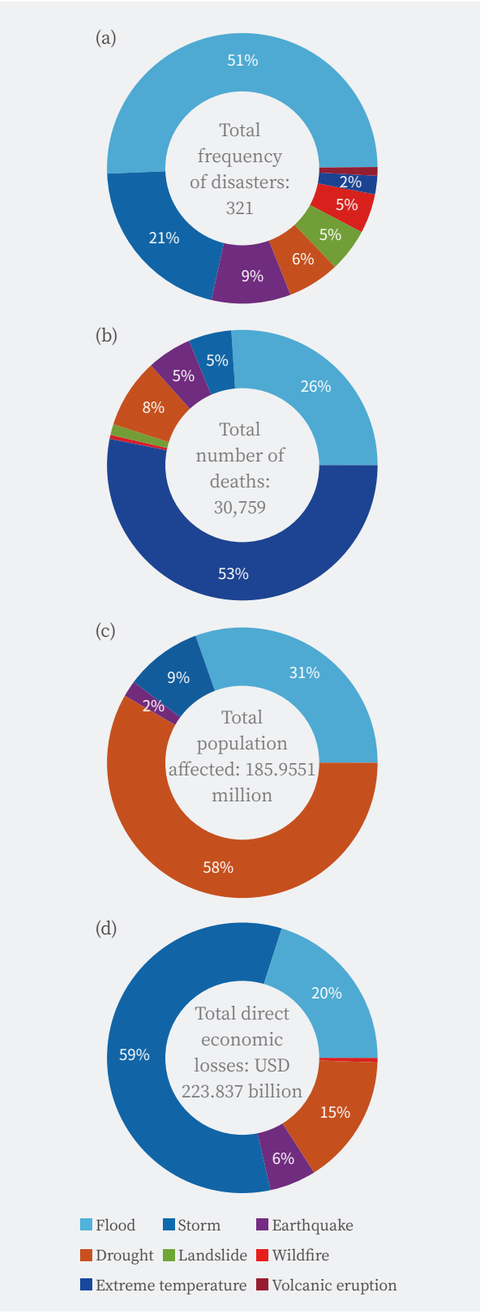


Figure 1 Breakdown of frequency and losses per disaster type worldwide in 2022

1.2 Characteristics of global natural disasters in 2022

1.2.1 The overall economic losses from natural disasters were relatively large, but the numbers of deaths and affected people remained low

In 2022, a total of 321 major natural disasters occurred worldwide, killing 30,759 people, affecting about 186 million people, and causing direct economic losses of USD 223.837 billion. Compared with the average for the last 30 years (1992-2021), the major natural disasters in 2022 was 3% less in frequency, 38% fewer in deaths, 4% less in the affected population, but 53% higher in direct economic losses. Compared with the average for the last 10 years (2012-2021), major natural disasters in 2022 was 2% less in frequency, 141% more in deaths, 30% more in the affected population, and 42% more in direct economic losses (Figure 2).

In 2022, catastrophic natural disasters were less frequent and generally less severe than those in the last 10 years and 30 years, but caused greater direct economic losses. There were five natural disasters with more than 1,000 deaths caused each time globally in 2022, more than the annual average for the last 30 years, and there was one natural disaster with more than 10,000 deaths (while 20 such natural disasters were recorded in the last 30 years). In 2022, there were three natural disasters with direct economic losses of more than USD 10 billion caused each time worldwide, slightly higher than the annual average for the last 30 years, and only one disaster that caused direct economic losses exceeding USD 50 billion.

Total frequency of major natural disasters

321 times

Number of deaths

30,759 persons

Affected population

186 million

Direct economic losses

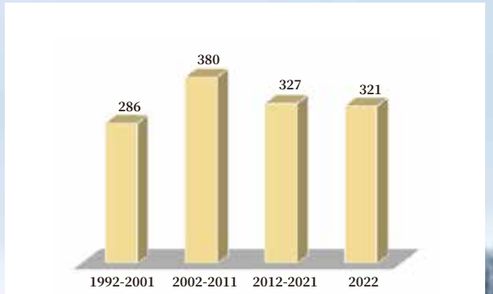
223.837 billion USD

Natural disasters with more than 1,000 deaths

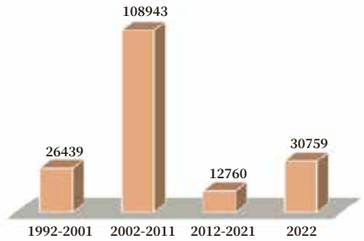
5 times

Natural disasters with direct economic losses of more than USD 10 billion

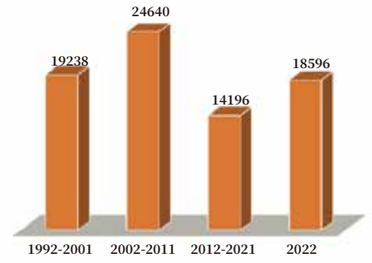
3 times



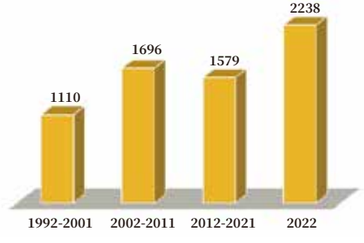
(a) Frequency of disasters (unit: time)



(b) Number of deaths (unit: person)



(c) Population affected (unit: ten thousand)



(d) Direct economic loss (unit: USD 0.1 billion)

Figure 2 Global average annual losses from natural disasters, 1992- 2021 vs. 2022

(Note: The direct economic losses from 1992 to 2021 are measured at the price level of 2021, and those of 2022 are measured at the price level of the current year)

Major floods
163 times

Proportion of total number of major natural disasters
>50%

Number of deaths
8,049 persons

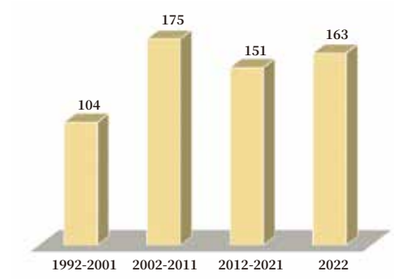
Proportion of total deaths
26%

Affected population about
57.53 million

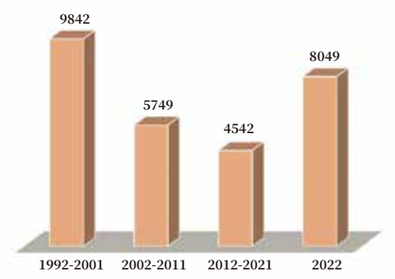
Direct economic losses exceed
44.9 billion USD

1.2.2 Floods were the most frequent, resulting in many deaths

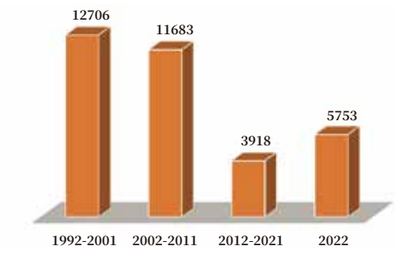
In 2022, there were 163 major floods worldwide, accounting for more than 50% of the total number of major natural disasters of the year; 8,049 deaths were caused by floods, accounting for about 26% of the total deaths; about 57.53 million people were affected, accounting for 31%, and nearly doubling the figure 29.896 million in 2021; and the direct economic losses exceed USD 44.9 billion. In 2022, compared with the average for the last 30 years (1992-2021), the frequency of floods increased by 14%, the number of deaths from floods was 20% more, the number of affected people was about 43% less, and the direct economic losses were 25% more. Compared with the average for the last 10 years (2012-2021), the frequency of floods increased by 8% in 2022, the number of deaths from floods was 77% more, the number of affected people was 47% more, and the direct economic losses increased slightly (Figure 3). There were 2 floods with more than 1,000 deaths caused each time in 2022, and one of them killed as many as 2,035 people. Countries such as India in Asia suffered severe flooding, with thousands of lives lost in floods or heavy rain during the monsoon period.



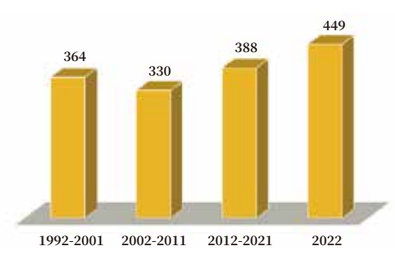
(a) Frequency of disasters (unit: time)



(b) Number of deaths (unit: person)



(c) Population affected (unit: ten thousand)



(d) Direct economic loss (unit: USD 0.1 billion)

Figure 3 Global average annual losses from floods, 1992-2021 vs. 2022

(Note: The direct economic losses from 1992 to 2021 are measured at the price level of 2021, and those of 2022 are measured at the price level of the current year)

1.2.3 Storms resulted in large direct economic losses, with a smaller affected population

In 2022, there were 66 major storms worldwide, accounting for 21% of the total number of major natural disasters of the year; 1,582 deaths were caused by storms, accounting for about 5% of the total deaths; 16.93 million people were affected, accounting for about 9%; and the direct economic losses exceed USD 131 billion, accounting for about 59%. Compared with the average for the last 30 years (1992-2021), the frequency of storms was 30% less in 2022, the number of deaths was 82% less, and the affected population was about 46% less, but the direct economic losses were 106% more. Compared with the average for the last 10 years (2012-2021), the frequency of storms was 26% less in 2022, the number of deaths was 38% less, and the number of affected people was 47% less, but the direct economic losses increased by 46% (Figure 4).

Major storms
66 times

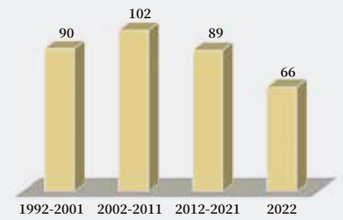
Proportion of total number of major natural disasters
21%

Number of Deaths
1,582 persons

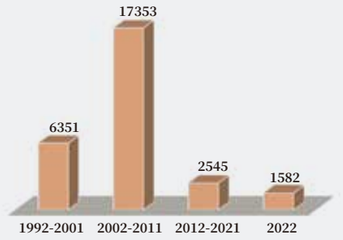
Proportion of total deaths
5%

Affected population
16.93 million

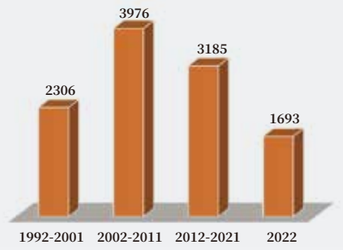
Direct economic losses exceed
131 billion USD



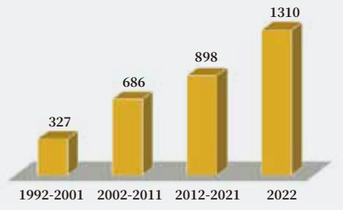
(a) Frequency of disasters (unit: time)



(b) Number of deaths (unit: person)



(c) Population affected (unit: ten thousand)



(d) Direct economic loss (unit: USD 0.1 billion)

Figure 4 Global average annual losses from storms, 1992-2021 vs. 2022

(Note: The direct economic losses from 1992 to 2021 are measured at the price level of 2021, and those of 2022 are measured at the price level of the current year)

1.2.4 Seismic activities increased in number but caused a relatively small number of deaths

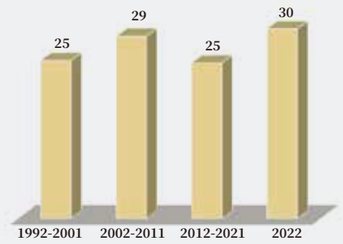
In 2022, there were 30 major earthquakes worldwide, accounting for about 9% of the total number of major natural disasters of the year. Deaths from earthquakes accounted for about 5% of the total deaths from natural disasters; the affected population accounted for less than 2%; and the direct economic losses accounted for about 6%. Compared with the average for the last 30 years (1992-2021), the frequency of earthquakes increased by 15% in 2022, the number of deaths was 94% less, the number of affected population was 22% less, and the direct economic losses were 62% lower. Compared with the average for the last 10 years (2012-2021), the frequency of earthquakes increased by 22% in 2022, the number of deaths was 26% less, the number of affected population grew by 31%, and the direct economic losses rose by 4% (Figure 5). There are two reasons for the relatively small losses from earthquakes in 2022. Firstly, there was no strong earthquake of magnitude 8 or higher. Secondly, the earthquakes did not trigger severe tsunamis or other secondary disasters.

Major earthquakes
30 times

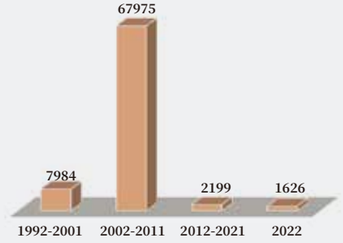
Affected population accounted for less than
2%

Deaths from earthquakes accounted for about
5%

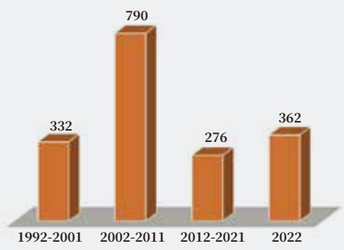
Direct economic losses accounted for about
6%



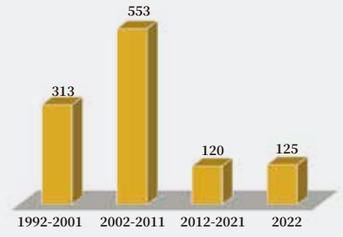
(a) Frequency of disasters (unit: time)



(b) Number of deaths (unit: person)



(c) Population affected (unit: ten thousand)



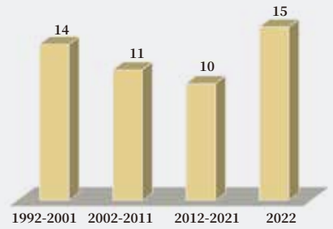
(d) Direct economic loss (unit: USD 0.1 billion)

Figure 5 Average annual global losses from earthquakes, 1992-2021 vs. 2022

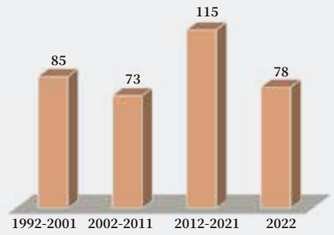
(Note: The direct economic losses from 1992 to 2021 are measured at the price level of 2021, and those of 2022 are measured at the price level of the current year)

1.2.5 Wildfires occurred more frequently but caused fewer direct economic losses

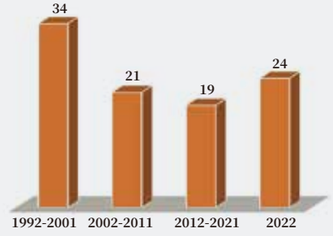
There were 15 wildfires (mainly forest fires) that caused large losses in 2022, accounting for 5% of the total number of major natural disasters and slightly higher than the level of recent years (an average of 12 times a year for the last 30 years and an average of 10 times a year for the last 10 years). Compared with the average for the last 30 years (1992-2021), the number of deaths from wildfires reduced by 14% in 2022, the number of affected population decreased by 4%, and the direct economic losses dropped by 77% . Compared with the average for the last 10 years (2012-2021), the number of deaths from wildfires reduced by 32% in 2022, the number of affected population rose by 25%, and the direct economic losses decreased by 87% (Figure 6). The frequency of wildfires in 2022 was the same as the historical average, and the deaths and direct economic losses from wildfires significantly decreased.



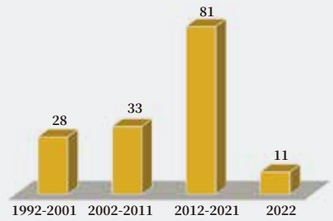
(a) Frequency of disasters (unit: time)



(b) Number of deaths (unit: person)



(c) Population affected (unit: ten thousand)



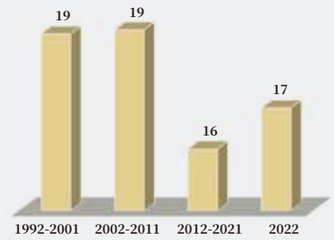
(d) Direct economic loss (unit: USD 0.1 billion)

Figure 6 Global average annual losses from wildfires, 1992-2021 vs. 2022

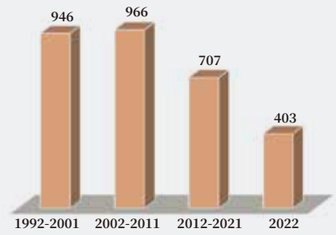
(Note: The direct economic losses from 1992 to 2021 are measured at the price level of 2021, and those of 2022 are measured at the price level of the current year)

1.2.6 Landslides affected more people but caused moderate losses

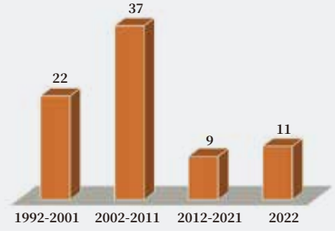
A total of 17 major landslides occurred in 2022, accounting for about 5% of the total number of major natural disasters. Compared with the average for the last 30 years (1992-2021), the frequency of landslides was 5% less in 2022, the number of deaths was 54% less, the number of affected population was 50% less, and the direct economic losses were 100% fewer. Compared with the average for the last 10 years (2012-2021), the frequency of landslides was 6% more in 2022, the number of deaths was 43% less, the number of affected population was 23% more, and the direct economic losses were 100% fewer (Figure 7).



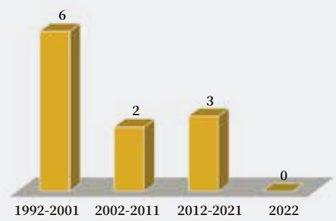
(a) Frequency of disasters (unit: time)



(b) Number of deaths (unit: person)



(c) Population affected (unit: ten thousand)



(d) Direct economic loss (unit: USD 0.1 billion)

Figure 7 Global average annual losses from landslides, 1992-2021 vs. 2022

(Note: The direct economic losses from 1992 to 2021 are measured at the price level of 2021, and those of 2022 are measured at the price level of the current year)

1.3 Global patterns of natural disasters in 2022

1.3.1 Spatial pattern of global natural disasters in 2022

In 2022, the major types of natural disasters occurring globally were meteorological and hydrological disasters, such as floods and storms, as well as earthquakes and geological disasters (Figure 8). Floods were the most frequent of all types of natural hazards around the world in 2022. There were 163 floods in total that cumulatively affected 80 countries and regions, mainly in Europe, Asia, Africa and South America. Storms were the second with a total of 66 occurrences, which cumulatively affected 53 countries, mainly in Asia, North America and Europe. 30 earthquakes were registered, cumulatively affecting 18 countries, mainly in Asia. 20 droughts occurred and cumulatively affected 23 countries, mainly in Africa. 17 landslides were recorded with 12 countries cumulatively affected, mainly in South America. 15 wildfires occurred and cumulatively affected 11 countries, mainly in Europe and the Americas. Six extreme temperatures cumulatively affected 12 countries, mainly in Europe and Asia. Four volcanic eruptions occurred and cumulatively affected four countries, mainly in Southeast Asia.

163 Floods	80 Affected countries and regions
66 Storms	53 Affected countries and regions
30 Earthquakes	18 Affected countries and regions
20 Droughts	23 Affected countries and regions
17 Landslides	12 Affected countries and regions
15 Wildfires	11 Affected countries and regions
6 Extreme temperatures	12 Affected countries and regions
4 Volcanic eruptions	4 Affected countries and regions

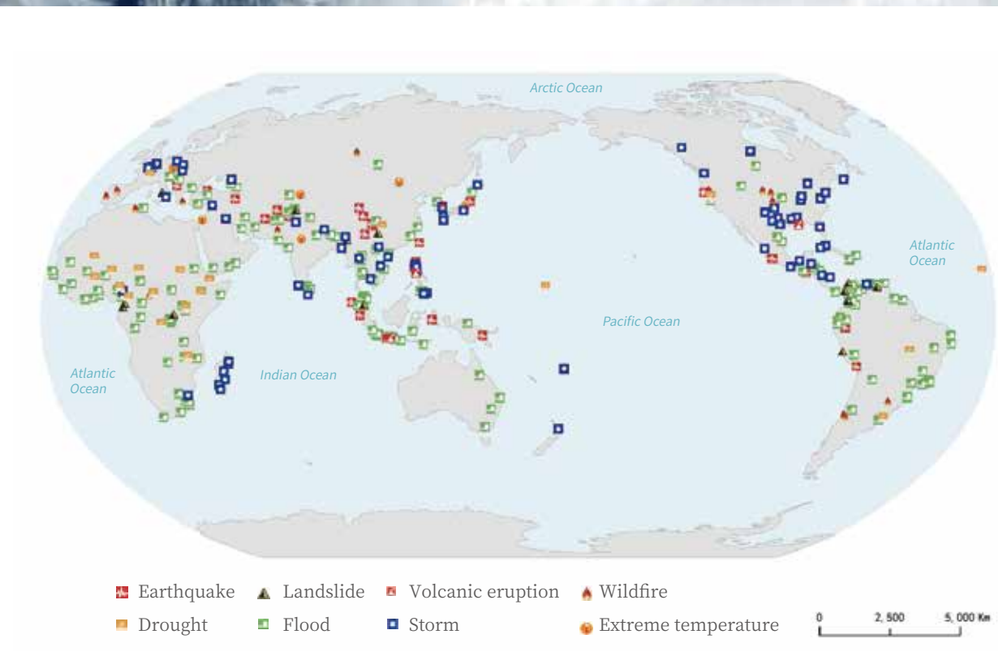


Figure 8 Spatial pattern of global natural disasters, 2022

1.3.2 Natural disasters by continent in 2022

Figure 9 shows the statistical results of the frequency of natural disasters, the number of deaths attributed to natural disasters, and the direct economic losses in all continents from January 1 to December 31, 2022. Among the 321 natural disaster events included in the statistics, Asia had the largest number of disaster events with a total of 121, accounting for 37.69% of the total number; followed by Africa, with 69 (21.5%); and South America and North America with similar figures, namely 53 (16.15%) and 51(15.89%); Oceania recorded the smallest number. In terms of the number of deaths attributed to natural disasters, Europe had the largest number with 16,393 in total, accounting for 53.29% of the global total; and Asia ranked second, with 7,574 deaths or 25.54% of the total. Among all major natural disasters, 26 caused more than 100 deaths each (10 in Asia, 6 in Africa, 5 in Europe, 3 in South America and 2 in North America). There were 8 catastrophic events that caused more than 1,000 deaths each, the most serious one being the high-temperature and heat waves in Europe in June 2022, with a total of 16,305 deaths. In terms of economic losses, North America suffered the most direct disaster economic losses (USD 149.795 billion), accounting for 66.92% of the global economic losses caused by natural disasters. Asia came in second with USD 48.746 billion of direct disaster economic losses. The direct economic losses caused by natural disasters in Asia and North America summed up to nearly 88.7% of the global total. The disaster events that caused direct economic losses of more than USD 100 million at a time occurred mostly in North America (26) and Asia (16). In addition, 16 such disaster events occurred in other parts of the world (five in South America, four in Oceania, four in Africa and three in Europe). The biggest loss was caused by Hurricane Ian which struck the United States and Cuba, resulting in total direct economic losses of USD 100.025 billion.

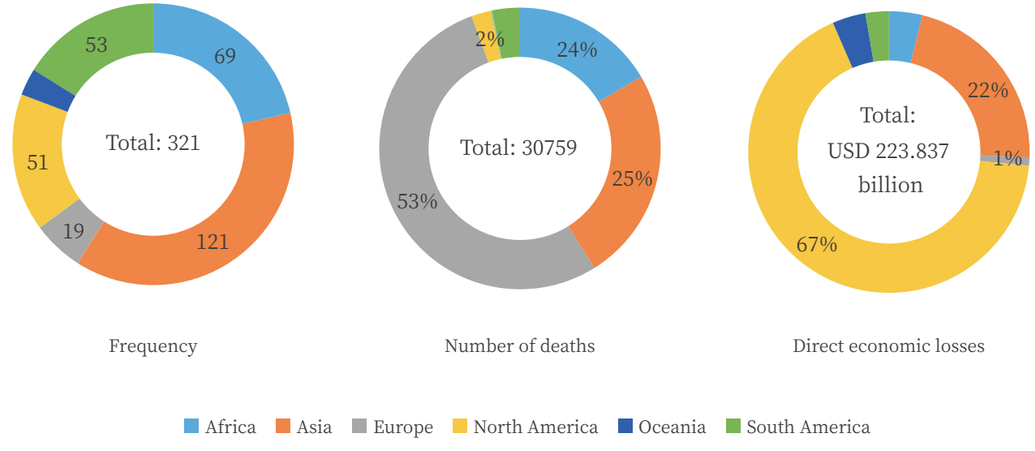


Figure 9 Statistics on the frequency of natural disasters, the death toll and direct economic losses by continent, 2022

(Note: The data come from the EM-DAT of the Université catholique de Louvain (UCLouvain), Belgium; and the time period is from January 1, 2022 to December 31, 2022. One volcanic activity event occurred across continents (South America-Oceania) and one hurricane event occurred across continents (South America-North America). They are counted separately when we count up the number of disasters by continent; and counted as a single disaster when we count up the total number of disasters across the world.)

1.3.3 Natural disasters in countries or regions in 2022

Figures 10, 11 and 12 show the spatial distribution of the frequency of natural disasters[1], the number of deaths, and direct economic losses for each country or region in 2022, respectively. Tables 2 and 3 respectively list the top ten countries in terms of the frequency of disasters, the death toll and mortality rates, direct economic losses and economic loss rates. The top ten countries with the highest frequency of disasters were mainly located in Latin America, and the southern and southeastern parts of Eurasia. Among them, the United States had the highest number at 26, followed by Indonesia at 20, and Columbia ranked third with 14. The countries with a larger number of disaster-related deaths were mainly located in the eastern, southern and southeastern parts of Asia, and the western part of Europe. The death tolls in the top ten countries all surpassed 500. Among them, Spain had the largest number at 4,655, followed by Germany at 4,507. Among the top ten countries with the largest number of deaths per million people, Palau ranked first with 221.93 deaths; and South Africa ranked tenth, with 9.75 deaths. The number of deaths per million people in China was 0.2. The countries with higher direct economic losses were mainly located in East Asia and the southern part of North America. The top ten countries all had direct economic losses of more than USD 2.5 billion, of which the United States had the most, at USD 146.436 billion, and China took second place with USD 16 billion. In terms of the proportion of direct economic losses in GDP of the previous year, the figures for all countries, except for Tonga, Pakistan, Belize, Puerto Rico and Nicaragua, were below 1%. Among the top ten countries, Tonga had the highest proportion of direct economic losses in GDP, reaching 25.15%, and Fiji had the lowest proportion, at 0.58%.

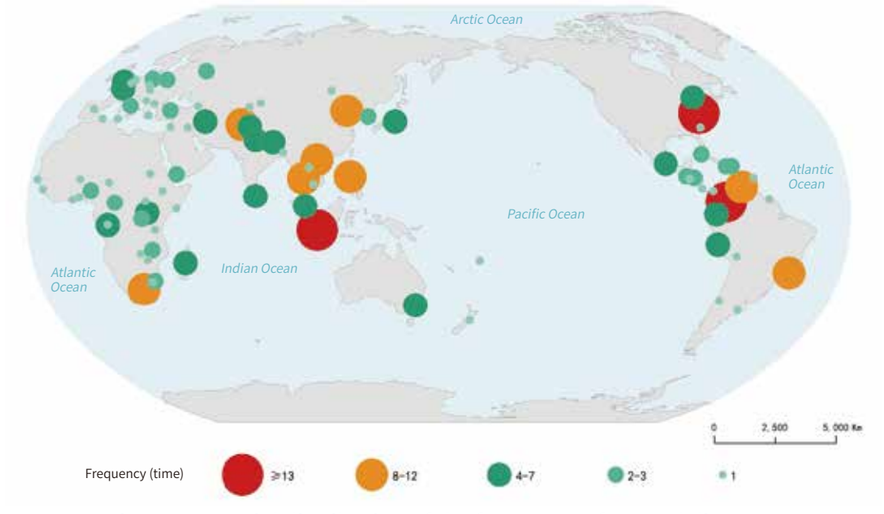


Figure 10 Spatial distribution of the frequency of natural disasters by country/region, globally in 2022

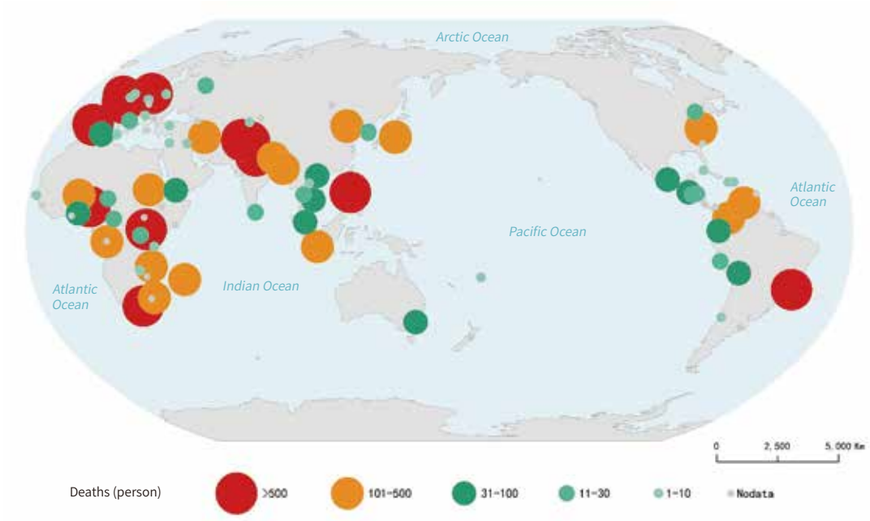


Figure 11 Spatial distribution of the death toll from natural disasters by country/region, globally in 2022

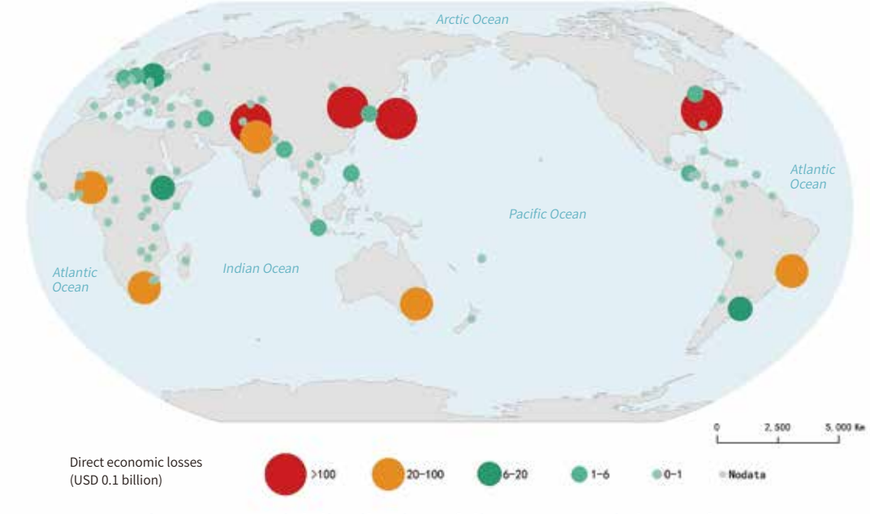


Figure 12 Spatial distribution of direct economic losses from natural disasters by country/region, globally in 2022

[1] The disaster frequency in this section is measured on a national or regional basis.

Table 2 Top ten countries (or regions) in terms of natural disaster frequency and losses in 2022

Country	Frequency (time)	Country	Deaths (person)	Country	Direct economic losses (USD 0.1 billion)
The United States	26	Spain	4,655	The United States	1,464.36
Indonesia	20	Germany	4,507	China	160
Colombia	14	The United Kingdom	3,277	Pakistan	150
China	12	France	2,822	Japan	116.93
Brazil	12	Uganda	2,541	Australia	84.46
The Philippines	12	India	2,210	Brazil	51.41
Thailand	11	Pakistan	1,808	India	42
South Africa	8	Afghanistan	1,335	Nigeria	42
Afghanistan	8	Portugal	1,066	South Africa	36.75
Vietnam	8	Nigeria	610	Puerto Rico	25.17

Table 3 Top ten countries (or regions) in terms of natural disaster loss rates in 2022

Country	Deaths per million population	Country	Percentage of direct economic losses (%)
Palau	221.93	Tonga	25.15
Portugal	103.24	Pakistan	4.31
Spain	98.17	Belize	4.01
Uganda	55.42	Puerto Rico	2.36
Germany	54.17	Nicaragua	1.28
The United Kingdom	48.67	Nigeria	0.95
France	41.65	South Africa	0.88
Tonga	37.73	Suriname	0.70
Afghanistan	33.29	The United States	0.63
South Africa	9.75	Fiji	0.58

Note: The number of deaths per million population in Table 3 refers to the proportion of deaths in 2022 in the total population in 2021 (expressed as deaths per million population), and the percentage of direct economic losses refers to the total direct disaster economic losses in 2022 as a share of GDP in 2021. The population and GDP (in current USD) data for 2021 are sourced from the World Bank (https://data.worldbank.org/).

1.3.4 Top ten natural disasters worldwide in terms of deaths and direct economic losses in 2022

Table 4 and Figure 13 respectively show the world's top ten disaster events with the highest death toll in 2022 and their spatial distribution. It can be observed that those events with a larger number of deaths mainly occurred in economically backward developing countries, and were mostly floods and earthquakes. This is related to the low level of economic development in these countries, weak disaster preparedness and prevention capabilities of their infrastructure, and low levels of their disaster monitoring and early warning, emergency rescue, and medical services.

Table 4 Top ten natural disasters worldwide by death toll in 2022

Ranking	Time	Country	Type of Disaster	Deaths (person)	Deaths per million population
1	June-August	Germany	Extreme temperature	16,305	194.3997
2	July-December	Uganda	Drought	2,465	51.2864
3	May 17-October 31	India	Flood	2,035	1.4504
4	June 14-September 14	Pakistan	Flood	1,739	7.6165
5	June 21-June 21	Afghanistan	Earthquake	1,079	26.6398
6	July 1-October 31	Nigeria	Flood	603	2.8010
7	April 8-April 18	South Africa	Flood	544	8.9828
8	April 10-April 12	The Philippines	Storm	346	3.0863
9	November 21-November 21	Indonesia	Earthquake	334	1.1998
10	February 13-February 16	Brazil	Flood	272	1.2652

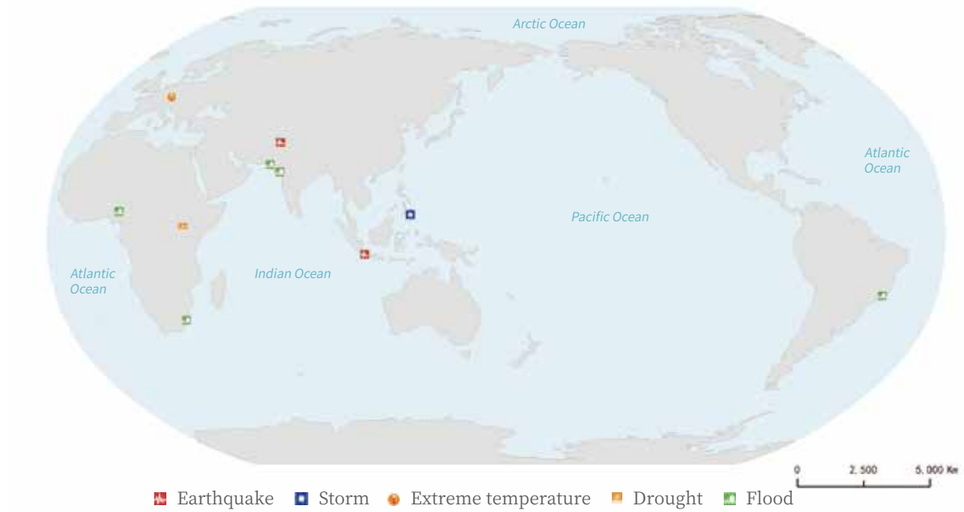


Figure 13 Spatial distribution of the world's top ten natural disasters by death toll in 2022

Table 5 and Figure 14 list the world's top ten disaster events in terms of direct economic losses in 2022 and their spatial distribution. It can be seen that those events with higher economic losses mainly occurred in countries with more developed coastal economies, and were mostly floods and storms.

Table 5 Top ten natural disasters worldwide by direct economic losses in 2022

Ranking	Time	Country	Type of Disaster	Direct economic losses (USD 0.1 billion)
1	September 28-October 2	The United States	Storm	1,000
2	January-December	The United States	Drought	220
3	June 14-September 14	Pakistan	Flood	150
4	March 16-March 16	Japan	Earthquake	88
5	January-December	China	Drought	76
6	February 22-March 3	Australia	Flood	66
7	May 9-May 15	China	Flood	50
8	May 17-October 31	India	Flood	42
9	July 1-October 31	Nigeria	Flood	42
10	January-December	Brazil	Drought	40

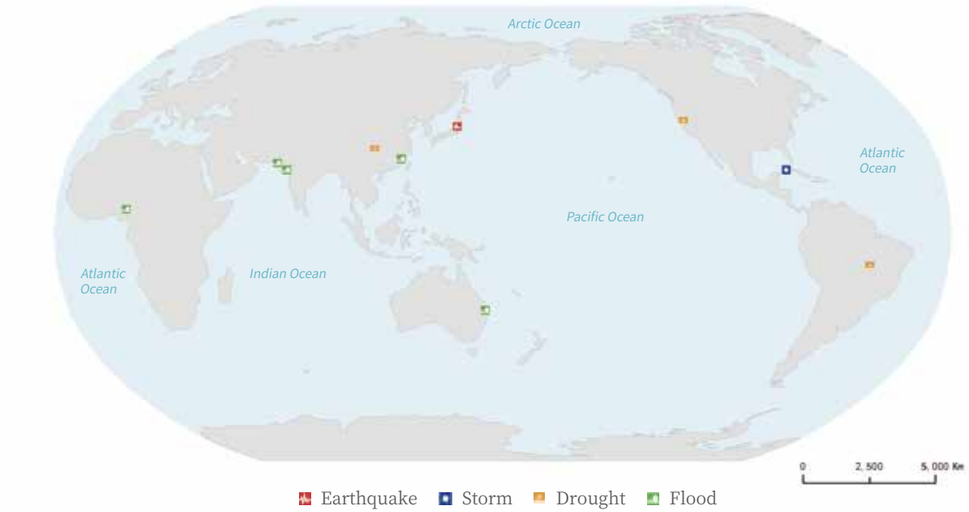


Figure 14 Spatial distribution of the world's top ten natural disasters by direct economic loss in 2022

1.4 Comparison of natural disasters between China and the rest of the world in 2022

1.4.1 Comparison of deaths from natural disasters between China and the rest of the world in 2022

Figure 15 shows the number of deaths from natural disasters per million population in major countries and regions around the world in 2022.

The number of disaster-related deaths per million population in China was 0.20 in 2022; among all the 79 countries and regions in the statistics, 63 countries and regions had a larger number of disaster-related deaths per million than China, accounting for 79.74% of the total; when ranked from low to high according to the number of deaths per million population, China was among the top 20.26% of the 79 countries and regions in the statistics. Countries on the same level as China included Poland (0.19), Ireland (0.20), the Netherlands (0.23), etc.

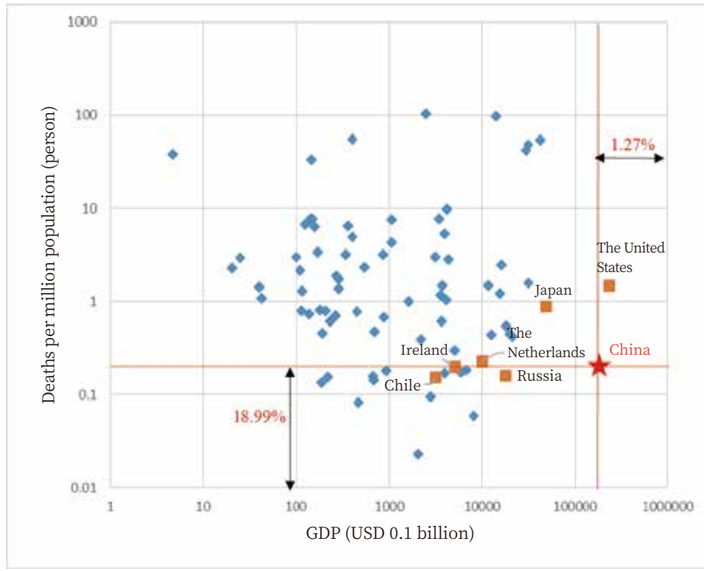
In terms of the number of disaster-related deaths per million population in relation to the level of economic development, China's number of disaster-related deaths per million population was basically consistent with the level of its economic development in 2022, and the count was relatively low in the global range. Among the countries with economic aggregates comparable to that of China, both the United States (1.48) and Japan (0.89) had a higher number of disaster-related deaths per million population than China. Among the countries with per capita GDP equivalent to that of China, both Russia (0.16) and Chile (0.15) had a lower number of disaster-related deaths per million population than China, while Malaysia (1.49) had a higher number.

Disaster-related deaths per million population in China

0.20 person

Among all the 79 countries and regions in the statistics, 63 countries and regions had a larger number of disaster-related deaths per million than China, accounting for

79.74%



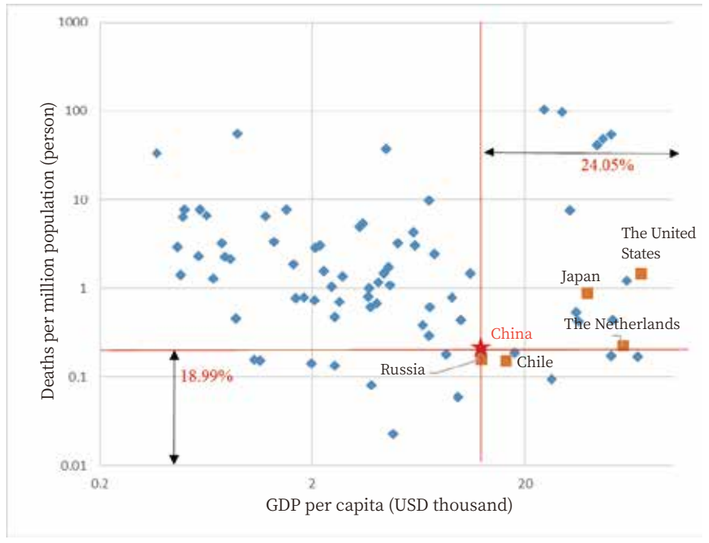


Figure 15 Comparison of deaths from natural disasters between China and the rest of the world in 2022

Note:
Horizontal comparison between China and the other countries and regions in the world;
China ranked in the top 20.26% in terms of the number of disaster-related deaths per million population, which was at the lower level;
China's total GDP ranked second; the per capita GDP ranked in the top 24.05%, which was in the upper-middle level;
The number of disaster-related deaths per million population in China was basically consistent with the level of its economic development.
(The number of disaster-related deaths per million population shown in the figure is calculated by dividing the number of disaster-related deaths in 79 countries and regions around the world in 2022 by the number of million population in the previous year. The population data come from the World Bank (https://data.worldbank.org/), and the GDP data are from the GDP figures (in current USD) in 2021 released by the World Bank).

Proportion of direct economic losses from natural disasters in China's GDP

0.09%

Among all the 40 countries and regions in the statistics, there were 21 countries and regions with a higher economic loss ratio than China, accounting for

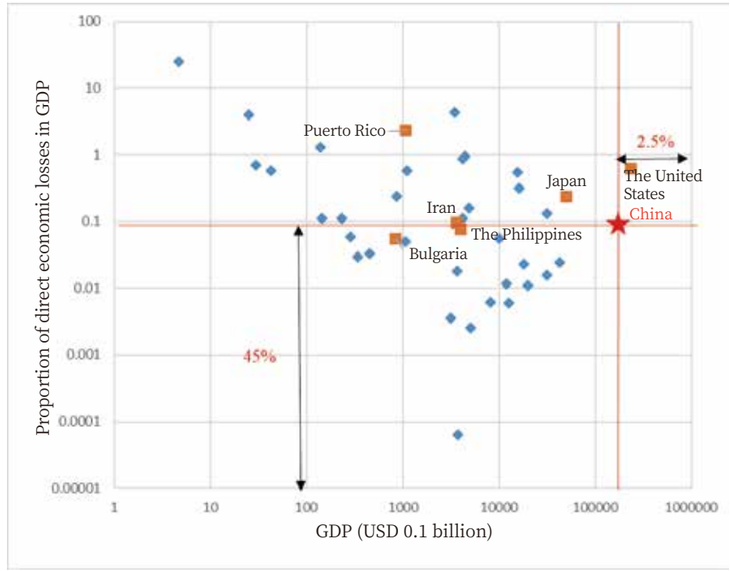
52.5%

1.4.2 Comparison of direct economic losses from natural disasters between China and the rest of the world in 2022

Figure 16 shows the direct economic losses as a share of GDP in major countries and regions worldwide in 2022.

China's direct economic losses from natural disasters accounted for 0.09% of its GDP; among all the 40 countries and regions in the statistics, there were 21 countries and regions with a higher economic loss ratio than China, accounting for 52.5% of the total; when ranked by the proportion of direct economic losses in GDP in ascending order, China was among the top 47.5% of the 40 countries and regions in the statistics. Countries on the same level as China included the Philippines (0.08%), Iran (0.10%), etc.

In terms of the relationship between the proportion of direct economic losses in GDP and the level of economic development in 2022, China's direct economic losses from natural disasters were roughly consistent with the level of its economic development, and China ranked in the middle position of the global range in terms of the proportion of direct economic losses in GDP. Among the countries with economic aggregates comparable to that of China, both the United States (0.63%) and Japan (0.24%) had a higher share of direct economic losses in GDP than China. Among countries with per capita GDP equivalent to that of China, Bulgaria (0.06%) had a lower share of direct economic losses in GDP than China, while Puerto Rico (2.36%) had a higher share than China.



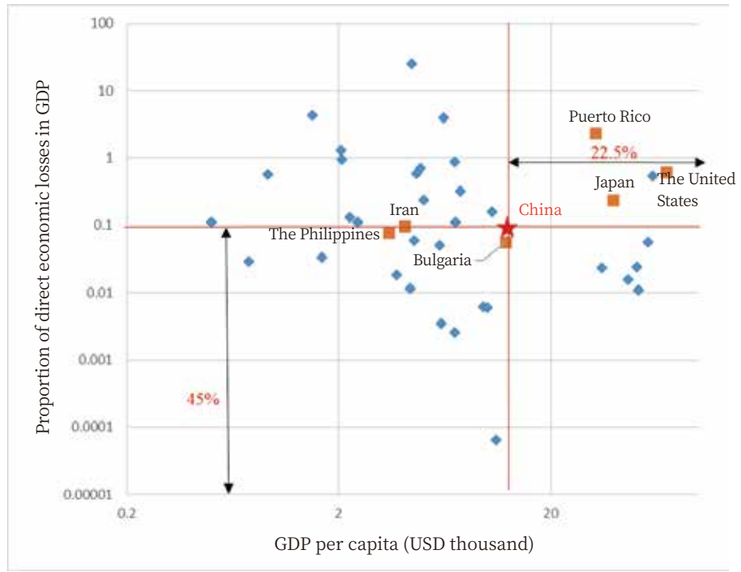


Figure 16 Comparison of direct economic losses from natural disasters as a share of GDP between China and the rest of the world in 2022

Note:

Horizontal comparison between China and the other countries and regions in the world;

China ranked in the top 47.5% in terms of direct economic losses as a percentage of GDP, which was in the middle level;

China's total GDP ranked second; the per capita GDP ranked in the top 25%, which was in the upper-middle level;

China's proportion of direct economic losses in GDP was basically consistent with the level of its economic development.

(The proportion of direct economic losses in GDP shown in the figure is calculated by dividing the direct economic losses from natural disasters in 40 countries and regions around the world in 2022 by their total GDP in the previous year. The population data, GDP (in current USD) and GDP per capita (in current USD) come from the World Bank (https://data.worldbank.org/).

02

Special Report 1

Natural disasters in China in 2022[2]

2.1 Overall review of natural disasters

In 2022, natural disasters in China were dominated by floods, droughts, strong wind and hail, earthquakes and geological disasters, while typhoons, cold waves, sand and dust storms, forest and grassland fires and marine disasters also occurred to varying degrees. Extreme disastrous weather caused major disaster events such as flooding in the Pearl River basin, dike breach in Raoyang River, a tributary of Liaohe River, flash floods in Datong, Qinghai Province and Pingwu and Beichuan, Sichuan Province, continuous drought in summer, autumn and winter in the Yangtze River basin, and forest fires in southern China. Disaster losses throughout the year read an affected population of 112 million people, death and missing toll of 554 people, an evacuated population of 2.428 million people; collapsed housing of 47,000 rooms, with another 796,000 rooms damaged to varying degrees; affected crops of 12,071.6 thousand hectares; and direct economic losses of CNY 238.65 billion.

Affected population
112 million

Death and missing toll
554 persons

Evacuated population
2.428 million

Collapsed housing
47,000 rooms

Affected crops
12,071.6 thousand hectares

Direct economic losses
238.65 billion CNY

[2] The original report is provided by: National Disaster Reduction Center of China, Ministry of Emergency Management.

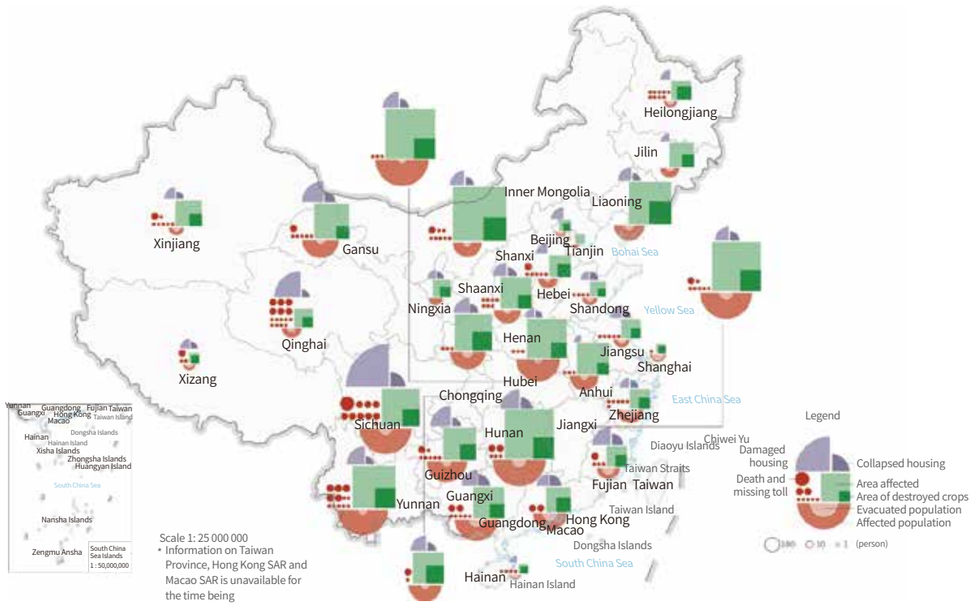


Figure 1 Spatial distribution of natural disasters in China in 2022

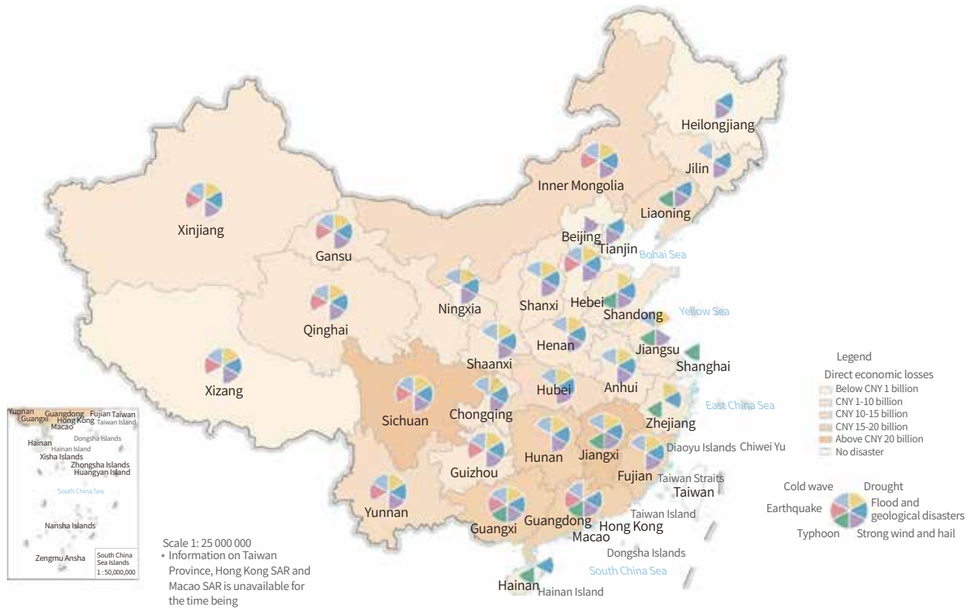


Figure 2 Spatial distribution of natural disasters in China by hazard type in 2022

2.1.1 Affected population by hazard type

Among the population affected by natural disasters in China in 2022, most were affected by droughts (46.6%), followed by floods (30.0%), cold waves (10.0%), strong wind and hail (8.3%) and typhoons (4.2%). The proportions of the population affected by other disasters, such as earthquakes, geological disasters and sand and dust storms, were relatively low.

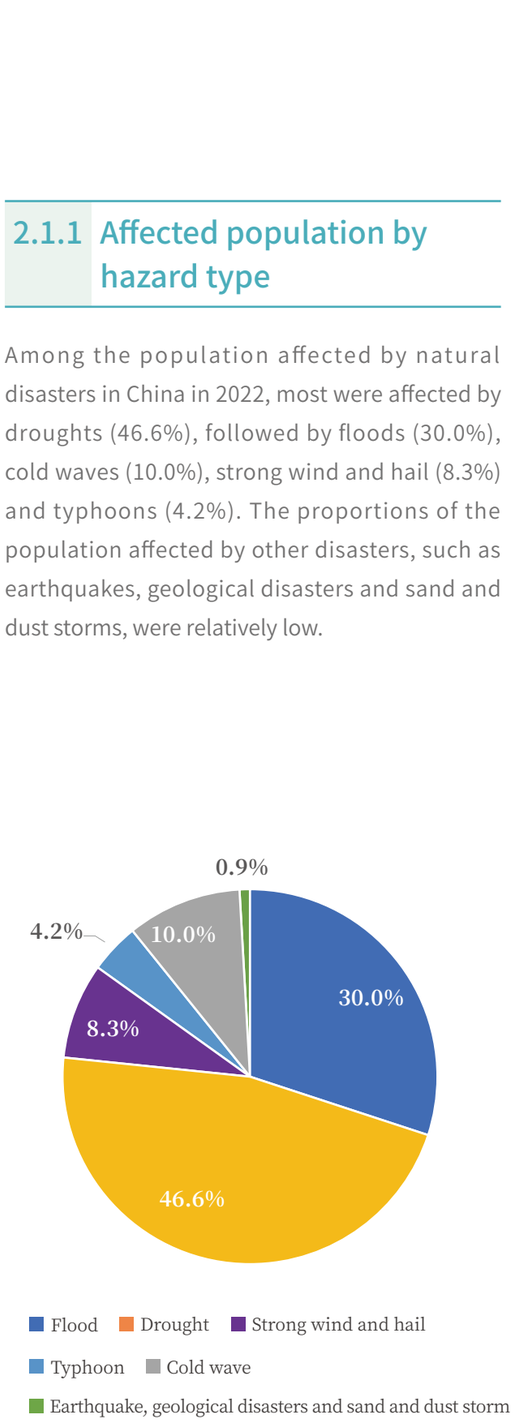


Figure 3 Pie chart of affected population by hazard type in 2022

2.1.2 Death and missing toll by hazard type

In 2022, floods accounted for the highest proportion (30.9%) of the death and missing toll from natural disasters in China, followed by geological disasters (24.5%), earthquakes (22.0%), and strong wind and hail (15.9%), while other disasters, such as forest and grassland fires, cold waves and typhoons, accounted for a relatively small share.

Geological disasters, drowning, lightning strikes, and the collapse of housing or structures were the main causes of the death and missing toll. To be precise, 40.1% was from geological disasters, such as landslides, mudslides and rockfall, 29.6% was from drowning by flash floods, 9.2% from lightning strikes, 8.8% from the collapse of housing or structures, 3.1% from forest fires, and 9.2% from other causes, including cold waves, avalanches, falling objects and being crushed by falling trees, as well as from disaster relief and rescue operations.

Figure 4 Pie chart of death and missing toll by hazard type in 2022

Figure 5 Pie chart of causes of death and missing toll in 2022

2.1.3 Direct economic losses by hazard type

In 2022, floods caused the most direct economic losses, accounting for 54.0% of the total statistics in China. Droughts (21.5%), earthquakes (9.4%), strong wind and hail (7.0%), cold waves (5.2%) and typhoons (2.3%) followed. Geological disasters, sand and dust storm and other disasters accounted for relatively low proportions.

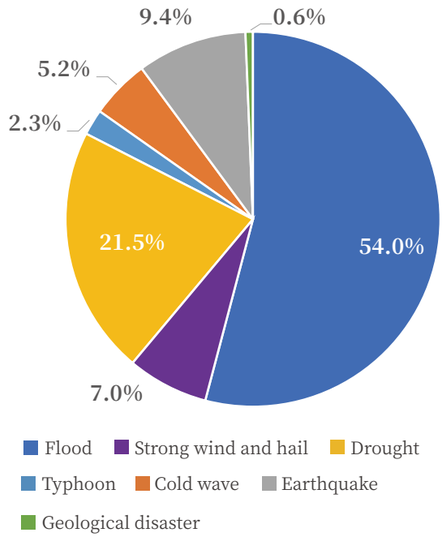


Figure 6 Pie chart of direct disaster economic losses by hazard type in 2022

2.1.4 Disaster index by province

In 2022, the comprehensive disaster index of China was 0.1, the lowest over the past two decades, down by 78.8% from the average of the period 2002-2021 (0.46, 2008 excluded), which shows an obviously mild situation of natural disasters. By province, measured by the median provincial disaster index of 0.023 and the median per capita GDP of CNY 68,000 in 2022, and with the occurrence of natural disasters in each province taken into account, Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Anhui and Shandong were regions with high per capita GDP but low disaster impact; and Jiangxi, Henan, Guangxi, Guizhou, Yunnan, Gansu and Qinghai were regions with low per capita GDP and heavy disaster impact.

2.1.5 Death and missing toll by province

Sichuan, Qinghai and Yunnan all had more than 50 deaths and missing people due to disasters in 2022, among the top three in China. Sichuan was the only province which suffered a death and missing toll of more than 100 people. Compared with annual means from 2002 to 2021, all provinces had decreases in these statistics.

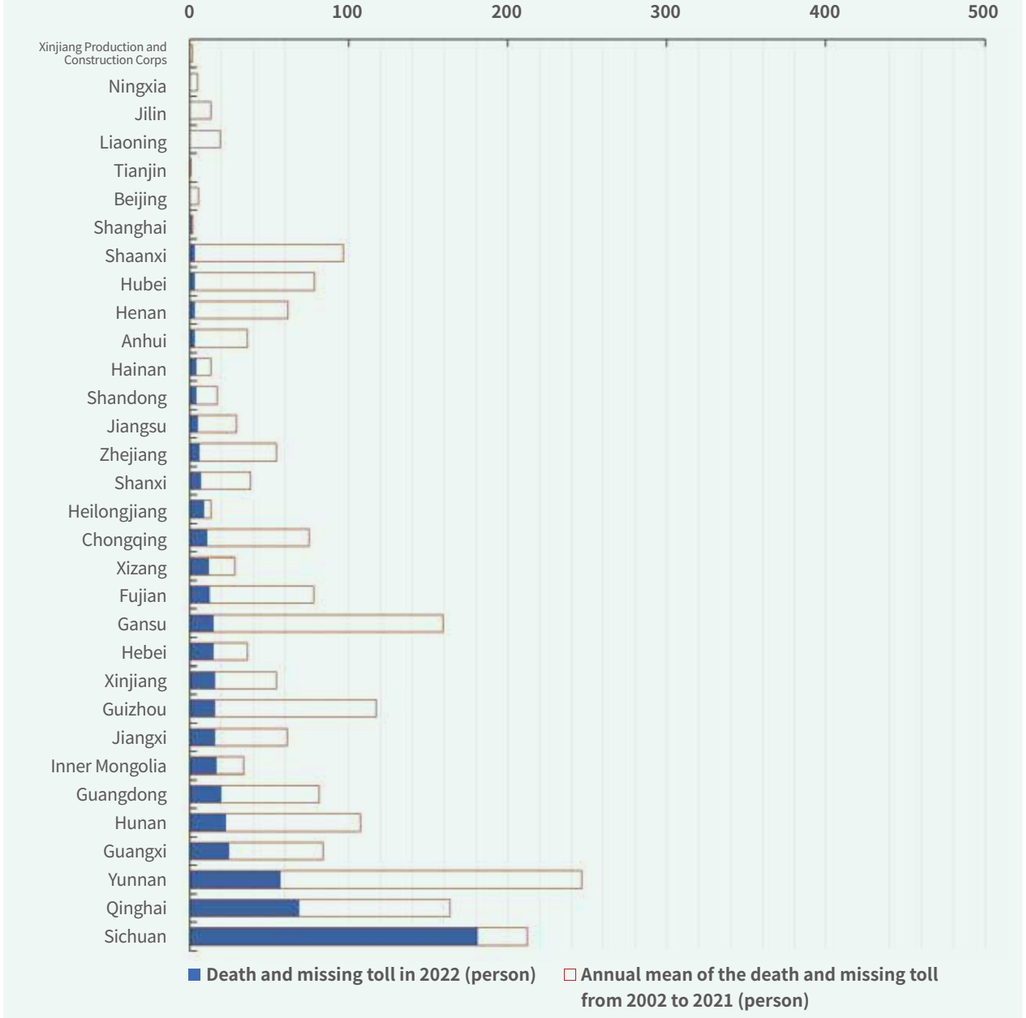


Figure 7 Statistics of death and missing toll from disasters by province in 2022 [3]

[3] Note: The statistics of 2008 is not included in the mean death and missing toll in Sichuan Province from 2002 to 2021.

2.1.6 Direct economic losses by province

In 2022, both Sichuan and Jiangxi suffered direct disaster economic losses of over CNY 17 billion (converted value), and Hunan, Guangdong, Fujian and Liaoning all suffered direct disaster economic losses of over CNY 10 billion (converted value).

Compared with the annual mean from 2002 to 2021, direct economic losses from disasters in Jiangxi, Fujian, Liaoning, Guangxi, Qinghai and Guangdong increased while loss statistics in other provinces decreased.

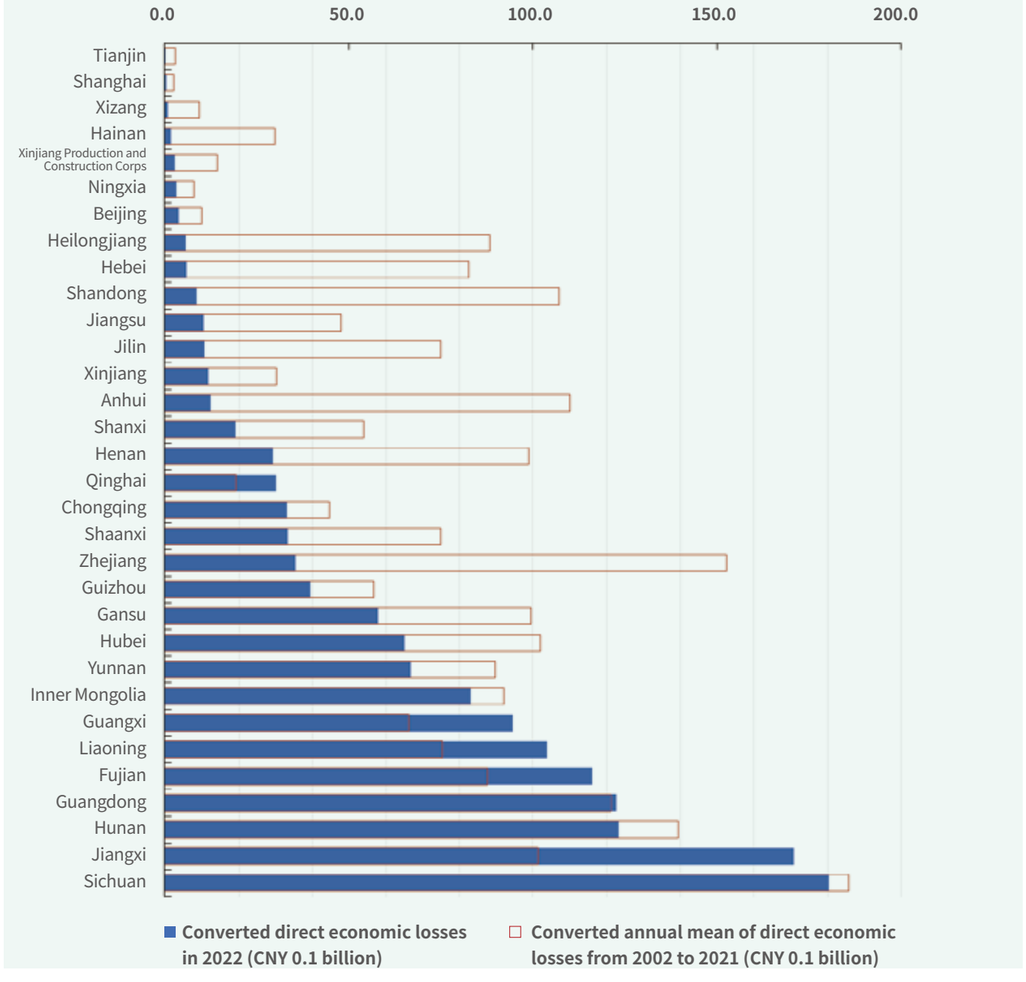


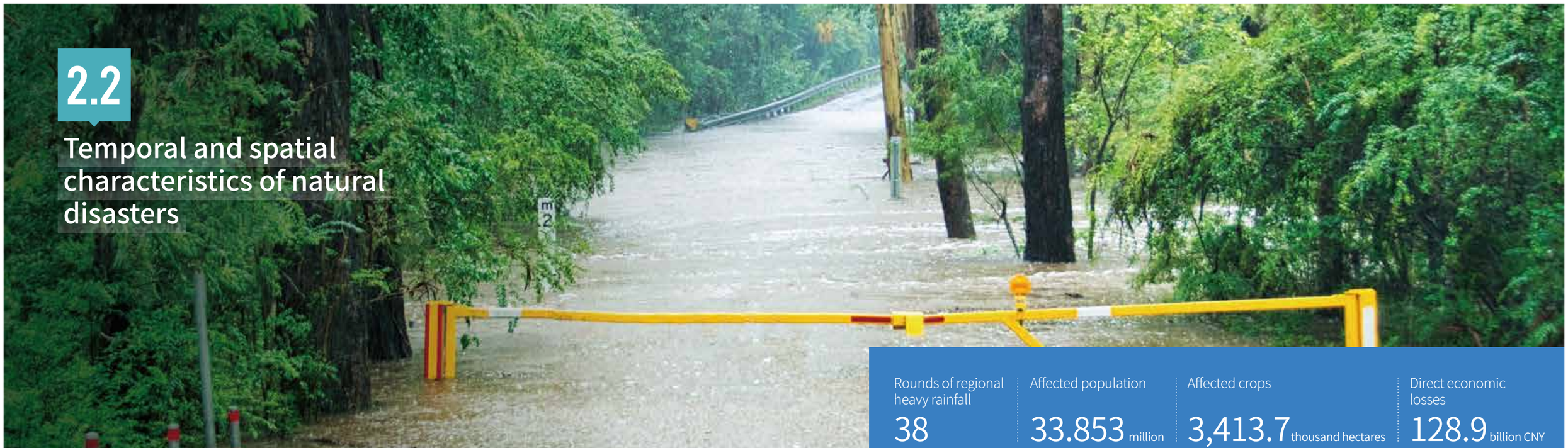
Figure 8 Statistics of direct disaster economic losses by province in 2022[4]

[4] Note: Annual data in each province were converted on the basis of comparable prices in 2022 according to the GDP indices. The statistics of 2008 is not included in the mean value of the converted direct economic losses in Sichuan province from 2002 to 2021.

Table 1 Top ten natural disaster events in China, 2022[5]

Natural disaster event	Affected population (10,000 persons)	Death and missing toll (person)	Direct economic losses (CNY 0.1 billion)
(1) Luding earthquake of Ms 6.8 in Sichuan on September 5	54.8	117	154.8
(2) Heavy rain and floods in the Pearl River basin in early and mid-June	648.9	37	278.2
(3) Heavy rains and floods in Fujian, Jiangxi and Hunan in June	814.2	29	433
(4) Heavy rain and floods in Sichuan in mid-July	27.9	36	24.8
(5) Flash flooding in Datong, Qinghai on August 17	6.5	31	6.9
(6) Typhoon Chaba (2203)	186.29	3	31.2
(7) Summer-autumn-winter drought in in the Yangtze River basin	3,978	0	408.5
(8) Cold waves in South China in the middle and late February	609.2	0	78.9
(9) Heavy rain and floods in Liaoning in early August	54.9	0	76
(10) Menyuan earthquake of Ms 6.9 in Qinghai on January 8	17.1	0	32.5
Total economic losses of top ten natural disaster events	6,397.79	253	1,524.8
National total losses	11,267.8	554	2,386.5
Percentage of top ten natural disaster events	57%	46%	64%

[5] Note: Events are ranked in descending order of the death and missing toll, and in descending order of direct economic losses when the death and missing tolls are the same.



2.2 Temporal and spatial characteristics of natural disasters

Rounds of regional heavy rainfall	Affected population	Affected crops	Direct economic losses
38	33.853 million	3,413.7 thousand hectares	128.9 billion CNY

2.2.1 Natural disasters were unevenly distributed in time and space throughout China. They were more frequent in summer and autumn, with the central and western parts of the country more badly hit

In 2022, the spatial and temporal differentiation of natural disasters in China was clearly evident. From January to April, except for the Menyuan Ms 6.9 earthquake in Qinghai in January and cold waves in some parts of southern China in February, natural disasters were generally mild, and the disaster losses were at a low level compared with the statistics in recent years. In summer and autumn, however, major disasters occurred successively and caused large casualties and losses. These disasters included the heavy rains and floods in South China, the regions south of the Yangtze River and the Liaohe River basin, the rare summer-autumn-winter drought in the Yangtze River basin, the flashfloods and mudslides in parts of Sichuan, Heilongjiang, Gansu and Qinghai, and the Lushan Ms 6.1 earthquake, Maerkang Ms 6.0 earthquakes and Luding Ms 6.8 earthquake in Sichuan. According to statistics, between the Beginning of Summer (May 5) and the Beginning of Winter (November 7) in 2022, various natural disasters caused 509 deaths and missing people and direct economic losses of CNY 216.3 billion, accounting for 92% and 91% of the annual total, respectively.

2.2.2 Floods were heavy in the north and the south and light in the central, and flash floods were frequent in some parts with severe damage

In 2022, China received 38 rounds of regional heavy rainfall, with an average precipitation of 606.1 mm, which was 5% less than annual normal. Rainfall during the flood season was mainly concentrated in the north and the south, and it was less in the central. The average precipitation in South China from May to June and that in Northeast China from June to July were ranked high in history, while the average precipitation in the middle and lower reaches of the Yangtze River from July to September was 50.6% less than the mean level for the same period of previous years, ranking the lowest in history. According to statistics, flood losses throughout the year read an affected population of 33.853 million, death and missing toll of 171 people, an evacuated population of 1.518 million; collapsed housing of 31,000 rooms, with another 262,000 rooms damaged; affected crops of 3,413.7 thousand hectares; and direct economic losses of CNY 128.9 billion. Compared with the annual mean of the last five years, the affected population, death and missing toll, collapsed housing and direct economic losses saw a decrease of 41%, 63%, 72% and 33%, respectively.

2.2.3 Historically rare summer-autumn-winter drought occurred in the Yangtze River basin, affecting a wide range of areas and causing heavy losses

In 2022, the average temperature in China was high, and the summer was marked by the most severe high temperature since 1961 in the central and eastern regions, resulting in serious drought disasters. First, droughts occurred in an obvious periodic and regional manner. Winter-spring drought in the Pearl River basin, spring-summer droughts in the Huang-Huai-Hai region and northwest region, and rare summer-autumn-winter drought in the Yangtze River basin successively occurred. Second, the Yangtze River basin suffered high temperatures and droughts rare in history. From July to November, the precipitation of the Yangtze River basin was abnormally low, and extreme high temperatures persisted, with 77 days in a situation severer than moderate drought, which is 54 days more than in the same period of previous years. Third, the droughts exerted widespread impacts, and led to many people in need of assistance. Extreme high temperatures and droughts had a serious impact on agricultural production, drinking water for humans and livestock, electricity supply, and the ecological environment in disaster-stricken areas. At the peak of the drought, a total of 52.452 million people were affected nationwide, 7.585 million people needed assistance, and 6,090.2 thousand hectares of crops were affected, with direct economic losses reaching CNY 51.28 billion. Compared with the annual mean of the last five years, the affected population, people in need of assistance, and direct economic losses saw an increase of 46%, 39% and 67%, respectively.

Affected population at the peak of the drought	Area of affected crops	Direct economic losses
52.452 million	6,090.2 thousand hectares	51.28 billion CNY

2.2.4 Strong convections were relatively fewer, wind and hail disasters were less severe, while lightning strikes were relatively more

In 2022, there were 37 regional strong convection disasters in China, less than the annual mean of the last five years (45). A total of 1,116 counties (cities and districts) in China were affected by strong wind and hail disasters, mainly in the northern, northwestern and southwestern parts of the country. Disaster losses were mainly in the agricultural, forestry and husbandry sectors. As for the causes of death, cloud-to-ground lightning events occurred more frequently than in recent years. Lightning strikes caused 51 deaths, accounting for 58% of the total number of deaths caused by strong wind and hail disasters, and the number of casualties caused by lightning strikes was higher in Qinghai and Sichuan. Other casualties were mainly from the collapse of structures and trees caused by strong winds. The strong wind and hail disasters in 2022 were generally not as severe as usual, causing total affected population of 9.306 million, death toll of 88 people, and direct economic losses of CNY 16.67 billion. Compared with the annual mean of the last five years, the affected population, death and missing toll and direct economic losses saw a decrease of 40%, 21% and 24%, respectively.

2.2.5 Moderate to strong earthquakes were relatively more in the western region, and losses from earthquakes were severe

In 2022, there were 108 earthquakes of Ms 4.0 or higher in the mainland of China, showing a higher frequency of moderate to strong earthquakes. The number of earthquakes of Ms 5 or higher (27) increased compared with that of last year (20) and the mean level of previous years (20). The spatial distribution of the earthquakes was relatively concentrated, mainly in Qinghai, Sichuan and Xinjiang. Among them, the Menyuan Ms 6.9 earthquake in Qinghai on January 8 recorded the highest magnitude scale of the year, affecting 171,000 people and causing direct economic losses of CNY 3.25 billion. Sichuan Province suffered severe losses from earthquakes, with the Luding Ms 6.8 earthquake resulting in an affected population of 548,000, the death and missing toll of 117, collapsed housing of 12,000 rooms, and direct economic losses of CNY 15.48 billion. Overall, earthquakes caused obviously severe losses in 2022, including a total affected population of 940,000, the death and missing toll of 122, and direct economic losses of CNY 22.45 billion, which, compared with the annual mean of the last five years, rose by 99%, 784% and 173%, respectively.

Number of earthquakes of Ms 4.0 or higher	Affected population	Death and missing toll	Direct economic losses
108 times	0.94 million	122 persons	22.45 billion CNY

2.2.6 A small number of typhoons made landfalls in China, with concentrated sites of landfalls

Among the 25 typhoons generated in the Northwest Pacific and the South China Sea in 2022, four made landfalls and affected China, which were fewer than usual and caused lower impacts and losses. Firstly, the first landfall was late. On July 2, Typhoon Chaba (2203) made landfall on the coast of Dianbai, Guangdong, four days later than the average time of the first landfall (June 28) in previous years. Second, the number of typhoons produced in autumn was greater, and the sites of landfalls were concentrated. From September to October, a total of 12 typhoons were generated in the Northwest Pacific and the South China Sea, more than the average (8.5) of previous years, and three of them made landfalls in western Guangdong. Third, Typhoon Muifa (2212) made four landfalls in Zhoushan of Zhejiang, Fengxian of Shanghai, Qingdao of Shandong, and Dalian of Liaoning, which was the first typhoon to make four landfalls in different parts of China since 1949, and went all the way north to affect many provinces. The typhoons in 2022 caused total affected population of 4.764 million, death and missing toll of 3, and direct economic losses of CNY 5.42 billion.

2.2.7 Cold waves affected the southwest and mid-south regions, and part of Xinjiang suffered severe snowstorms

China was affected by 35 cold waves in 2022, 5.9 more than the normal level for the same period (29.1). Cold waves were intense in southern region in February, with the average temperature was the lowest for the same period since 2009. The affected regions were mainly concentrated in the southwest and mid-south regions, and heavy losses were caused in field vegetables, cash forests and fruits. Agricultural greenhouses, livestock sheds, and simply-constructed factories for industrial and commercial uses collapsed in parts of Jiangxi, Hunan and Yunnan due to snow accumulation. Local infrastructures for electricity supply and communications were also damaged.

The resulting direct economic losses accounted for 80% of the annual total from cold waves. From November 26 to December 1, China experienced the strongest cold waves since the beginning of winter, which brought sharp temperature drops, strong winds, sand and dust storms and extensive rains and snows to most regions. Overall, a total of 870.7 thousand hectares of agricultural crops were affected by cold waves in 2022, with direct economic losses of CNY 12.45 billion. Compared with the annual mean of the last five years, the area of affected crops and direct economic losses fell by 27% and 19%, respectively.

Cold waves	Area of affected crops	Direct economic losses
35 times	870.7 thousand hectares	12.45 billion

2.2.8 The spatio-temporal distribution of forest and grassland fires was relatively concentrated

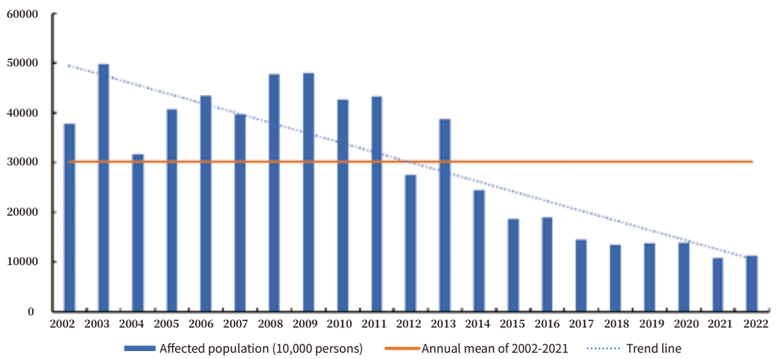
In 2022, a total of 709 forest fires occurred in China, affecting an area of some 4,689.5 hectares of forest, causing 17 people dead. In terms of temporal distribution, the periods from March to April and from September to October were high-incidence seasons of forest fires, with a total of 521 occurrences, accounting for 74% of the annual total. In terms of spatial distribution, affected by high temperatures, droughts and other factors, six provinces (autonomous regions), namely Hunan, Guangxi, Jiangxi, Hubei, Guangdong and Chongqing, suffered 503 forest fires, accounting for 71% of the total event counts. A total of 21 grassland fires occurred in China, of which 16 or 76% were in Inner Mongolia and Qinghai.

Forest fires	Area of affected forest	Death toll
709 times	4,689.5 hectares	17 persons

2.3 Trend analysis of disaster indicators

2.3.1 Affected population

Overall speaking, the affected population by natural disasters across China has demonstrated a downward trend from 2002 to 2022. The affected population in 2022 was 112.678 million, ranking the second lowest since 2002 (only higher than that in 2021). Compared with the annual mean from 2002 to 2021 (300.86 million, 2008 excluded), this statistics dropped by 62.5%.



Affected population

112.678

million persons

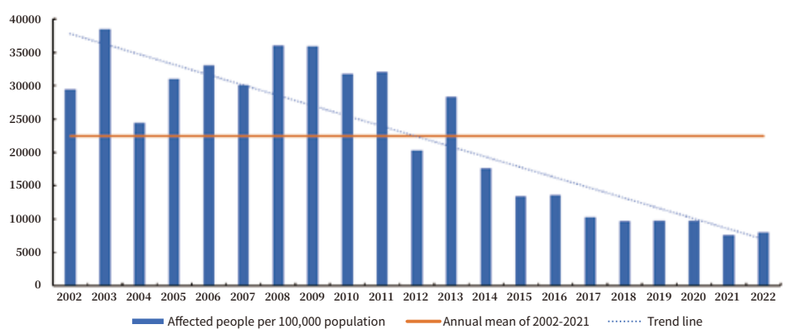
Dropped by

62.5%

Figure 9 Annual statistics of affected population in China, 2002-2022

2.3.2 Affected people per 100,000 population

The statistics of affected people per 100,000 population have also shown a decreasing trend from 2002 to 2022. In 2022, the number of affected people per 100,000 population was 7,981, which was the second lowest since 2002 (only higher than that in 2021) and dropped by 64.5% compared with the annual mean from 2002 to 2021 (22,469, 2008 excluded).



Affected people per 100,000 population

7,981

persons

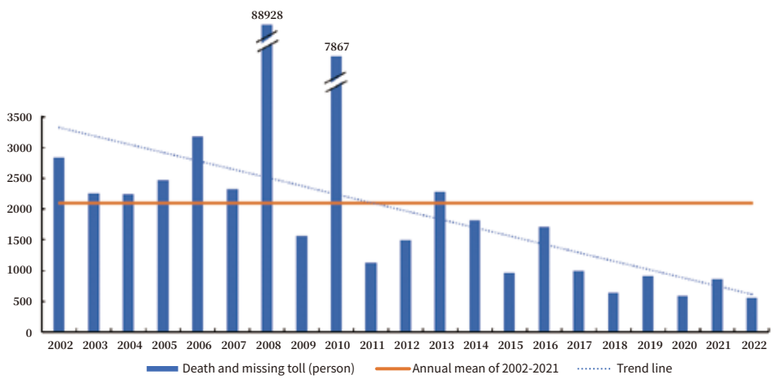
Dropped by

64.5%

Figure 10 Annual statistics of affected people per 100,000 population in China, 2002-2022

2.3.3 Death and missing toll

From 2002 to 2022, the annual death and missing toll caused by natural disasters in China was also declining. The death and missing toll in 2022 was 554 (487 deaths and 67 missing people), ranking the lowest since 2002. Compared with the average level from 2002 to 2021 (2,009, 2008 excluded), the decrease was as high as 72.4%.



Death and missing toll

554

persons

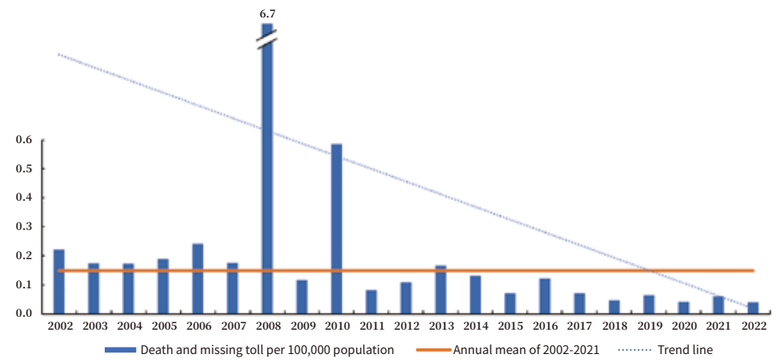
Decreased by

72.4%

Figure 11 Annual statistics of death and missing toll in China, 2002-2022

2.3.4 Death and missing toll per 100,000 population

From 2002 to 2022, the death and missing toll per 100,000 population caused by natural disasters in China went down as well, which was 0.039 in 2022, the lowest since 2002. Compared with the annual mean from 2002 to 2021 (0.15, 2008 excluded), there was a decrease of 73.8%.



Death and missing toll per 100,000 population

0.039

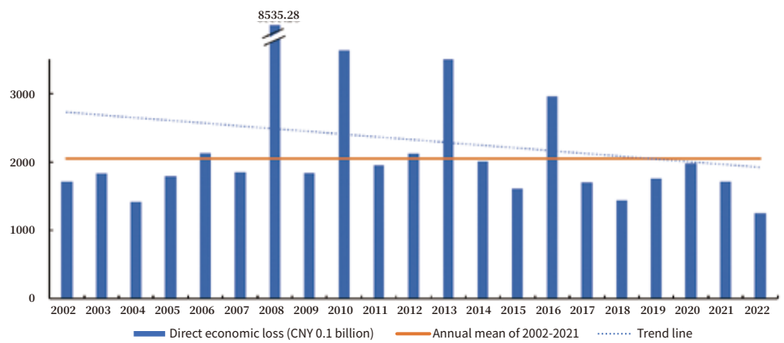
Decreased by

73.8%

Figure 12 Annual statistics of death and missing toll per 100,000 population in China, 2002-2022

2.3.5 Direct economic losses

From 2002 to 2022, direct economic losses caused by natural disasters in China showed a downward trend (annual data were converted based on 2022 comparable prices, in accordance with GDP index). The loss data in 2022 read CNY 124.98 billion, ranking the lowest since 2002, with a decrease of 39.1% from the annual mean from 2002 to 2021 (CNY 205.14 billion, 2008 excluded).



Direct economic losses

124.98

billion CNY

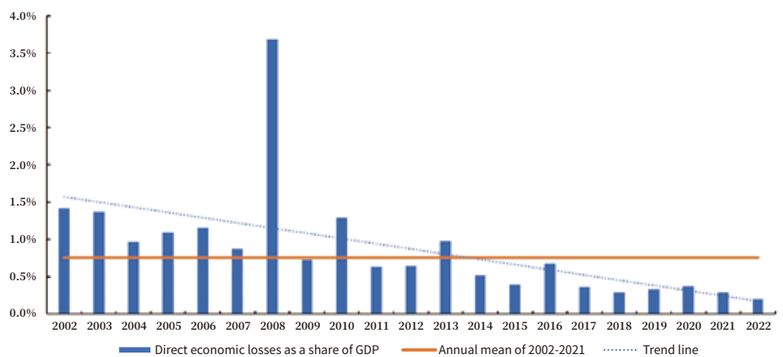
Decreased by

39.1%

Figure 13 Annual statistics of direct economic losses in China, 2002-2022[6]

2.3.6 Direct economic losses as a share of GDP

From 2002 to 2022, the ratio of direct economic losses from natural disasters over GDP in China was declining as well. In 2022, this ratio was 0.20%, which was the lowest since 2001, and decreased by 73.9% from the annual mean from 2002 to 2021 (0.76%, 2008 excluded).



The ratio of direct economic losses from natural disasters over GDP

0.20%

Decreased by

73.9%

Figure 14 Annual statistics of direct economic losses as a share of GDP in China, 2002-2022

[6] Note: annual data were converted based on 2022 comparable prices, in accordance with GDP index.

03

Special Report 2

Assessment on global climate extremes from 2000 to 2022[7]

3.1 Overview of global climate extremes

3.1.1 Current situation and criteria

Extreme weather events and extreme climate events are one of the seven major scientific challenges of the World Climate Research Programme (WCRP), and also a key concern of the Assessment Reports of the United Nations Intergovernmental Panel on Climate Change (IPCC). Extreme weather events and extreme climate events are often characterized by sudden onset, devastating effects, wide impacts and long duration, which pose great difficulties and challenges to emergency management in countries around the world.

In August 2021, the IPCC released the Working Group I contribution to the Sixth Assessment Report (AR6), *Climate Change 2021: The Physical Science Basis* , which defines extreme weather events as "events that are rare at particular places and time of year" and extreme climate events as "extreme weather patterns that persist for a period of time, such as a season" [8]. The Working Group I contribution also provides, for the first time in a separate chapter (Chapter 11), an assessment of changes in climate extremes, covering physical mechanisms and drivers, observed trends, modeling simulation capabilities evaluation, detection and attribution, and future change estimates. The contribution argues that future changes in climate extremes are related to the magnitude of global warming, and that even a small amount of global warming will increase the frequency and intensity of extreme events. It is important to note that, in addition to natural variability, the impacts reported are increasingly attributable to climate change caused by human activities, in particular the increased frequency and intensity of extreme events, such as an increase in the extent of wildfires, and excess mortality due to heat waves.

[7]Note: As the Synthesis Report of the Sixth Assessment Report (AR6) issued by the Intergovernmental Panel on Climate Change (IPCC) on March 2023 explicitly defines the criteria for Climate Extremes, and a high-level meeting on the midterm review of the Sendai Framework was held in May 2023, the 2023 special report, in line with those new criteria, reviews the impacts of the climate extremes and their changes since the implementation of the Sendai Framework.

[8]Note: https://report.ipcc.ch/ar6/wg1/IPCC_AR6_WGI_FullReport.pdf

The IPCC finalized the *AR6 Synthesis Report: Climate Change 2023* [9] during the Panel's 58th Session held in Switzerland in March 2023, pointing out that the characteristics of extreme weather can vary in absolute terms from place to place, and that when an extreme weather pattern lasts for a period of time (e.g., a quarter), it may be classified as an extreme climate event, especially if the average or total value it produces is extreme in itself (for example, high temperatures, droughts or heavy rainfall in a quarter). For simplicity, the AR6 Synthesis Report refers to extreme weather events and extreme climate events collectively as "climate extremes" [10].

[9]Note: https://www.ipcc.ch/report/ar6/syr/

[10]Note: https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_Annex-I.pdf

This assessment report, in line with the IPCC Sixth Assessment Report, also refers to extreme weather events and extreme climate events collectively as “climate extremes”, and determines that a climate extreme should meet at least one of the following criteria by taking into account the hazard intensity and the extreme nature of the event:

01 The intensity of the event ranked in the top 1% of the global equivalent[11]

02 With a death toll 5 hundred

03 With an affected population of over 10 million;

04 With direct economic losses of over USD 1 billion

3.1.2 Types of climate extremes

According to the EM-DAT statistics, there were 7,093 weather and climate events worldwide during the period of 2000-2022. According to the criteria of 1.1 above, 652 climate extremes were selected, including seven types of hazards, namely extreme flood, extreme drought, extreme high temperature, extreme low temperature, tropical cyclone, convective storm, and other storms.

Extreme floods (209) accounted for the highest proportion of the global total climate extremes, at 32%, followed by tropical cyclones (178 or 27%), convective storms (141 or 22%), extreme droughts (66 or 10%), extreme high temperatures (34 or 5%), and extreme low temperatures (16 or 3%). Other storm events accounted for 1% of the global total. Figure 1 shows the proportions of different types of hazards.

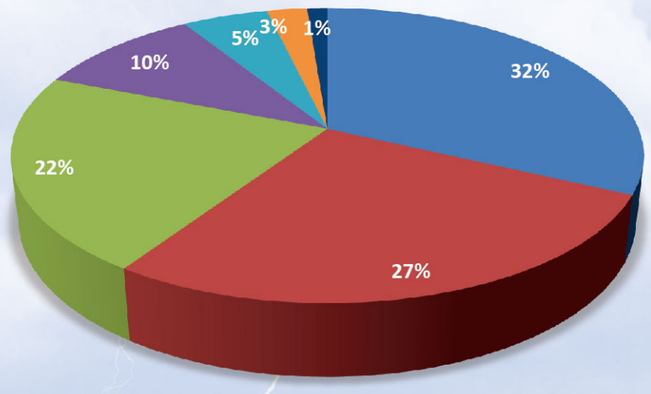
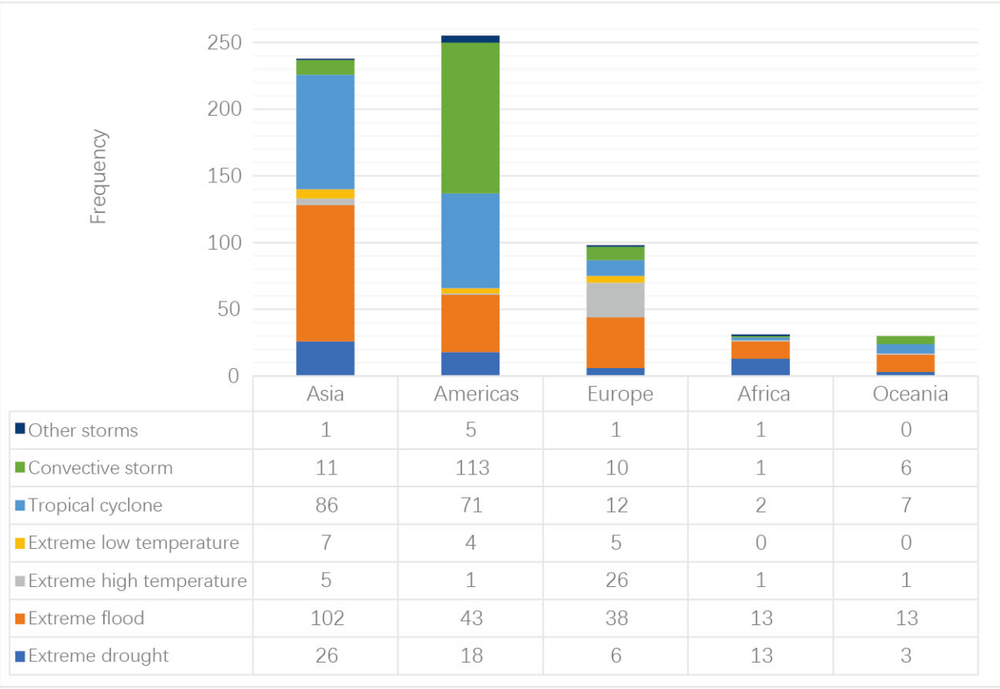


Figure 1 Statistics on global climate extremes by hazard type (2000-2022)

[11]Note:Based on EM-DAT data, the disaster intensity thresholds for the top 1% of global weather and climate events are: extreme high temperature (52℃), extreme low temperature (-51℃), extreme flooding (585,146 km2), extreme drought (32,650 km2), and extreme storm (320 kph).

3.1.3 Spatial distribution of climate extremes



	Asia	Americas	Europe	Africa	Oceania
Other storms	1	5	1	1	0
Convective storm	11	113	10	1	6
Tropical cyclone	86	71	12	2	7
Extreme low temperature	7	4	5	0	0
Extreme high temperature	5	1	26	1	1
Extreme flood	102	43	38	13	13
Extreme drought	26	18	6	13	3

Figure 2 Statistics on global climate extremes by region (2000-2022)

In terms of the distribution of climate extremes by continent over the period of 2000-2022 (Figure 2), the Americas and Asia have exhibited a relatively high frequency of climate extremes, at 255 and 238, respectively, which accounted for 39.1% and 36.5% of the global total.

The most frequent climate extremes in the Americas were convection storms, with 113 occurrences (accounting for 17.3% of the global total climate extremes, the same below), followed by tropical cyclones (71 or 10.9%), extreme floods (43 or 6.6%), extreme droughts (18 or 2.8%) and other events (10 or 1.5%). The most frequent climate extremes in Asia were extreme floods (102 or 15.6%), followed by tropical cyclones (86 or 13.2%), extreme droughts (26 or 41%), convective storms (11 or 1.7%) and other events (13 or 2%).

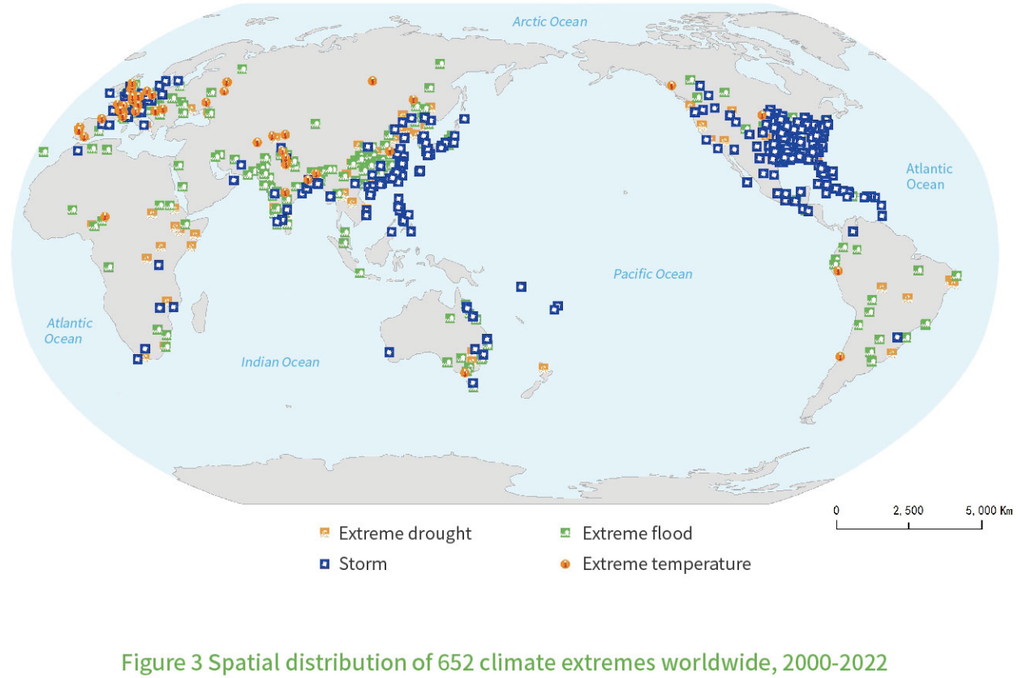
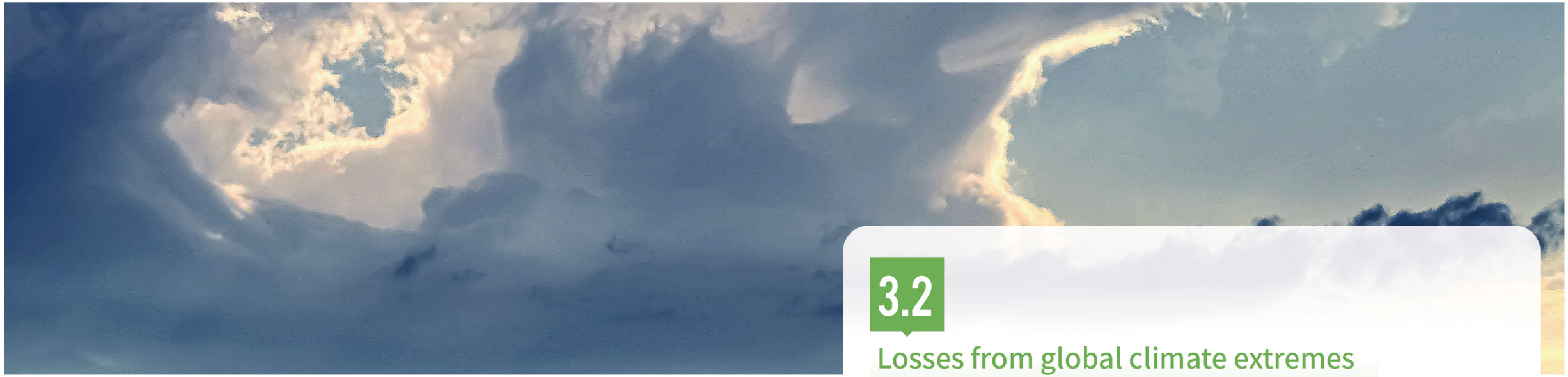


Figure 3 Spatial distribution of 652 climate extremes worldwide, 2000-2022

In the period of 2000-2022, Europe was next only to the Americas and Asia in terms of the frequency of climate extremes, but its number of climate extremes was 98, only about 40% of that in the Americas or Asia, accounting for 15% of the global total climate extremes (the same below), including 38 extreme floods (5.8%), 26 extreme high temperatures (4%), 12 tropical cyclones (1.8%), 10 convective storms (1.5%) and six extreme droughts (1%). In Africa and Oceania, the frequencies were comparable, with 31 (4.8%) and 30 (4.6%), respectively, and extreme floods were the most frequent for both continents, with 13 occurrences each (2%).

At the same time, 13 extreme droughts (2%), two tropical cyclones, one extreme high temperature and one convection storm occurred in Africa; and seven tropical cyclones (1.1%), six convection storms (1%), three extreme droughts and one extreme high temperature event occurred in Oceania.



3.2 Losses from global climate extremes from 2000 to 2022

From 2000 to 2022, 652 global climate extremes affected 6.21 billion people worldwide, resulting in 1.837 million casualties (510,000 deaths and 1.327 million injuries), and direct economic losses of more than USD 3.27 trillion.

6.21 billion
Affected population

1.837 million
Number of casualties

In terms of hazard types, extreme droughts caused the largest affected population, exceeding 2.3 billion, accounting for 37.1% of the total population affected by climate extremes worldwide. Tropical cyclones and extreme high temperatures caused the largest death toll, both surpassing 150,000, with 181,000 and 168,000 deaths, respectively, accounting for 35.5 % and 33% of the total number of deaths from global climate extremes. Tropical cyclones caused the most direct economic losses, at USD 1,527 billion, accounting for 46.7% of the total direct economic losses from global climate extremes and almost the sum of the direct economic losses caused by all other types of climate extremes.

Regionally, up to 3.46 billion people were affected in Asia, more than all other regions combined, accounting for 56% of the total population affected by climate extremes worldwide. The number of deaths from climate extremes in Asia was 223,400, which accounted for 43.8% of the total number of deaths from climate extremes worldwide, almost the same as the sum of deaths from climate extremes in Europe, the Americas, Africa and Oceania. The Americas suffered the largest direct economic losses, at USD 1,932.9 billion, accounting for 59% of the total direct economic losses from climate extremes worldwide, followed by Asia at USD 931.3 billion (29%). The two continents accounted for 88% of the total global economic losses.

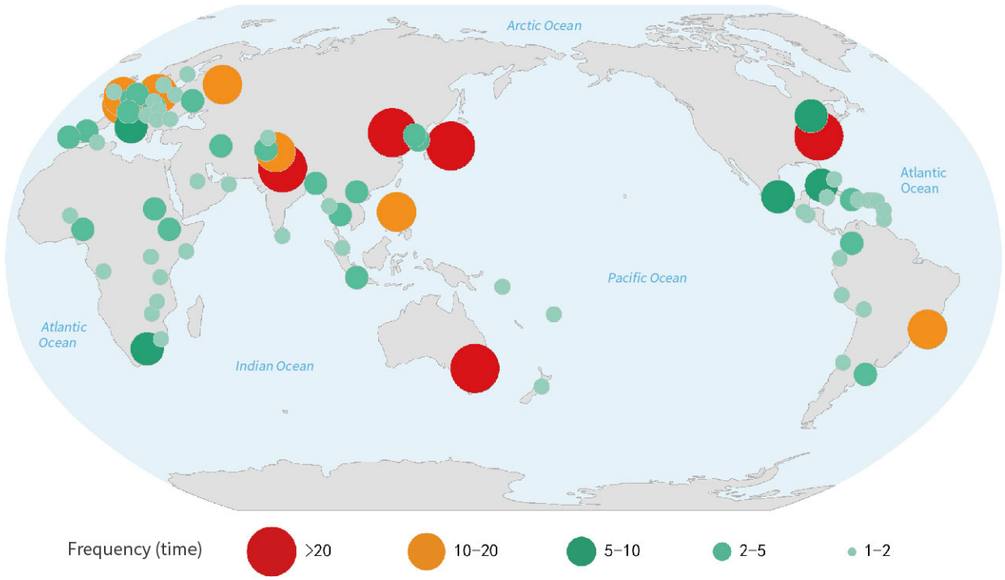


Figure 4 Spatial distribution of frequency of climate extremes in countries (or regions) around the world, 2000-2022

3.3 Overview of climate extremes in countries (or regions) around the world

Table 1 lists the top ten countries (or regions) in terms of the frequency, deaths, and direct economic losses of global climate extremes from 2000 to 2022. It can be seen that the top ten countries in terms of the frequency of climate extremes from 2000 to 2022 were widely distributed in eastern Asia, western Europe, North America, South America and Oceania, among which, the United States had the highest frequency at 185, followed by China at 100, and India ranked third with 45 occurrences. The countries with a larger number of disaster-related deaths were mainly located in Eurasia and Africa. The top ten countries all had more than 10,000 deaths, of which Myanmar had the largest number of 138,000, followed by Somalia at 63,000, and Russia ranked third with 56,000 deaths. The countries with higher direct economic losses were mainly located in North America, eastern and southern parts of Asia, western Europe and Australia. The top nine countries all had direct economic losses of more than USD 50 billion, of which the United States had the most, at USD 1,478.6 billion, followed by China at USD 457.7 billion.

Table 1 Top ten countries (or regions) in terms of frequency, deaths, and direct economic losses caused by global climate extremes from 2000 to 2022

Country	Frequency (time)	Country	Deaths (person)	Country	Direct economic losses (USD 0.1 billion)
The United States	185	Myanmar	138,366	The United States	14786
China	100	Somalia	63,000	China	4577
India	45	Russia	56,027	Canada	1163
Australia	26	India	35,705	Japan	1349
Japan	25	France	30,492	India	1325
France	16	Ethiopia	30,214	Germany	1099
Germany	13	Italy	20,134	Cuba	822
The Philippines	13	Spain	19,773	Thailand	573
The United Kingdom	13	The Philippines	15,981	Australia	563
Brazil	12	Germany	14,228	Czech Republic	495

Table 2 lists the ten climate extremes with the highest global death toll from 2000 to 2022. Six of the disasters occurred in economically backward developing countries, and they included extreme high temperatures, extreme droughts and tropical cyclones; the other 4 occurred in developed countries in Europe, and were all extremely high temperature events. According to statistics, the total number of deaths caused by the top ten climate extremes from 2000 to 2022 was 358,500, accounting for 70% of the total number of deaths caused by global climate extremes. This indicates that a single high-intensity climate extreme has a significant impact on human lives. Analysis of the news reports on related disasters found that the large number of deaths due to extreme high temperatures in Europe is associated with the low air-conditioning penetration rate in Europe. According to the International Energy Agency (IEA), the air-conditioning penetration rate in Europe is only about 5%, compared to 90% in the United States, 89% in Japan, 6% in India, and 60% in China[12] .

358.5 thousand

the total number of deaths caused by the top ten climate extremes

Table 2 Top ten climate extremes in terms of global death toll from 2000 to 2022

Ranking	Time	Country	Type	Deaths (person)
1	2008.5.2-2008.5.3	Myanmar	Tropical cyclone	138,366
2	2010.6-2010.8	Russia	Extreme high temperature	55,736
3	2021.3-2022.12	Somalia	Extreme drought	43,000
4	2003-2004	Ethiopia	Extreme drought	30,000
5	2003.7.16-2003.8.15	Italy	Extreme high temperature	20,089
6	2010.2-2011.11	Somalia	Extreme drought	20,000
7	2003.8.1-2003.8.20	France	Extreme high temperature	19,490
8	2003.8.1-2003.8.11	Spain	Extreme high temperature	15,090
9	2003.8.1-2003.8.20	Germany	Extreme high temperature	9,355
10	2013.11.8-2013.11.8	The Philippines	Tropical cyclone	7,354

[12]Note:https://www.statista.com/statistics/721746/ac-demand-units-by-country-europe/

3.4 Comparison of losses from climate extremes

Table 3 lists the world's ten climate extremes with the maximum direct economic losses from 2000 to 2022. The extremes were mostly tropical cyclones, and mainly affected North America. Six of tropical cyclones affected the United States, namely Hurricane Katrina, Hurricane Harvey, Hurricane Ian, Hurricane Ida, Hurricane Irma and Hurricane Sandy, and they all took a heavy toll on economically developed coastal areas, thus causing significant direct economic losses. The total direct economic losses caused by the top ten climate extremes were USD 905.7 billion, accounting for 28%, or nearly one-third, of the global total direct economic losses from climate extremes.

$905.7 billion

Direct economic losses caused by the top ten climate extremes

Table 3 Top ten climate extremes in terms of global direct economic losses from 2000 to 2022

Ranking	Time	Country	Type	Direct economic losses (USD 0.1 billion)
1	2005.8.29-2005.9.19	The United States	Tropical cyclone	1,873
2	2017.8.25-2017.8.29	The United States	Tropical cyclone	1,134
3	2021.6.26-2021.7.1	Canada	Extreme high temperature	1,000
4	2022.9.28-2022.10.2	The United States	Tropical cyclone	1,000
5	2017.9.19-2017.9.21	Puerto Rico	Tropical cyclone	916
6	2017.9.10-2017.9.28	The United States	Tropical cyclone	842
7	2021.8.28-2021.9.2	The United States	Tropical cyclone	702
8	2012.10.28-2012.10.28	The United States	Tropical cyclone	637
9	2011.8.5-2012.1.4	Thailand	Extreme flood	520
10	2021.7.12-2021.7.15	Germany	Extreme flood	432

3.4.1 Comparison of climate extreme-related deaths between China and the rest of the world from 2000 to 2022

Figure 5 shows the annual average number of climate extreme-related deaths per million population in major countries and regions around the world from 2000 to 2022.

The annual average number of deaths per million population in China from 2000 to 2022 was 0.36; among all the 82 countries and regions where climate extremes were recorded, 50 countries and regions had a larger number of disaster-related deaths per million population than China, accounting for 60.98% of the total; when ranked from low to high in terms of the number of disaster-related deaths per million population, China was among the top 35.37% of the 82 countries and regions where climate extremes were recorded. Countries with a number of disaster-related deaths per million population similar to China included Italy (0.40 people), South Korea (0.34 people) and Egypt (0.32 people), etc.

In terms of the number of deaths per million population in relation to the level of economic development, China's annual average number of disaster-related deaths per million population was basically consistent with the level of its economic development from 2000 to 2022, and the country ranked at an upper-middle level in the global range (in ascending order). Among the countries with economic aggregates comparable to that of China, the United States (0.94) had a higher number of disaster-related deaths per million population than China, while Japan (0.30) had a lower number. Among the countries with per capita GDP equivalent to that of China, Thailand (0.57) had a higher number of disaster-related deaths per million population than China, while Romania (0.10) had a lower number.

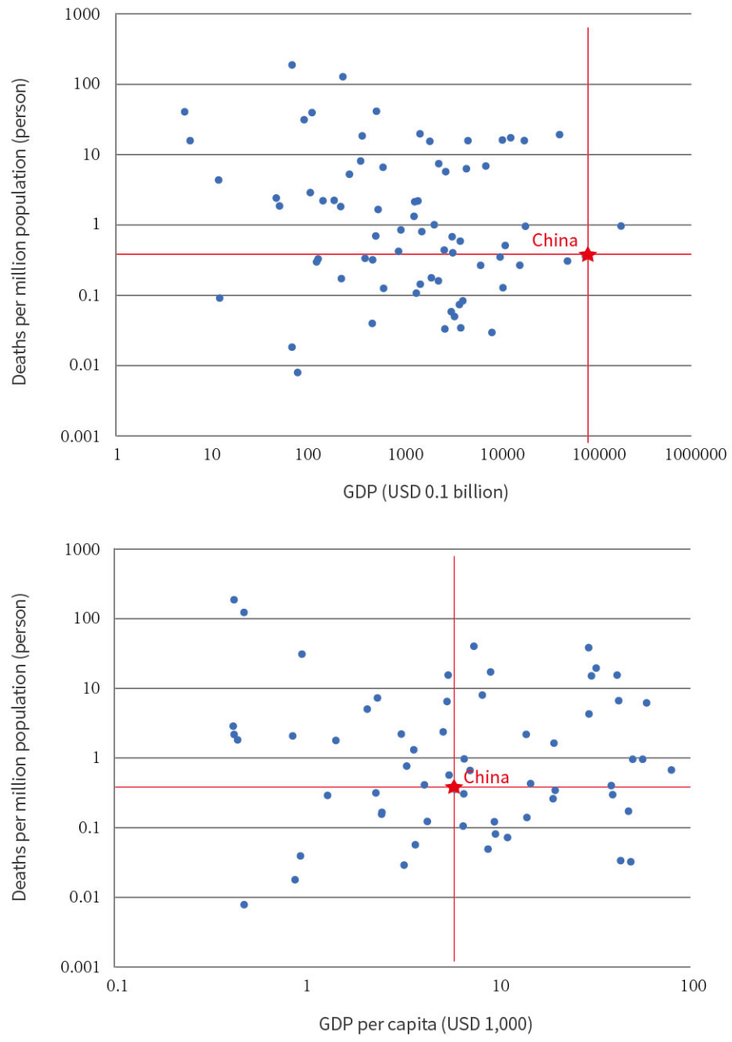


Figure 5 Comparison of annual average deaths caused by climate extremes between China and the rest of the world from 2000 to 2022

Note: Horizontal comparison between China and the other countries and regions in the world;

China ranked in the top 35.37% in terms of the annual average number of disaster-related deaths per million population in ascending order, which was in the upper-middle level;

China's total GDP ranked second; the per capita GDP ranked in the top 58% (in descending order), which was in the middle level;

The annual average number of disaster-related deaths per million population in China was basically consistent with the level of its economic development.

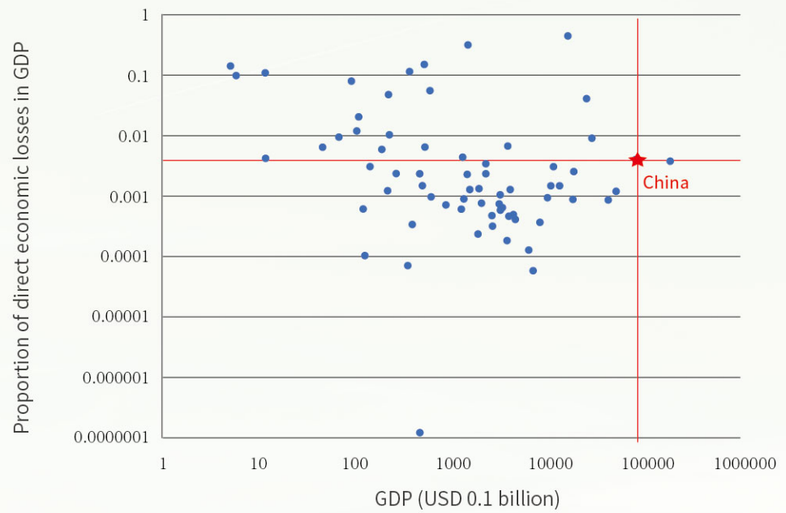
The annual average number of deaths per million population shown in the figure is calculated by dividing the number of deaths from disasters in 82 countries and regions around the world from 2000 to 2022 by the number of million population in the previous year and then averaging. The population data come from the World Bank (https://data.worldbank.org/), and the GDP data are from the GDP figures (in current USD) in 2022 released by the World Bank.

3.4.2 Comparison of direct economic losses from climate extremes between China and the rest of the world from 2000 to 2022

Figure 6 shows the annual average direct economic losses as a share of GDP in major countries and regions worldwide from 2000 to 2022.

From 2000 to 2022, China's annual average direct economic losses from climate extremes accounted for 0.39% of its GDP; among all the 82 countries and regions in the statistics, there were 27 countries and regions with a higher direct economic loss ratio than China, accounting for 32.93% of the total; when ranked by the proportion of average annual direct economic losses in GDP in ascending order, China was among the top 59.76% of the 82 countries and regions in the statistics. Countries with a proportion of direct economic losses from climate extremes similar to China included Uganda (0.42%), the United States (0.38%), etc.

In terms of the relationship between the proportion of direct economic losses in GDP and the level of economic development from 2000 to 2022, China's direct economic losses from climate extremes were roughly consistent with the level of its economic development, and China ranked in the middle position of the global range (in ascending order) in terms of the proportion of annual average direct economic losses in GDP. Among the countries with economic aggregates comparable to that of China, the United States (0.38%) had a share of average annual direct economic losses in GDP similar to China, while Japan (0.12%) had a lower share. Among countries with per capita GDP equivalent to that of China, Thailand (0.67%) had a higher share of average annual direct economic losses in GDP than China, while Romania (0.09%) had a lower share than China.



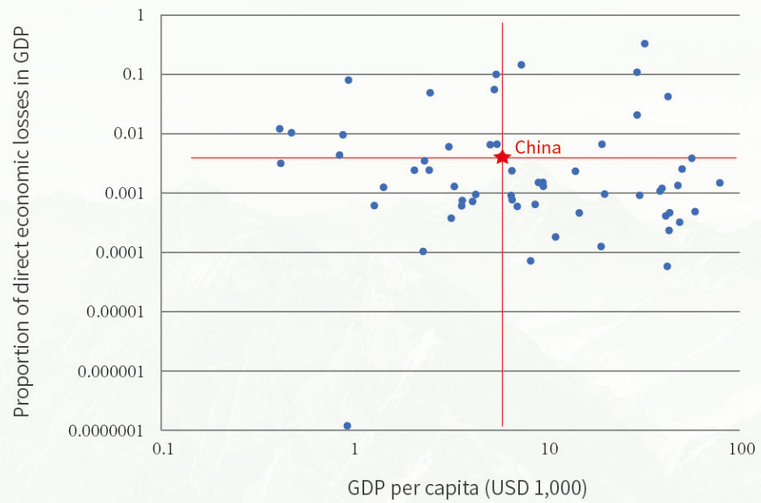


Figure 6 Comparison of annual average direct economic losses from climate extremes as a share of GDP between China and the rest of the world from 2000 to 2022

Note:

Horizontal comparison between China and the other countries and regions in the world;

China ranked in the top 59.76% in terms of the annual average direct economic losses as a share of GDP in ascending order, which was at the middle level;

China's total GDP ranked second; the per capita GDP ranked in the top 58% (in descending order), which was in the middle level;

China's proportion of annual average direct economic losses in GDP was basically consistent with the level of its economic development.

The proportion of annual average direct economic losses in GDP shown in the figure is calculated by dividing the direct economic losses from climate extremes in 82 countries and regions worldwide from 2000 to 2022 by the total GDP in the previous year and then averaging. The population data, GDP (in current USD) and GDP per capita (in current USD) come from the World Bank (https://data.worldbank.org/).

04

Special Report 3

Assessment on compound high temperature and drought disaster risks in Yangtze River basin in 2022 [13]

Global warming is increasing the frequency and intensity of high temperatures and heat waves. Since June 2022, many countries have witnessed record-high temperatures, and extensive and persistent high temperatures occurred in all the northwestern, southwestern, northern and southern parts of China. Taking into account the average intensity, range of impacts and duration of high temperature and heat wave events, the comprehensive intensity of regional high-temperature events in the Yangtze River basin has reached its highest level since 1961, when the complete meteorological observations were recorded. In the 21st century, the comprehensive risks of climate extremes in the Yangtze River basin have been increasing, and compound high temperature and drought events associated with extreme temperatures and extreme droughts frequently occur. Examples included many extreme high temperature and drought events in 2006, 2011, 2013 and 2019, which caused serious impacts on the local socio-economic situation. In 2022, the high temperature and drought in the Yangtze River basin generally showed a tendency to reoccur, with long duration, wide range of impacts, large intensity, and strong extremes.

4.1 Overall analysis of disaster characteristics

4.1.1 The extreme high temperature and unusually low rainfall in the summer in the Yangtze River basin provided a climatic background for the occurrence and development of droughts

From June to October, 2022, the numbers of days of high temperature (above 35℃) and drought exceeded 10 and 45 days, respectively, in the regions from the middle and lower reaches of the Yangtze River to Sichuan and Chongqing, both increasing from west to east. The regions from the west of Hubei to the east of Chongqing, and from the northwest of Hunan to the east of Jiangxi saw the overlapping of high frequencies of both high temperatures and droughts (Figure 1), and thus were heavily affected by the compound high temperatures and drought extremes. In terms of the evolution of the occurrence proportions of high temperatures and droughts over time, high temperatures and droughts occurred simultaneously in the upper, middle and lower reaches of the Yangtze River basin since June. In late June, the impacts of high temperatures and droughts began to expand rapidly, and both high temperatures and droughts were frequent in the upper and lower reaches. In early August, high temperatures in the whole basin widely persisted, and droughts developed rapidly to the peak, showing the most obvious characteristics of compound high temperature and drought events. In autumn, the high temperatures were eased significantly, while widespread droughts were still ongoing (Figure 2). In general, compound high temperature and drought events occurred periodically, and were in high frequency especially in the region from Sichuan and Chongqing to the middle and lower reaches of the Yangtze River.

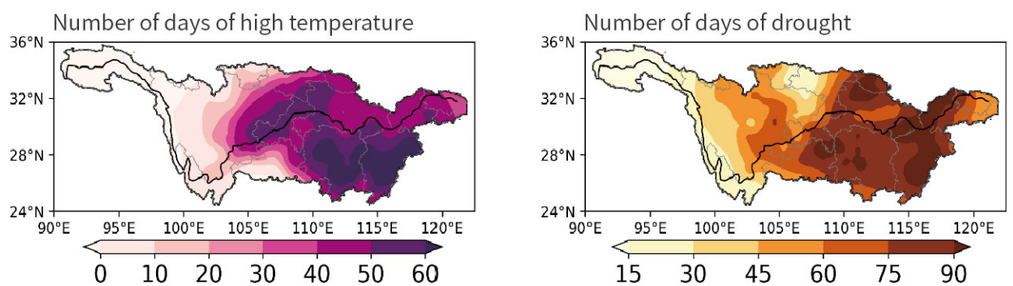


Figure 1 Distribution of days of high temperature and drought in the Yangtze River basin from June to October, 2022 (unit: day)

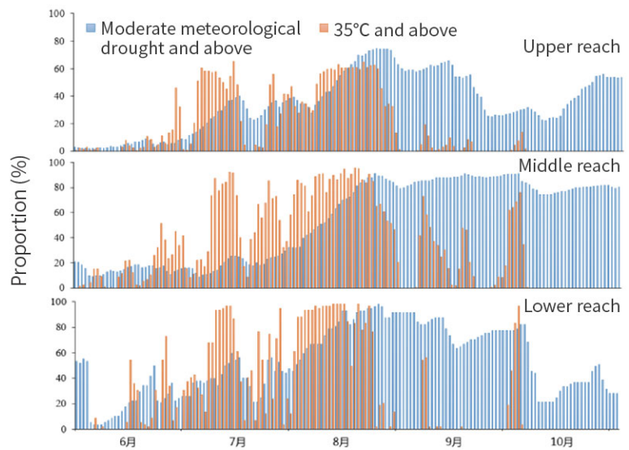


Figure 2 Day-to-day changes in the proportion of meteorological stations recording high temperatures and droughts in upper, middle and lower reaches of the Yangtze River basin in the total stations in the region from June to October, 2022 (unit: %)

[13]Note:The original report is provided by: National Climate Centre, China Meteorological Administration.

4.1.2 Evolution trend of compound high temperature and drought disasters in the Yangtze River basin from 1961 to 2022

Figure 3 shows the linear trend of the frequency, average intensity, and average duration of high temperatures, droughts and compound extremes in Yangtze River basin from June to October over the period of 1961-2022. The frequency of high temperatures was showing a significant increase at most stations throughout the basin. The frequency of droughts was showing an upward trend in the upper and middle reaches and a downward trend in the lower reach, with opposite trends distributed zonally, but there was no significant trend of change at most stations. The frequency of compound extremes was showing an overall increase, but only the south-central Sichuan basin, northern Yunnan and southeastern Jiangxi saw significant growth, and these regions were also the regions with a consistent increase in the above three categories of events.

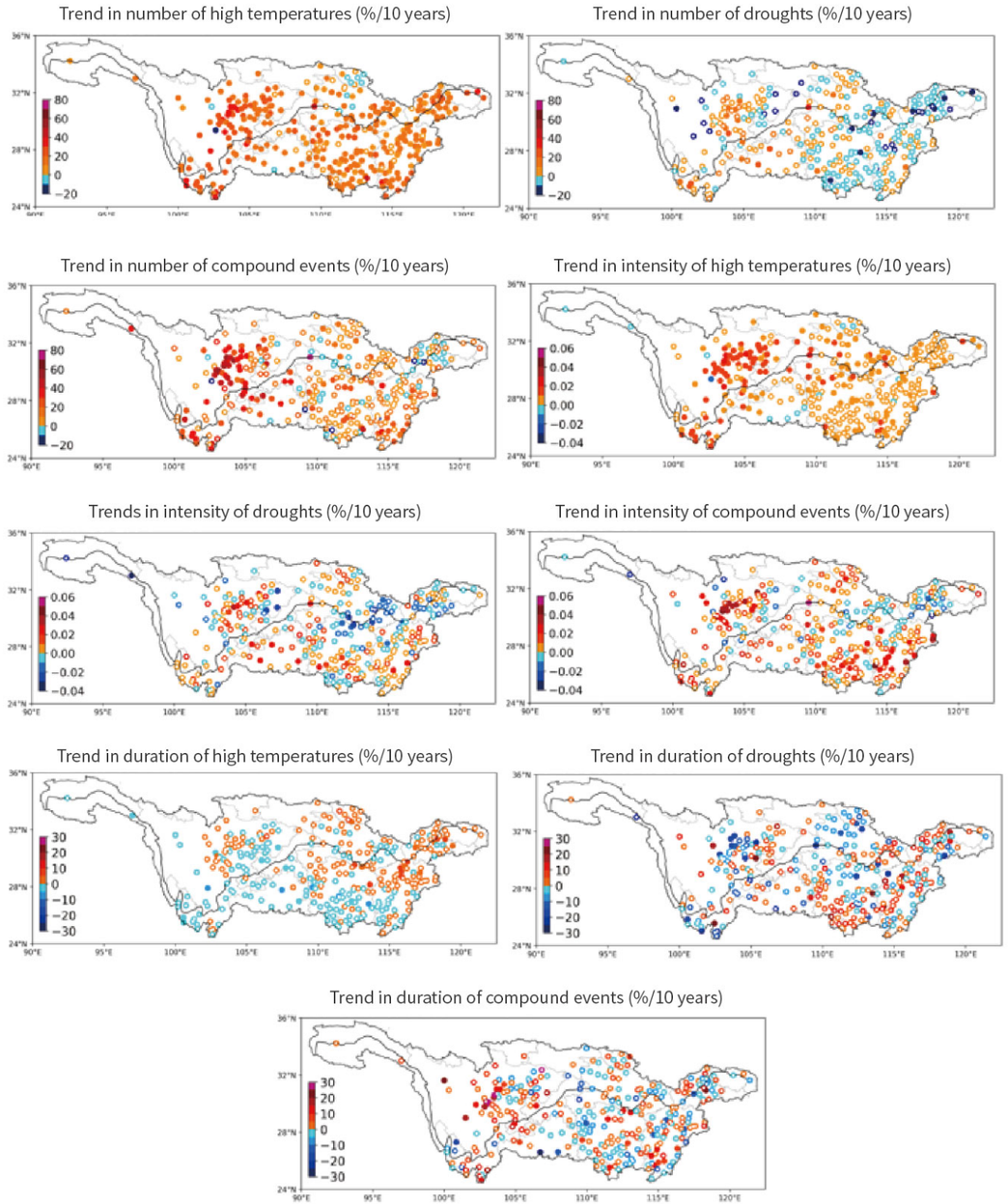


Figure 3 Relative trends of changes in frequency, average intensity and average duration of high temperatures, droughts and compound events in the Yangtze River basin from June to October, 1961-2022 [14]

[14]Note:Solid circles indicate being verified by the 90% significance test

Figure 4 shows the ratio of the trends of maximum intensity and maximum duration days of the three types of extremes to the trends of average intensity and average duration days in the Yangtze River basin, reflecting the relative trend of the extremes. Warm colors represent the same direction of the trend of maximum and that of average, and cold colors show the opposite. In terms of the trends of maximum intensity, in the downstream regions and the southeast of the basin, the trend of increase in the maximum intensity of high temperatures was 2-6 times the average intensity and up to 6-10 times in some areas. Compound extremes in the eastern part of the Sichuan basin, the southeastern part of the Yangtze River basin and parts of northern Yunnan were 2-3 times the average and as high as 3-5 times in some localities, indicating that the overall extremeness of high temperatures and compound extremes tend to be stronger. Droughts in the whole basin show the characteristic that the maximum intensity and average intensity change in the same direction.

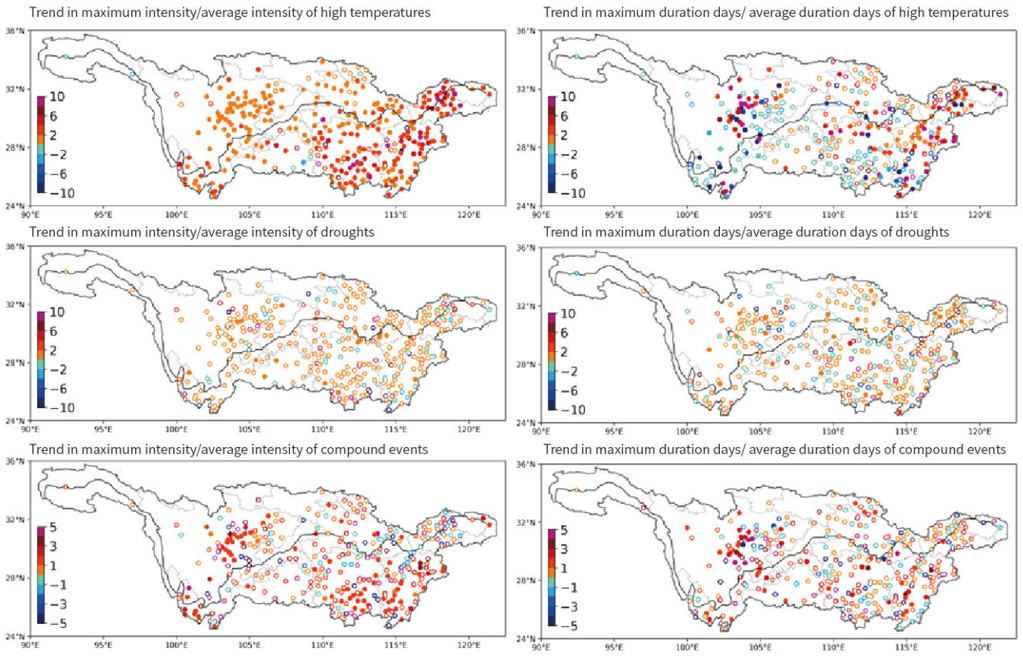


Figure 4 Ratio of the trends of maximum intensity (maximum duration days) of high temperatures, droughts and compound events to the trends of average intensity (average duration days) in the Yangtze River basin from June to October, 1961-2022 (Unit: /10 years) [15]

[15]Note:Solid circles indicate that the trend of maximum characteristics is verified by the 90% significance test

A compound event is the intersection of a high temperature event and a drought event, and its trend of changes is influenced by the changes in both the union and intersection of high temperatures and droughts. The total number of the three types of events and the share of compound events in the total at most stations simultaneously increased (Figure 5), indicating that the increase in compound events is faster than the increase in the total number of the three types of events. As the frequency of high temperatures showed an overall trend of significant increase, while droughts increased not significantly or decreased (Figure 3), the rapid increase in high temperature events contributed mainly to the increase in compound events, which is consistent with the previous study. Meanwhile, the compound events accounted for a lower proportion of high temperature events (Figure 5), suggesting that independent high temperature events other than compound events is increasing more rapidly; and compound events accounted for a significantly higher proportion of drought events, indicating that more and more drought events are associated with high temperatures, particularly in the upstream and downstream areas of the basin.

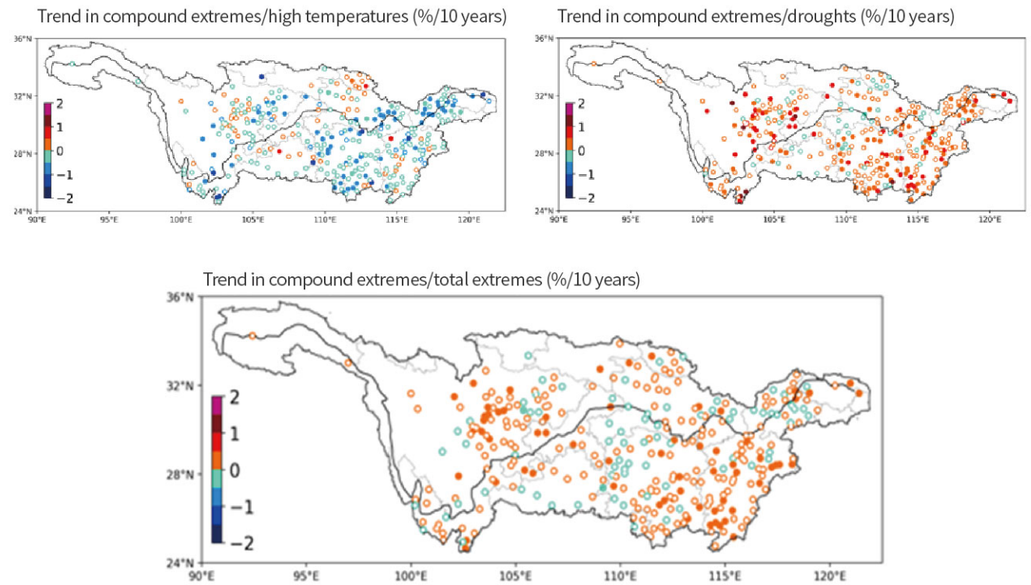


Figure 5 Trend of changes in the number of compound high temperature and drought extremes occurring in the Yangtze River basin as a share in the number of high temperatures, droughts, and total extremes from June to October, 1961-2022 (unit: %/10 years)[16]

[16]Note:Solid circles indicate being verified by the 90% significance test

4.2 Causes of compound high temperature and drought

4.2.1 The abnormal atmospheric circulation in the northern hemisphere at mid and high latitudes caused extreme high temperatures and extremely low precipitation, which triggered the development and intensification of sustained droughts in the Yangtze River basin, resulting in compound disasters

From July to September, 2022, subtropical high pressure was unusually strong, and was more west located, being temporarily integrated with Iranian high pressure. Therefore, the powerful subtropical high pressure entrenched in southern China for a long time, and under its control, the sky was clear with few clouds, and the solar radiation reaching the ground increased, which in turn caused a sharp rise in temperature in the ground. As a result, the record-breaking extreme high temperature event in the summer of 2022 continued into September. Almost in the same period, as the East Asian summer monsoon was strong, the main rain belt directly passed the Yangtze River basin and moved to North China in late June, and the Yangtze River basin continued to suffer from low rainfall from July to September, with 13.6 more days of no rainfall than usual, hitting a record high since 1961. In addition, only four typhoons made landfall in China in the first three quarters of 2022, 3.1 fewer than the same period of previous years, and except for Typhoon Chaba, the other three typhoons only affected part of coastal areas and typhoon precipitation did not deeply affect the inland areas. In summary, extreme high temperatures, which aggravated soil evaporation, insufficient rainfall replenishment, and a small impact of typhoons were the main causes of the extreme droughts in summer and autumn in the Yangtze River basin.

4.2.2 Both Arctic climate anomalies and changes in external forcing factors affected atmospheric circulation anomalies at mid and high latitudes

The emergence of continuous La Niña events and the constant cold sea temperature in the middle and east Pacific restrained the convection in some areas, and produced Rossby waves spreading toward the west, causing anomalous sinking movement and anticyclone in the northwest Pacific, which in turn led to anomalous subtropical high pressures in the region. The amplification effect of arctic warming was also a non-ignorable factor. In March 2022, the Arctic and the Antarctic witnessed record-high temperatures, with blocking high penetrated into high latitudes, leading warm air deep into the polar regions, therefore, the ground temperatures at medium and high latitudes constantly rose, the meridional temperature gradient was flattened, and the westerly wind was weakened with increasing volatility and amplitude. Therefore, it was easy to form a blocking situation, and in summer the mid-and high-latitude atmospheric circulation wave type was adjusted from 4 waves to 3 waves, thus forming a strong high-pressure belt around the northern hemisphere. Since the spring, the accumulated snow on the Qinghai-Tibet Plateau had melted relatively quickly, the plateau heat source had been strengthened, the high pressure in South Asia had been strengthened, and the increased differences in sea and land heat had been conducive to strong summer monsoon in east Asia. The eastern rain belt was more north located, and high temperatures and droughts occurred in the south. In addition, the negative phase of Pacific Decadal Oscillation (PDO) on the interdecadal scale provided a favorable interdecadal background for the hot and dry weather in the eastern and central parts of China in the summer of 2022.

4.2.3 Global warming has become a major background for the occurrence of compound high temperature and drought disasters

The IPCC AR6 shows that the global average surface temperature has increased by about 1°C compared to that before the industrial revolution, and the *Blue Book on Climate Change in China (2022)* shows that the trend of increase in average surface temperature in China (0.26°C) is higher than the global average, making China a climate-sensitive region in the context of global warming. Climate estimates show that the frequency, intensity and duration of high temperatures in China will further increase in the future. High temperature and heat waves have become a new normal, and as high temperatures increase evaporation, if superimposed against the background of low rainfall inter-annual changes, they may cause more serious droughts in summer and autumn.

4.3 Impacts of compound high temperature and drought

4.3.1 Agricultural production

The soil moisture state in most areas south of the Yangtze River was obviously poor. Droughts affected the growth of rice, corn, cotton, autumn harvesting crops, and cash forests and fruits and reduced their yield or put an end to their harvest. Sustained droughts were also not conducive to the timely autumn seeding of crops. During the drought peak in late August 2022, 66.32 million mu (about 4.42 million hectares) of crops in the Yangtze River basin were affected, and 810,000 people and 920,000 large livestock experienced a temporary shortage of drinking water due to drought[17] . In late October, 2022, 88 counties (cities and districts) in Jiangxi (95% of the total) recorded severe meteorological drought and above, and 49 counties (cities and districts) in Hunan experienced more than 30 consecutive days of extreme drought, which was not conducive to the planting of autumn sown crops such as oilseed rape and other vegetables and the growth of late rice and dryland crops in water-scarce areas.

66.32 million mu

Area of affected crops

[17]Note:https://www.hubei.gov.cn/hbfb/rdgz/202211/t20221124_4424706.shtml

4.3.2 Water resources development and utilization

The sustained high temperature and low rainfall caused increased evaporation, and decreased river water levels, and water shortage caused drought, resulting in a shortage of water for domestic use in some areas. Since July 2022, the droughts in the south had caused “low water level in flood season” , a rare phenomenon in the Yangtze River basin, which had a certain impact on the scheduling of reservoirs. The water volumes to the mainstream and tributaries of the Yangtze River were 20-80% less than the same period of previous years. The water volume to the upper and middle reaches was the lowest since 1949, the water to Three Gorges Reservoir was 40% less, and the water to major rivers in Sichuan Province was over 60% less than the same period in history. Many tributaries of Dongting Lake dried up, and Poyang Lake has set a record for a dry period and low-water dry period since 1951. High temperatures and droughts led to a shortage of water for domestic use and drinking water for livestock in some high-mountain areas of Shiyan, Shennongjia and Enshi, Hubei Province.

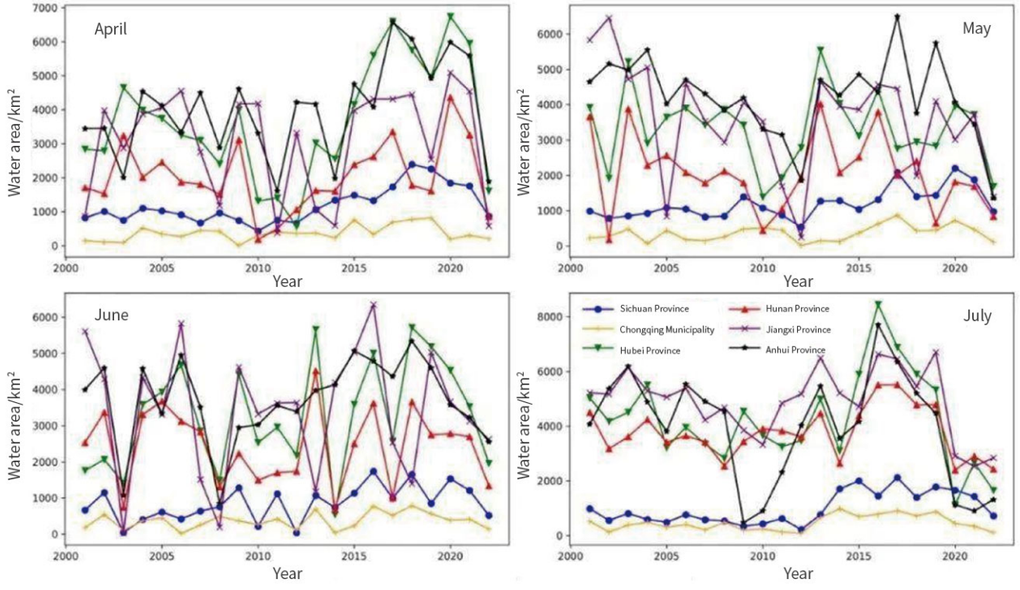


Figure 6 Water areas in six provinces (municipalities) in China from April to July, 2001-2022[18]

[17]Note:https://www.hubei.gov.cn/hbfb/rdgz/202211/t20221124_4424706.shtml

4.3.3 Electricity supply

High temperatures and droughts caused record-high electricity consumption, leading to a shortage of electricity supply. Power loads of 21 provincial power grids hit a record high. Power supply in the eastern and central parts of China faced a challenging situation, and relation between electricity supply and demand was strained in Zhejiang, Jiangsu, Anhui, Sichuan, Chongqing and Hubei, among other regions . Affected by the decline in hydropower and continued high temperatures, Sichuan and Chongqing experienced serious power gaps and extensive power curbs. The Yangtze River basin bore the heaviest electricity consumption loads in history. As a result of the droughts, the water supply for hydropower in Sichuan was over 50% less than usual, power from the natural water supply decreased by 50% over the same period in 2021, while the province's peak load of electricity demand soared to 65 million kW, an increase of 25% year-on-year, representing a serious imbalance in power supply and demand and a shortage of power supply. Sichuan Province initiated a first-level emergency response for emergency energy supply security.

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Power loads of provincial power grids hit a record high

4.3.4 Ecosystem conservation

High temperatures and droughts caused severe deficiencies of soil moisture and poor vegetation growth, with negative impacts on ecosystems. According to meteorological satellite data monitoring, in mid-September, vegetation growth was poor in the south of the Huanghuai region, Jianghan region, central and western parts in the south of the Yangtze River and most parts of the southwestern region. In Dongting Lake, Poyang Lake, Yangtze River and other lakes and rivers, water levels and areas were drastically reduced, and a large number of wild fish were stranded. Fish also died from high water temperatures. High temperatures and droughts led to a high forest fire risk rating in some areas of the Yangtze River basin, and many forest fires occurred in Sichuan, Chongqing, Guizhou, and Jiangxi.

Negative impacts on ecosystems

[19]Note:http://lwzb.stats.gov.cn/pub/lwzb/fbjd/202306/W020230605420997463323.pdf

4.3.5 Affected population

Due to the prolonged high temperatures and droughts, many people were diagnosed with thermoplegia and more people were in shortage of drinking water in Zhejiang, Jiangsu, Sichuan and other regions. At the peak of the drought, a total of 52.452 million people were affected nationwide, and 7.585 million people were in need of assistance due to the drought, 6,090.2 thousand hectares of crops were affected and direct economic losses reached CNY 51.28 billion.[20] As of the end of October 2022, 1.3276 million people were in need of assistance due to droughts in Hunan Province, of whom 636,100 needed relief from a shortage of drinking water, and the figures in Jiangxi Province were 407,000 (distributed in 86 counties and districts) and 19,000 respectively.

[20]Note:https://www.mem.gov.cn/xw/yjglbgzdt/202301/t20230113_440478.shtml

4.4 Conclusion

From June to October, 2022, the frequency, intensity, maximum intensity and maximum duration of high-intensity and persistent high temperatures, droughts and compound events throughout the Yangtze River basin were significantly greater (stronger). Overall assessment found that the eastern part of the Sichuan basin and the areas along and to the south of the middle and lower reaches of the mainstream of Yangtze River were the areas suffering the greatest relative impacts of the compound high temperature and drought events in 2022.

From 1961 to 2022, the trends of high temperatures, droughts and their compound events varied considerably in different regions of the Yangtze River, but the combined risks of high temperatures and droughts have increased significantly in the eastern part of the Sichuan basin and the areas to the south of the lower reaches of the Yangtze River. Although the risks of drought around the middle and lower reaches of the mainstream are lower, the risk of drought in these areas is still likely to be exacerbated by the combined effect of increased duration of the compound events in some localities and increased risks of the compound events at upstream. The southeast of the basin is the region where the extremeness of intensity and duration of high temperatures and compound extremes has been obviously increased, fully demonstrating the characteristic that extremes will become more extreme in the context of climate warming. In the upper and lower reaches, the increase in high-temperature events is the main cause of the increase in compound events, and an increasing number of drought events are associated with high temperatures. In the upper and middle reaches, the number of years, when the intensity of high temperatures contributed primarily to the intensity of compound events, has significantly increased since the late 1990s.

In terms of combined risks, concurrent intense high-temperature events throughout the basis occurred for many years, and severe droughts has often evolved in two of the upper, middle and lower reaches. Historically, compound high temperature and drought events with high risks affecting the whole Yangtze River basin occurred from June to October in 2006, 2013, 2019 and 2022, and all of them seriously affected agricultural production, water supply, energy supply, ecosystem balance and human health. It is needed to strengthen capacity building for assessment and early warning of risks of high temperatures, droughts and other disasters, carry out more intensive research in compound disaster risks and improve multidisciplinary and multisectoral data collection and sharing.

Appendix

Top 50 natural disasters worldwide in terms of death toll and direct economic losses from 1991 to 2022

Top 50 natural disasters worldwide by death toll, 1991-2022

No.	Time	Countries or regions affected	Type of disaster	Deaths (person)	Direct economic losses (USD 0.1 billion, current year prices)
1	2010/1/12	Haiti	Earthquake	222,570	80
2	2004/12/26	Indonesia	Earthquake	165,708	44.516
3	1991/4/29-5/10	Bangladesh	Storm	138,866	17.8
4	2008/5/2-3	Myanmar	Storm	138,366	40
5	2008/5/12	China	Earthquake	87,476	850
6	2005/10/8	Pakistan	Earthquake	73,338	52
7	2010/6/-2010/8/	Russia	Extreme high temperature	55,736	4
8	2004/12/26	Sri Lanka	Earthquake	35,399	13.165
9	1999/12/15-12/20	Venezuela	Flood	30,000	31.6
10	2003/12/26	Iran	Earthquake	26,796	5
11	2003/7/16-8/15	Italy	Extreme high temperature	20,089	44
12	2001/1/26	India	Earthquake	20,005	26.23
13	2010/2/-2011/11/	Somalia	Drought	20,000	0
14	2011/3/11	Japan	Earthquake	19,846	2,100
15	2003/8/1-8/20	France	Extreme high temperature	19,490	44
16	1999/8/17	Turkey	Earthquake	17,127	200
17	2004/12/26	India	Earthquake	16,389	10.228
18	2022/6/1-8/22	Germany, Spain, France, United Kingdom, Portugal	Extreme high temperature	16,305	0
19	2003/8/1-8/11	Spain	Extreme high temperature	15,090	8.8
20	1998/10/25-11/8	Honduras	Storm	14,600	37.936
21	1999/10/28-10/30	India	Storm	9,843	25
22	1993/9/29	India	Earthquake	9,748	2.8
23	2003/8/-2003/8/	Germany	Extreme high temperature	9,355	16.5
24	2015/4/25	Nepal	Earthquake	8,831	51.74
25	2004/12/26	Thailand	Earthquake	8,345	10
26	2013/11/8	The Philippines	Storm	7,354	100
27	2013/6/12-6/27	India	Flood	6,054	11
28	1991/11/5-11/8	The Philippines	Storm	5,956	1
29	2006/5/26	Indonesia	Earthquake	5,778	31
30	1995/1/17	Japan	Earthquake	5,297	1,000
31	1998/5/30	Afghanistan	Earthquake	4,700	0.1
32	2018/9/28	Indonesia	Earthquake	4,340	14.5
33	2007/11/15-11/19	Bangladesh	Storm	4,234	23
34	1997/11/2-11/4	Vietnam	Storm	3,682	4.7
35	1998/7/1-8/30	China	Flood	3,656	300
36	1998/10/25-11/8	Nicaragua	Storm	3,332	9.877
37	2015/6/29-8/9	France	Extreme high temperature	3,275	0
38	2010/4/14	China	Earthquake	2,968	5
39	1998/6/9-6/11	India	Storm	2,871	4.69
40	1996/6/30-7/26	China	Flood	2,775	126
41	2004/9/17-9/18	Haiti	Storm	2,754	0.5
42	2003/8/-2003/8/	Portugal	Extreme high temperature	2,696	0
43	2004/5/23-6/1	Haiti	Flood	2,665	0
44	2021/8/14	Haiti	Earthquake	2,575	16.2
45	2020/6- 2020/8	The United Kingdom	Extreme high temperature	2,556	0
46	1998/5/26	India	Extreme high temperature	2,541	0
47	1992/12/12	Indonesia	Earthquake	2,500	1
48	2022/7/-12/	Uganda	Drought	2,465	0
49	1998/2/4	Afghanistan	Earthquake	2,323	0.1
50	1997/10/19-11/17	Somalia	Flood	2,311	0

Appendix

Top 50 natural disasters worldwide in terms of death toll and direct economic losses from 1991 to 2022

Top 50 natural disasters worldwide by direct economic losses, 1991-2022

No.	Time	Countries or regions affected	Type of disaster	Direct economic losses (USD 0.1 billion, current year prices)	Deaths (person)
1	2011/3/11	Japan	Earthquake	2,100	19,846
2	2005/8/29-9/19	The United States	Storm	1,250	1,833
3	1995/1/17	Japan	Earthquake	1,000	5,297
4	2022/9/26-10/2	Cuba, the United States	Storm	1,000	155
5	2017/8/25-8/29	The United States	Storm	950	88
6	2008/5/12	China	Earthquake	850	87,476
7	2017/9/20	Puerto Rico	Storm	680	64
8	2021/8/28-9/2	The United States	Storm	651	96
9	2017/9/10-9/28	The United States	Storm	570	58
10	2012/10/28	The United States	Storm	500	54
11	2021/7/12-7/15	Germany	Flood	417	242
12	2011/8/5-2012/1/4	Thailand	Flood	400	813
13	1998/7/1-8/30	China	Flood	300	3,656
13	2010/2/27	Chile	Earthquake	300	562
13	2021/2/10-2021/2/20	The United States	Storm	300	235
13	2008/9/12-9/16	The United States	Storm	300	82
13	1994/1/17	The United States	Earthquake	300	60
18	2004/10/23	Japan	Earthquake	280	40
19	1992/8/24	The United States	Storm	265	44
20	2019/10/10-10/17	The United States	Wildfire	250	3
21	2016/6/28-7/13	China	Flood	220	289

Top 50 natural disasters worldwide by direct economic losses, 1991-2022

No.	Time	Countries or regions affected	Type of disaster	Direct economic losses (USD 0.1 billion, current year prices)	Deaths (person)
21	2022/1/-12/	The United States	Drought	220	136
23	2008/1/10-2/5	China	Extreme low temperature	211	129
24	1999/8/17	Turkey	Earthquake	200	17,127
24	2016/4/16	Japan	Earthquake	200	49
24	2012/6/-2012/12/	The United States	Drought	200	0
27	2010/5/29-8/31	China	Flood	180	1691
27	2004/9/15-9/16	The United States	Storm	180	52
29	2019/10/12-10/17	Japan	Storm	170	99
29	2020/5/21-7/30	China	Flood	170	280
31	2021/6/1-2021/8/30	China	Flood	165	352
31	2018/11/8-11/16	The United States	Wildfire	165	88
33	2014/9/	India	Flood	160	298
33	2018/10/10-10/11	The United States	Storm	160	45
33	2005/9/23-10/1	The United States	Storm	160	10
33	2004/8/13	The United States	Storm	160	10
37	2012/5/20	Italy	Earthquake	158	7
38	2011/2/22	New Zealand	Earthquake	150	181
38	1995/8/1-9/8	South Korea	Flood	150	68
38	2022/6/14-9/14	Pakistan	Flood	150	1,739
41	2005/10/24	The United States	Storm	143	4
42	1999/9/21	China	Earthquake	141	2,264
43	2011/5/20-5/25	The United States	Storm	140	176
43	2018/9/12-9/18	The United States	Storm	140	53
45	1994/1/-1994/12/	China	Drought	138	0
46	2020/5/20	India	Storm	135	90
47	2020/8/27-8/28	The United States	Storm	130	33
47	2017/10/8-10/20	The United States	Wildfire	130	30
47	2020/8/16-10/1	The United States	Wildfire	130	31
50	2013/5/28-6/18	Germany	Flood	129	4

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