GLOBAL NATURAL DISASTER ASSESSMENT REPORT

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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 (1991-2020), the total frequency of global natural disasters in 2021 was 13% higher, with 81% lower in deaths, 48% less in the affected population, and 82% more in direct economic losses. Global flood disasters in 2021 were the most frequent, 48% more than the historic levels, causing 4,393 deaths, which was more than the death toll from other natural disasters but 35% less than the historical average of flood-related deaths; the direct economic losses caused by storm disasters were the largest, reaching USD 137.7 billion, 133% more than the historical average; there were fewer strong earthquakes and their disaster losses were relatively small; the number of deaths from wildfires decreased, but the population affected rose by 219% and the direct economic losses were 109% higher than the historic levels. Regionally, Asia has seen the highest frequency of natural disasters in 2021, followed by North America; among all continents, Asia had the largest number of deaths due to disasters, followed by North America; North America has seen the highest economic losses due to disasters, followed by Europe; compared with developed countries, developing countries were more severely affected by natural disasters, mostly floods, storms, and extreme temperatures.

In 2021, deaths from natural disasters in China were at an above-average level in the world, basically consistent with the level of its economic development; the proportion of direct economic losses in GDP was at a lower-middle level, which was largely consistent with the level of its economic development. The flood losses in China were higher than those from other disasters and accounted for a large proportion of the global flood losses.

In 2021, China faced a complicated natural disaster situation , with extreme weather and climate events occurring frequently. The natural disasters mainly included flood, strong wind and hail, drought, typhoon, earthquake, geological disasters and cold wave, while sand and dust storm, forest and grassland fires and marine disasters also hit to varying degrees. On the whole, however, natural disaster situation in China was relatively moderate.

The report analyzes the characteristics of global extreme weather disasters from 2000 to 2021. During this period, annual direct economic losses from extreme disasters in Asia, America, Europe and Africa showed an increasing trend. The frequency of such disasters was far higher in Asia than on other continents, and the total losses in Asia from 2011 to 2021 were twice those of Asia from 2000 to 2010. The report also summarizes the characteristics of global climate, and the major weather and climate events in 2021, coupled with an analysis of the causes of typical major weather and climate events, including rainstorm-induced flood, drought, tropical cyclone, heat wave and wildfire, cold wave and severe convection. The report calls for greater world attention to tackling increasingly frequent extreme weather and climate events, and boosting collaborative research toward that end.

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01

General Report

Global natural disaster profile for 2021

1. Overview of global natural disasters in 2021
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General Report

Global natural disaster profile for 2021

1 Overview of global natural disasters in 2021

A total of 367 major natural disasters (excluding epidemic diseases) occurred worldwide in 2021, affecting 127 countries and regions. Among all these disasters, 206 were caused by floods, with the highest frequency, accounting for 56.13% of the total; 82 caused by storms (typhoons, hurricanes), accounting for 22.34%; 25 by earthquakes, accounting for 6.81%; 19 by wildfires, accounting for 5.18%; 13 by droughts, accounting for 3.54%; 11 by landslides, accounting for 3%; 8 by volcanic eruptions, accounting for 2.18%; and 3 by extreme temperatures, accounting for 0.82% (Table 1 and Figure 1).

Table 1 The Frequency and losses of natural disasters worldwide in 2021

Type of disaster	Frequency (time)/%	Deaths (persons)/%	Population affected (ten thousand)/%	Direct economic losses (USD 0.1 billion)/%
Flood	206/56.13	4393/41.87	2919.81/28.03	746.07/29.59
Storm	82/22.34	1876/17.88	1761.45/16.91	1376.76/54.60
Earthquake	25/6.81	2742/26.13	109.13/1.05	113.06/4.48
Wildfire	19/5.18	128/1.22	71.77/0.69	92.54/3.67
Drought	13/3.54	0/0	5504.67/52.84	121.00/4.80
Landslide	11/3.00	224/2.13	0.56/0.01	2.50/0.10
Volcanic eruption	8/2.18	85/0.81	49.37/0.47	13.45/0.53
Extreme temperature	3/0.82	1044/9.95	0/0	56.00/2.22
Total	367/100	10492/100	10416.76/100	2521.38/100

(Note: The global natural disaster data come from the EM-DAT of the Université catholique de Louvain (UCLouvain), Belgium; the time period is from January 1, 2021 to December 31, 2021, the same hereinafter.)

A total of 10,492 people were killed by natural disasters worldwide in 2021. Floods caused the largest number of deaths, reaching 4,393 people and accounting for 41.87%; followed by earthquakes with 2,742 deaths, accounting for 26.13%; storms with 1,876 deaths, accounting for 17.88%; extreme temperatures with 1,044 deaths, accounting for 9.95%; landslides with 224 deaths, accounting for 2.13%; wildfires with 128 deaths, accounting for 1.22%; and volcanic eruptions with 85 deaths, accounting for 0.81%.

A total of 104.1676 million people were affected by natural disasters globally in 2021, of whom 52.84% were affected by droughts, reaching 55.0467 million people, accounting for the largest proportion of the total; 28.03% by floods, reaching 29.1981 million people; 16.91% by storms, reaching 17.6145 million people; 1.05% by earthquakes, reaching 1.0913 million people; 0.69% by wildfires, reaching 0.7177 million people; 0.47% by volcanic eruptions, reaching 0.4937 million people; and 0.01% by landslides, reaching 5,600 people.

A total of USD 252.138 billion in direct economic losses were caused by natural disasters worldwide in 2021, of which 54.60% were caused by storms, reaching USD 137.676 billion, accounting for the most portion of the total amount; 29.59% were caused by floods, reaching USD 74.607 billion; 4.80% by droughts, reaching USD 12.1 billion; 4.48% by earthquakes, reaching USD 11.306 billion; 3.67% caused by wildfires, reaching USD 9.254 billion; 2.22% by extreme temperatures, reaching USD 5.6 billion; 0.53% by volcanic eruptions, reaching USD 1.345 billion; and 0.1% by landslides, reaching USD 250 million.

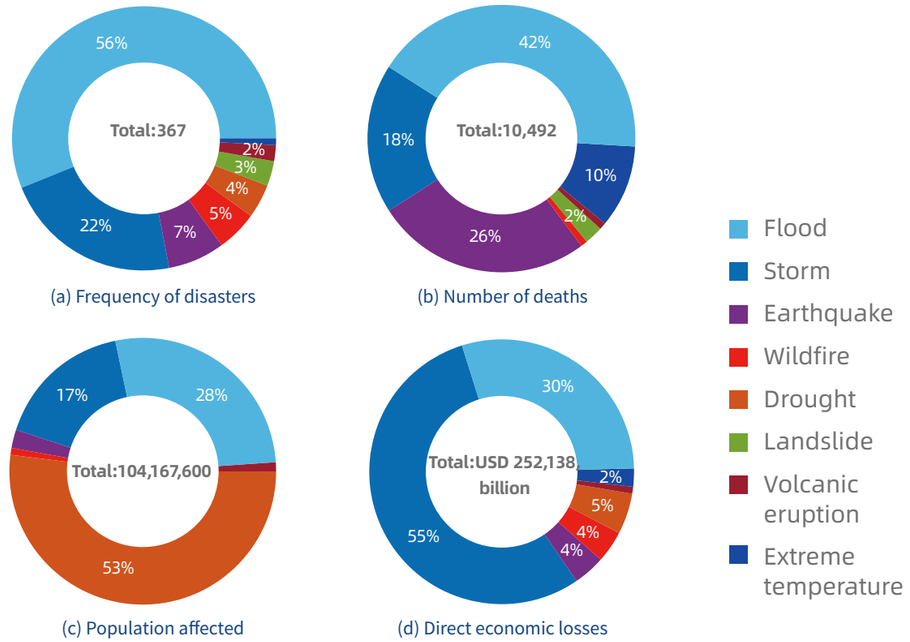


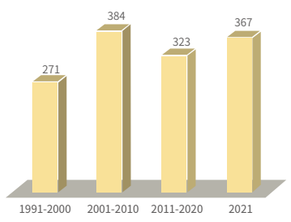
Figure 1 Breakdown of frequency and losses per disaster type worldwide in 2021

2 Characteristics of global natural disasters in 2021

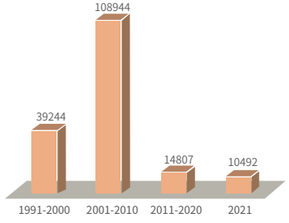
2.1 The overall economic losses from natural disasters were large, but the number of deaths and affected people decreased

In 2021, a total of 367 major natural disasters occurred worldwide, killing 10,492 people, affecting 104.1676 million people, and causing direct economic losses of USD 252.138 billion. Compared with the average for the last 30 years (1991-2020), the frequency of major natural disasters was 13% more in 2021, the death toll was 81% less, the affected population was 48% less, and the direct economic loss was 82% higher. Compared with the average for the last 10 years (2011-2020), the frequency of major natural disasters was 14% more in 2021, the number of deaths was 29% less, the number of affected people was 32% less, and the direct economic loss was 41% more (Figure 2).

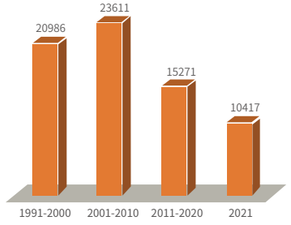
Although the year 2021 witnessed several catastrophic natural disasters, they were generally less severe than those in the last 10 years and 30 years, which is the main reason for the overall low level of natural disasters in 2021. There were two natural disasters with more than 1,000 deaths caused each time globally in 2021, which was lower than the annual average for the last 30 years, and there were no natural disasters with more than 10,000 deaths (while 19 such natural disasters were recorded in the last 30 years). In 2021, there were four 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 there was only one disaster that caused direct economic losses exceeding USD 50 billion. There were nine disasters with direct economic losses exceeding USD 50 billion at a time in the last 30 years, three of which caused losses valued at over USD 100 billion.



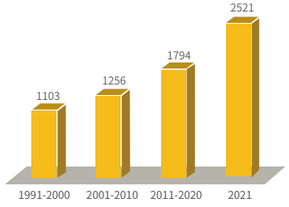
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand)



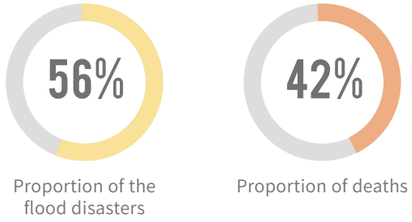
(d) Direct economic loss (unit: USD 0.1 billion)

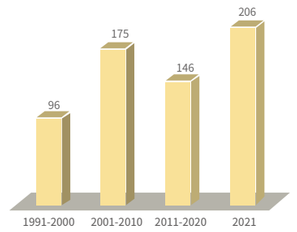
Figure 2 Global average annual natural disaster losses, 1991-2020 vs. 2021

(Note: The direct economic losses from 1991 to 2020 are measured at the price level of 2020, and those of 2021 are measured at the price level of the current year)

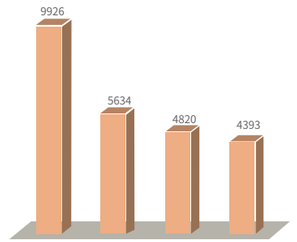
2.2 Flood disasters were the most frequent, resulting in large direct economic losses and many deaths

There were 206 major flood disasters in 2021, accounting for more than 56% of the total number of major natural disasters of the year; 4,393 deaths were caused by flood disasters, accounting for about 42% of the total deaths; some 29.2 million people were affected, accounting for 28%, a decrease from 33.21 million in 2020; the direct economic losses exceeded USD 74.6 billion, accounting for about 30% of the total direct disaster economic losses. Compared with the average for the last 30 years (1991-2020), the frequency of flood disasters increased by 48% in 2021, the number of deaths from flood disasters was 35% less, the number of affected people was 71% less, and the direct economic losses were 118% more. Compared with the average for the last 10 years (2011-2020), the frequency of flood disasters increased by 41% in 2021, and the number of deaths from flood disasters was 9% less, the number of affected people was 43% less, and the direct economic losses were 79% more (Figure 3). There was only one flood disaster with more than 1,000 deaths in 2021. India and some other Asian countries suffered from severe floods, with thousands of lives lost in floods or heavy rains during the monsoon period.

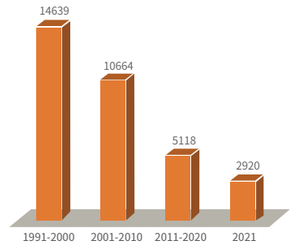




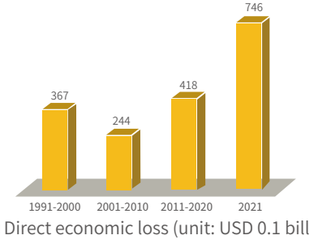
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand)

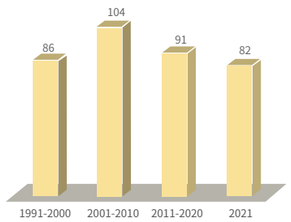


(d) Direct economic loss (unit: USD 0.1 billion)

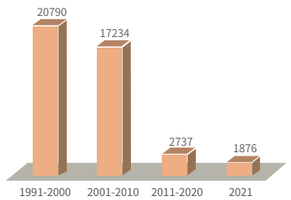
Figure 3 Global average annual flood disaster losses, 1991-2020 vs. 2021

(Note: The direct economic losses from 1991 to 2020 are measured at the price level of 2020, and those of 2021 are measured at the price level of the current year)

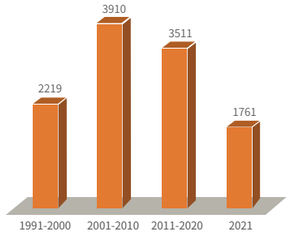
2.3 Storm disasters resulted in large direct economic losses, with a greater affected population



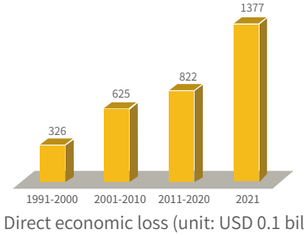
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand)



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

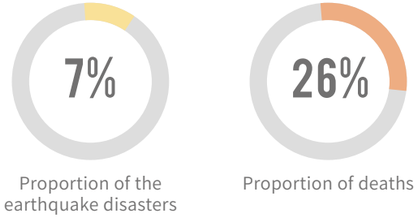
There were 82 major storm disasters in 2021, accounting for over 22% of the total number of major natural disasters; storm disasters caused 1,876 deaths (about 18%) and affected over 17.61 million people (around 17%); the direct economic losses amounted to USD 137.7 billion, accounting for about 55%. Compared with the average for the last 30 years (1991-2020), the frequency of storm disasters was 13% less in 2021, the number of deaths was 86% less, the affected population was 45% less, and the direct economic losses were 133% higher. Compared with the average for the last 10 years (2011-2020), the frequency of storm disasters was 10% less in 2021, the number of deaths was 31% less, the affected population reduced by 50%, and the direct economic losses were 68% higher (Figure 4).

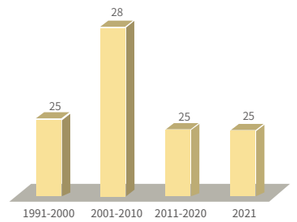
Figure 4 Global average annual storm disaster losses, 1991-2020 vs. 2021

(Note: The direct economic losses from 1991 to 2020 are measured at the price level of 2020, and those of 2021 are measured at the price level of the current year)

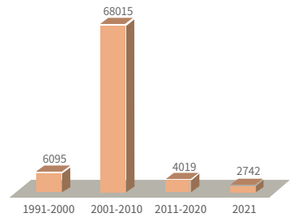
2.4 Weaker seismic activities and smaller earthquake disaster losses

There were 25 major earthquake disasters worldwide in 2021, accounting for about 7% of the total major natural disasters; these earthquakes caused 2,742 deaths (approximately 26%); less than 1% of the people were affected by earthquakes; and the direct economic losses accounted for more than 4% of the total amount. Compared with the average for the last 30 years (1991-2020), the frequency of earthquake disasters reduced by 5% in 2021, the number of deaths was 89% less, the number of affected people was 77% less, and the direct economic losses were 64% lower. Compared with the average for the last 10 years (2011-2020), the frequency of earthquake disasters was 1% lower in 2021, the number of deaths was 32% less, the number of affected people was 61% less, and the direct economic losses were 70% fewer (Figure 5). The magnitude-7.0 earthquake in Haiti was the deadliest disaster in 2021, killing 2,575 people. There were no earthquakes of magnitude 8.0 or above, and no secondary disasters caused by earthquakes, such as large-scale tsunamis, occurred, which was also one of the important reasons for the relatively small losses from earthquakes in 2021.

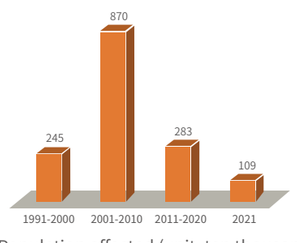




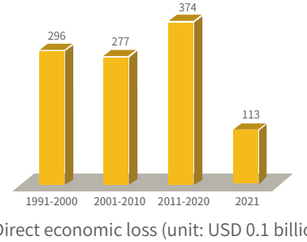
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand)

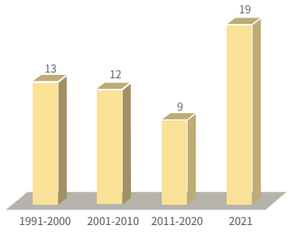


(d) Direct economic loss (unit: USD 0.1 billion)

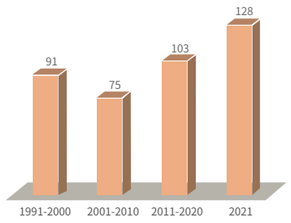
Figure 5 Global average annual earthquake disaster losses, 1991-2020 vs. 2021

(Note: The direct economic losses from 1991 to 2020 are measured at the price level of 2020, and those of 2021 are measured at the price level of the current year)

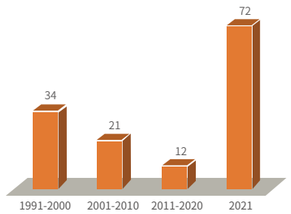
2.5 Wildfire disasters were more frequent and affected more people



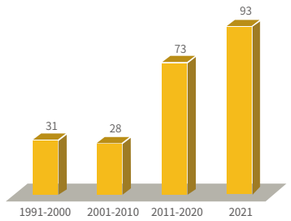
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand)



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

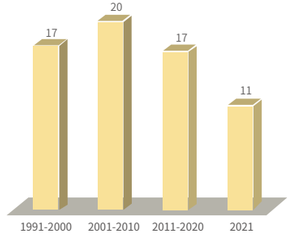
Figure 6 Global average annual wildfire disaster losses, 1991-2020 vs. 2021

(Note: The direct economic losses from 1991 to 2020 are measured at the price level of 2020, and those of 2021 are measured at the price level of the current year)

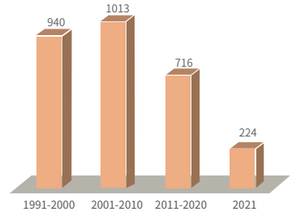
There were 19 wildfire disasters (including 9 forest fires) that caused large losses in 2021, which was higher than the level of recent years (an average of 11 times a year for the last 30 years and an average of 9 times a year for the last 10 years). Compared with the average for the last 30 years (1991-2020), the number of deaths from wildfire disasters worldwide was 43% more in 2021, the number of affected people was 219% more, and the direct economic losses increased by 109%. Compared with the average for the last 10 years (2011-2020), the deaths from wildfire disasters worldwide increased by 24% in 2021, the affected population rose sharply by 499%, and the direct economic losses grew by 26% (Figure 6). The direct economic losses caused by forest fires were about USD 5.4 billion, accounting for 58% of the total losses from wildfire disasters, and the number of deaths was 34, accounting for about 27% of the total. On July 28, 2021, wildfire disasters occurred in four places of Manavgat in Antalya, Turkey, which affected over 560,000 people. As a result, the population affected by wildfire disasters in 2021 was more than the annual averages for the last 30 years and the last 10 years respectively.

2.6 Landslide disasters became less frequent and caused fewer deaths

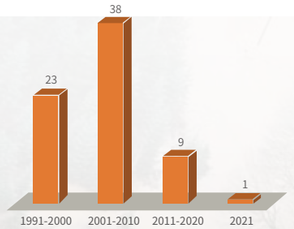
A total of 11 major landslide disasters occurred in 2021, accounting for about 3% of the total major natural disasters. Compared with the average for the last 30 years (1991-2020), the frequency of landslide disasters was 38% less in 2021, the number of deaths from landslide disasters was 75% less, the number of affected people was 98% less, and the direct economic losses were 30% fewer. Compared with the average for the last 10 years (2011-2020), the frequency of landslide disasters was 34% less in 2021, the number of deaths was 69% less, the number of affected people was 94% less, while the direct economic losses were almost the same (Figure 7).



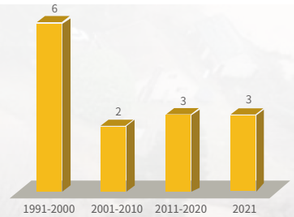
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand)

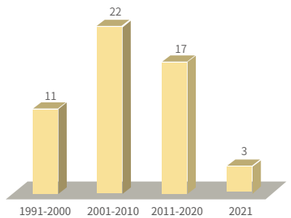


(d) Direct economic loss (unit: USD 0.1 billion)

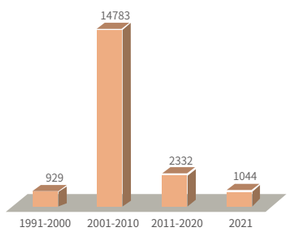
Figure 7 Global average annual landslide disaster losses, 1991-2020 vs. 2021

(Note: The direct economic losses from 1991 to 2020 are measured at the price level of 2020, and those of 2021 are measured at the price level of the current year)

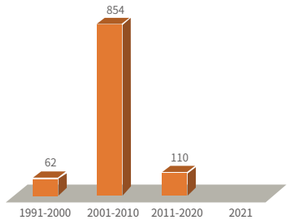
2.7 Extreme temperatures became less frequent but caused more direct economic losses



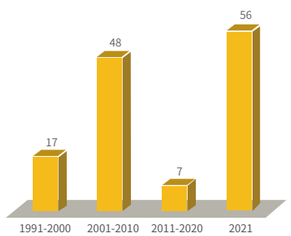
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand)



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

Figure 8 Global average annual extreme temperature losses, 1991-2020 vs. 2021

(Note: The direct economic losses from 1991 to 2020 are measured at the price level of 2020, and those of 2021 are measured at the price level of the current year, no data on affected people)

A total of three extreme temperature events (including two extreme high temperature events and one extreme low temperature event) occurred in 2021, accounting for about 1% of the total major natural disasters. Compared with the average for the last 30 years (1991-2020), the frequency of global extreme temperatures was 82% less in 2021, the number of deaths was 83% less, but the direct economic losses increased by131%. Compared with the average for the last 10 years (2011-2020), the frequency of global extreme temperatures was 82% less in 2021, the death toll was 55% less, but the direct economic losses were 655% more (Figure 8). In April 2021, many regions in France were hit by a massive cold wave, which caused direct economic losses of USD 5.6 billion. As a result, the economic losses from extreme temperatures in 2021 were much higher than the historical average.

3 Global patterns of natural disasters in 2021

3.1 Spatial pattern of global natural disasters in 2021

In 2021, the main types of natural disasters occurring globally were meteorological and hydrological disasters, such as flood and storm disasters, and earthquake and geological disasters (Figure 9). Floods were the most frequent of all types of natural hazards around the world in 2021. There were 206 floods in total that cumulatively affected 225 countries and regions, mainly in Europe, Asia, Africa, and America. Storms were the second with a total of 82 occurrences, which cumulatively affected 119 countries and regions, mainly in Asia, North America, Europe, and Africa. 25 earthquakes were registered, cumulatively affecting 28 countries and regions, mainly in East Asia, the Middle East, South America, and southern Europe. 19 major wildfires occurred and cumulatively affected 19 countries and regions, mainly in the Middle East, North America, and Europe. 13 droughts were recorded, with 15 countries and regions cumulatively affected, mainly in the Middle East and eastern Africa. 11 landslides occurred and cumulatively affected 12 countries and regions, mainly in Asia and South America. Eight volcanic eruptions occurred which cumulatively affected nine countries and regions, mainly in Central Africa, South America, and Southeast Asia. Three extreme temperature disasters hit which cumulatively affected three countries and regions in North America and Europe.

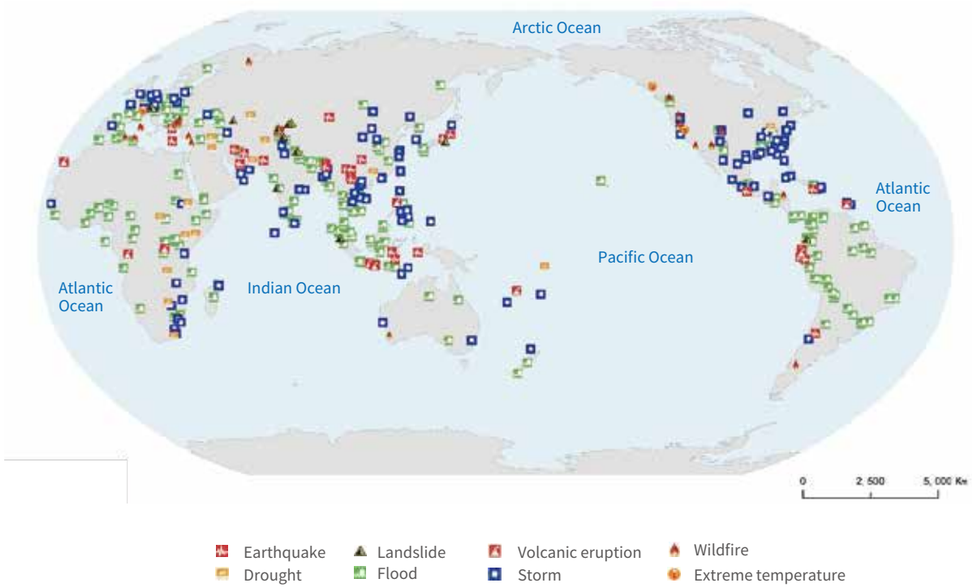


Figure 9 Spatial pattern of global natural disasters, 2021

3.2 Natural disasters by continent in 2021

Figure 10 shows the statistical results of the frequency of natural disasters, the number of deaths attributed to disasters, and the direct economic losses in all continents from January 1 to December 31, 2021. Among the 367 natural disaster events included in the statistics, Asia had the largest number of disaster events with a total of 150, accounting for 40.87% of the total number; followed by North America, Africa, South America and Europe, with 69 (18.80%), 50 (13.62%), 49 (13.35%) and 35 (9.53%), respectively; Oceania recorded the smallest number. In terms of the number of deaths attributed to disasters, Asia and North America had the largest numbers with 5,107 deaths and 4,275 deaths in total, accounting for 48.68% and 40.75% of the global total respectively. Among all major disasters, 16 caused more than 100 deaths each (11 in Asia, 4 in North America, and 1 in Europe). There were two catastrophic events that caused more than 1,000 deaths each. One of them occurred in Asia (flooding in India, with 1,282 deaths), and the other in North America (the earthquake in Haiti, with 2,575 deaths). In terms of economic losses, North America suffered the most direct disaster economic losses (USD 147.82 billion), accounting for 58.63% of the total global economic losses caused by natural disasters. Europe and Asia came in second and third with USD 52.184 billion and USD 47.684 billion of direct disaster economic losses respectively. Such economic loss in Asia, Europe, and North America accounted for nearly 98.24% of the global amount. The disaster events that caused direct economic losses of more than USD 100 million at a time occurred mostly in North America (42) and Asia (26). In addition, 17 such disaster events occurred in other parts of the world (9 in Europe, 6 in Oceania, and 2 in South America). The biggest loss was caused by Hurricane Ida which struck the United States and Cuba, resulting in total direct economic losses of USD 65.1 billion. The floods that occurred in many European countries in mid-July 2021 also led to USD 41.7 billion of direct economic losses.

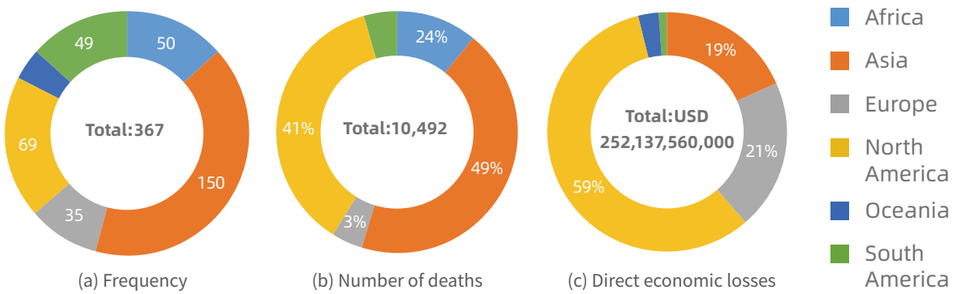


Figure 10 Statistics on the frequency of natural disasters, the number of deaths, and direct economic losses by continent, 2021

(Note: If one disaster event occurred across continents (Asia and Oceania), it was counted as one event both for Asia and for Oceania when we counted up the number of disasters by continent; and was counted as one event as a whole when we counted up the total number of disasters across the world.)

3.3 Natural disasters in countries or regions in 2021

Figure 11, Figure 12 and Figure 13 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 2021 respectively. Table 2 and Table 3 list the top ten countries in terms of the frequency of disasters, the death toll and mortality rates, direct economic losses and loss rates. The top ten countries with the highest frequency of disasters were mainly located in North America and the southern and southeastern parts of Asia. Among them, the United States had the highest number at 43, followed by Indonesia at 28. China ranked third with 21. The countries with a larger number of disaster-related deaths were mainly located in North America and the southern and southeastern parts of Asia. The death tolls in the top ten countries all surpassed 250. Among them, Haiti had the largest number at 2,582, followed by India at 2,126. China ranked seventh at 475. Among the top ten countries with the largest number of deaths per million people, Haiti ranked first with 226.44 deaths; the Philippines ranked tenth, with 5.22 deaths. The number of deaths per million population in China was 0.32. The countries with higher direct economic losses were mainly located in East Asia, North America and Europe. The top ten countries all had losses of more than USD 1.7 billion, of which the United States had the most, at USD 142.415 billion; Germany took second place with USD 40 billion. In terms of the proportion of direct economic losses in GDP of the previous year, countries, except for Saint Vincent and the Grenadines, Haiti, Saint Lucia and Germany, were all below 1%. Among the top ten countries, Saint Vincent and the Grenadines had the highest proportion of direct economic losses in GDP, reaching 40.25%, and India and Czech were about on par at 0.29%. China' s proportion of direct economic losses in GDP was 0.17%.

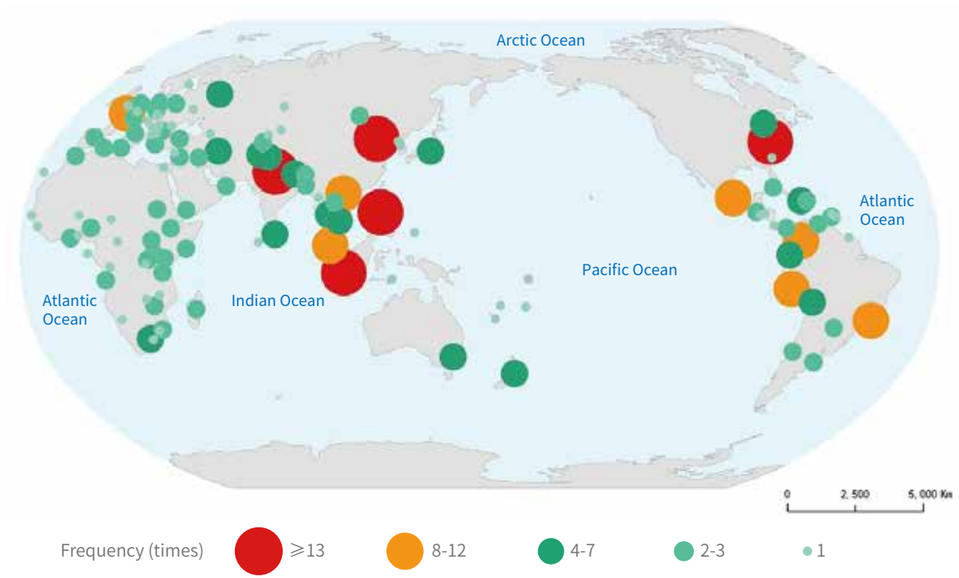


Figure 11 Spatial distribution of the frequency of natural disasters by country/region, globally in 2021

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

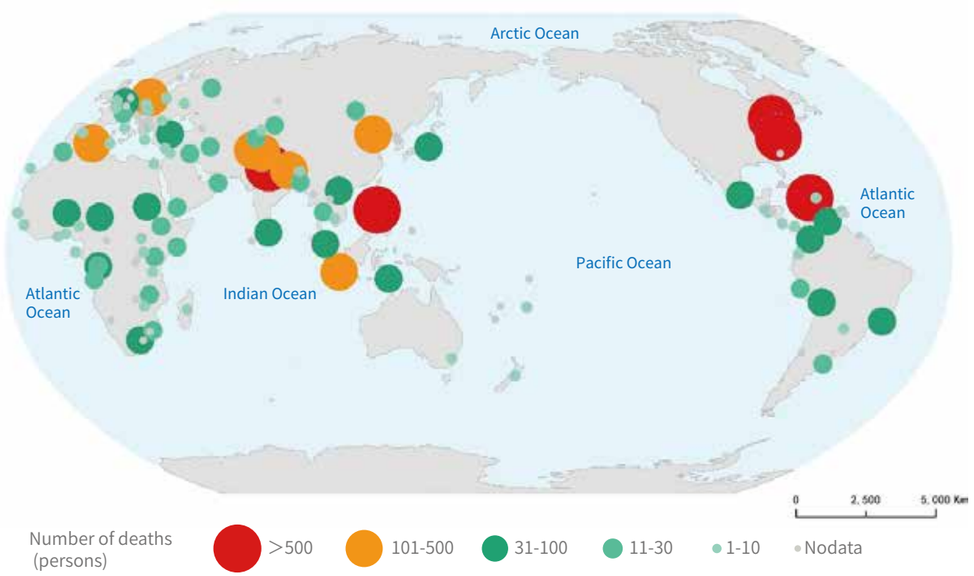


Figure 12 Spatial distribution of the death toll from natural disasters, by country/region, globally in 2021

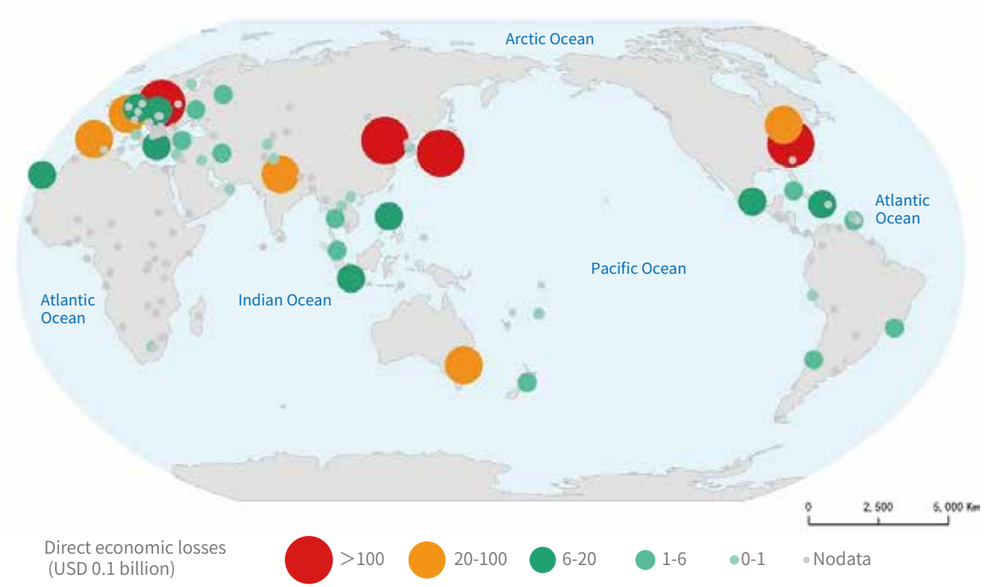


Figure 13 Spatial distribution of direct economic losses from natural disasters by country/region, globally in 2021

Table 2 Top ten countries (or regions) in terms of natural disaster frequency and losses in 2021

Country	Frequency (times)	Country	Deaths (persons)	Country	Direct economic losses (USD 0.1 billion)
The United States	43	Haiti	2,582	The United States	1425.15
Indonesia	28	India	2,126	Germany	400.00
China	21	Canada	822	China	255.57
India	19	The United States	786	Japan	106.00
The Philippines	14	The Philippines	572	India	78.10
Mexico	11	Indonesia	492	France	56.33
Columbia	11	China	475	Australia	33.35
Peru	10	Afghanistan	396	Canada	21.06
France	9	Pakistan	264	Spain	20.41
Vietnam, Malaysia, Brazil	8	Nepal	251	Belgium	17.00

Table 3 Top ten countries (or regions) in terms of natural disaster loss rate in 2021

Country	Deaths per million population	Country	Percentage of direct economic losses (%)
Haiti	226.44	Saint Vincent and the Grenadines	40.25
Sao Tome and Principe	36.50	Haiti	11.17
East Timor	31.10	Saint Lucia	2.10
Canada	21.63	Germany	1.04
Bhutan	12.96	The United States	0.68
Afghanistan	10.17	Greece	0.33
Nepal	8.61	Belgium	0.33
Fiji	6.69	The Philippines	0.30
Saint Lucia	5.45	India	0.29
The Philippines	5.22	Czech Republic	0.29

Note: The number of deaths per million population in Table 3 refers to the proportion of the number of deaths in 2021 in the total population in 2020 (expressed as deaths per million population), and the percentage of direct economic losses refers to the total direct disaster economic losses in 2021 as a share of GDP in 2020. The population and GDP (in current US dollar) data for 2020 are sourced from the World Bank (https://data.worldbank.org/).

3.4 Top ten global natural disasters in terms of death toll and direct economic losses in 2021

Table 4 and Figure 14 respectively show the world' s top ten disaster events with the highest death toll in 2021 and their spatial distribution. It can be seen that the events with a larger number of deaths mainly occurred in economically backward developing countries, and most of them were floods, storms and extreme temperatures. This is related to the low economic development level of these countries, weak disaster preparedness and prevention capabilities of their infrastructure, and low levels of disaster monitoring and early warning, emergency rescue, and medical services.

Table 4 Top ten natural disasters worldwide by death toll in 2021

Ranking	Time	Country	Hazard type	Number of deaths	Deaths per million population
1	August 14-August 14	Haiti	Earthquake	2575	225.8270
2	June 1-September 30	India	Flood	1282	0.9290
3	June 26-July	Canada	Extreme low temperature	815	21.4444
4	December 16-December 17	The Philippines	Storm	460	4.1978
5	June 1-August 30	China	Flood	352	0.2510
6	April 2-April 6	Indonesia	Storm	268	0.9798
7	July 28-July 29	Afghanistan	Flood	260	6.6789
8	February 10-February 20	The United States	Storm	235	0.7132
9	February 7-February 8	India	Flood	234	0.1696
10	June 26-June 30	The United States	Extreme high temperature	229	0.6950

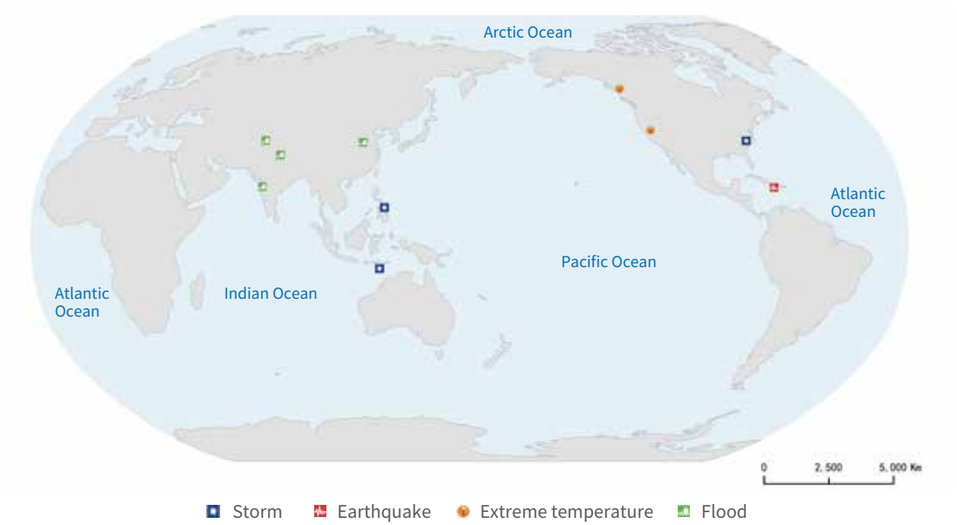


Figure 14 Spatial distribution of the world' s top ten natural disasters in death toll in 2021

Table 5 and Figure 15 list the world' s top ten disaster events with the most direct economic losses in 2021 and their spatial distribution. It can be seen that those events with higher economic losses mainly occurred in countries with relatively developed coastal economies, and most of them were floods and storms.

Table 5 Top ten major natural disasters worldwide in direct economic losses in 2021

Ranking	Time	Country	Hazard type	Direct economic losses (USD 0.1 billion)
1	August 28-September 2	The United States	Storm	651
2	July 12-July 15	Germany	Flood	417
3	February 10-February 20	The United States	Storm	300
4	June 1-August 30	China	Flood	165
5	January 1-December 13	The United States	Drought	90
6	February 13-February 13	Japan	Earthquake	77
7	April 5-April 8	France	Extreme low temperature	56
8	December 10-December 11	The United States	Storm	52
9	December 30-December 31	The United States	Wildfire	33
10	June 1-September 30	India	Flood	31

Figure 15 Spatial distribution of the world' s top ten natural disasters in direct economic losses in 2021

4 Comparison of natural disasters between China and the rest of the world in 2021

4.1 Comparison of natural disaster deaths between China and the rest of the world in 2021

Figure 16 shows the number of deaths per million population in major countries and regions around the world in 2021.

The number of disaster-related deaths per million population in China was 0.32 in 2021; among all the 87 countries and regions in the statistics, 54 countries and regions had a larger number of deaths per million than China, accounting for 62.07% of the total; when ranked from low to high according to the number of deaths per million population, China was among the top 37.93% of the 87 countries and regions in the statistics. Countries on the same level as China included Iran (0.31), Argentina (0.33) and Ecuador (0.34), etc.

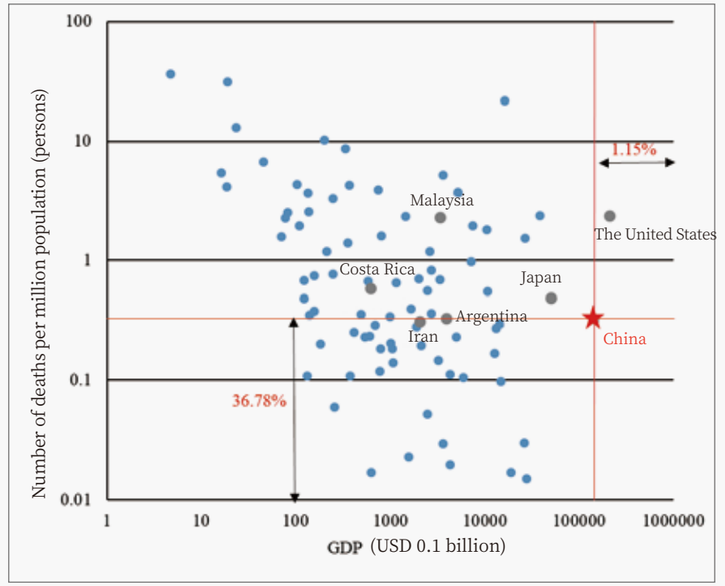
0.32

The number of disaster-related deaths per million population in China in 2021

In terms of the number of deaths per million population in relation to the level of economic development, China's number of disaster-related deaths per million was basically consistent with the level of its economic development in 2021, and the count was relatively above average in the global range. Among the countries with economic aggregates comparable to that of China, both the United States (2.39) and Japan (0.49) had a higher number of deaths per million population than China. Among the countries with per capita GDP equivalent to that of China, Argentina (0.33), Malaysia (2.32), and Costa Rica (0.59) all had a higher number of deaths per million than China.

54

The number of countries and regions that had a larger number of deaths per million than China in 2021



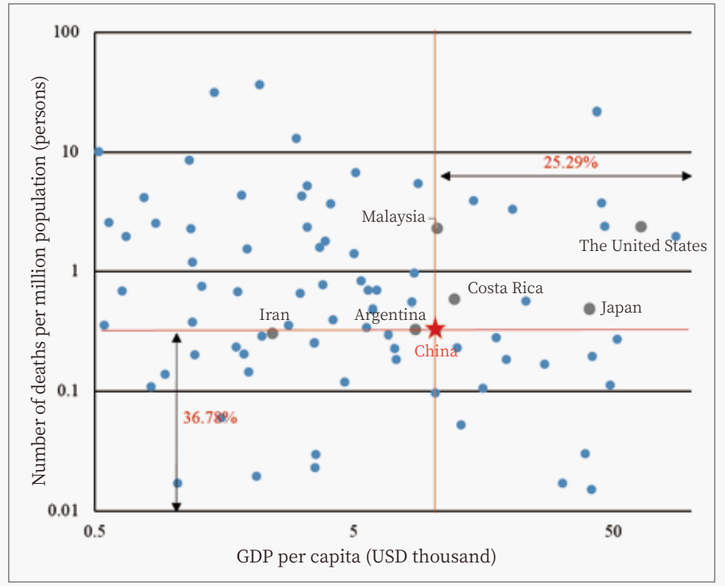


Figure 16 Comparison of natural disaster deaths between China and the rest of the world in 2021

Notes:
Horizontal comparison between China and the other countries and regions in the world;
China ranked in the top 37.93% in terms of the number of deaths per million population, which was in the upper-middle level;
China's total GDP ranked second; per capita GDP ranked in the top 26.44%, which was in the upper-middle level;
The number of deaths per million population in China was basically consistent with the level of its economic development.
(The number of deaths per million population shown in the figure is calculated by dividing the number of deaths from disasters in 87 countries and regions around the world in 2021 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 US dollar) in 2020 released by the World Bank))

4.2 Comparison of direct economic losses from natural disasters between China and the rest of the world in 2021

Figure 17 shows the direct economic losses as a share of GDP in major countries and regions worldwide in 2021.

China' s direct natural disaster economic losses accounted for 0.0017 of its GDP; among all the 41 countries and regions in the statistics, there were 15 countries and regions with a higher economic loss ratio than China, accounting for 37% of the total; when ranked by the proportion of direct economic losses in GDP in ascending order, China was among the top 61% of the 41 countries and regions in the statistics. Countries on the same level as China included Japan (0.0021), Canada (0.0013), etc.

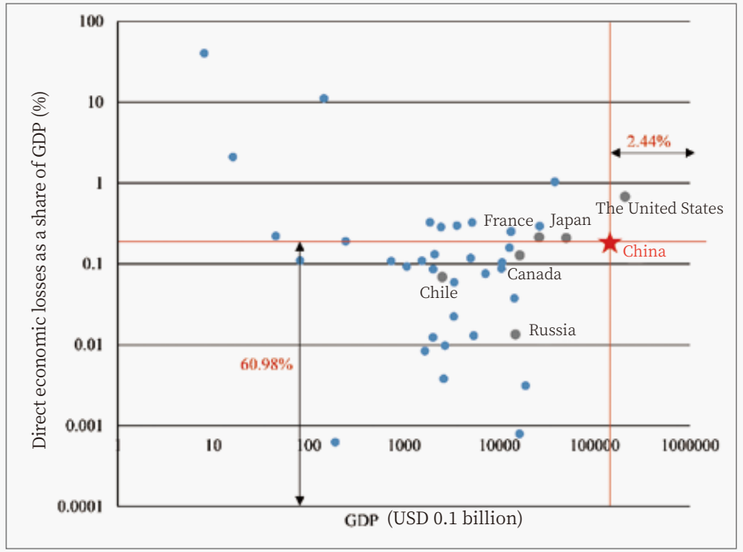
0.0017

The direct economic losses as a share of GDP in China in 2021

In terms of the relationship between the proportion of direct economic losses in GDP and the level of economic development in 2021, China' s direct natural disaster economic losses were roughly consistent with the level of its economic development, and China ranked in the lower 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, the United States (0.0068) had a higher share of direct economic losses in GDP than China, and Japan (0.0021) had a slightly higher share than China. Among countries with per capita GDP equivalent to that of China, Russia (0.0001) and Chile (0.0007) were far lower than China.

15

The number of countries and regions that had a higher disaster-related direct economic loss ratio than China in 2021



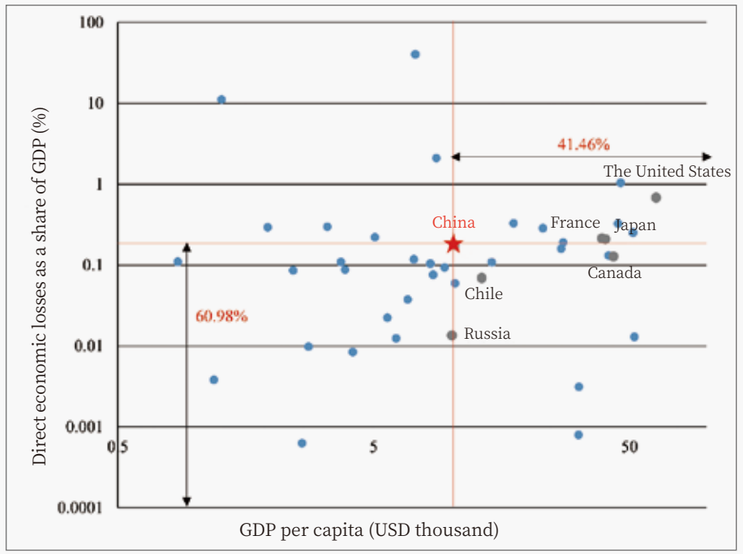


Figure 17 Comparison of direct economic losses from natural disasters as a share of GDP between China and the rest of the world in 2021

Notes:
Horizontal comparison between China and the other countries and regions in the world;
China ranked in the top 61% in terms of direct economic losses as a share of GDP, which was in the lower-middle level;
China' s total GDP ranked second; per capita GDP ranked in the top 41%, which was in the upper-middle level;
The proportion of direct economic losses in GDP was roughly consistent with the level of its economic development.
(The direct economic losses as a share of GDP shown in the figure is calculated by dividing the direct economic losses from natural disasters in 41 countries and regions around the world in 2021 by the total GDP of the previous year. Population data, GDP (in current US dollars), and GDP per capita (in current US dollars) are from the World Bank (https://data.worldbank.org/)).

02

Special Report 1

Natural disasters in China in 2021

1. Overall review of natural disasters in 2021
2. Temporal and spatial characteristics of disasters in 2021
3. Trend analysis of disaster indicators from 2001 to 2021

Special Report 1

Natural disasters in China in 2021[2]

1 Overall review of natural disasters in 2021

In 2021, China witnessed severe and complicated natural disaster situations, with extreme weather events occurring frequently. Main natural disasters included flood, strong wind and hail, drought, typhoon, earthquake, geological disasters and cold wave, while sand and dust storm, forest and grassland fires and marine disasters also hit to varying degrees. Reviewed disaster losses in 31 provinces (autonomous regions, municipalities) and the Xinjiang Production and Construction Corps throughout the year read an affected population of 107 million people, death and missing toll of 867 people (765 deaths and 102 missing), an evacuated population of 5.738 million people; collapsed housing of 162,000 rooms, with another 1.981 million rooms damaged to varying degrees; affected crops of 11,739 thousand hectares, including destroyed crops of 1,632 thousand hectares; and direct economic losses of CNY 334.02 billion.

107 million
Affected population

5.738 million
Evacuated population

11739 thousand hectares
Area of affected crops

334.02 billion CNY
Direct economic losses

1.1 Affected population by hazard type

Among all natural disasters, flood accounted for the highest proportion (55%) of the affected population in China in 2021, followed by drought (19.3%), strong wind and hail (15.9%), typhoon (6%), and cold wave (3.1%). Earthquake, geological disasters, sand and dust storm and other disasters accounted for relatively small proportions.

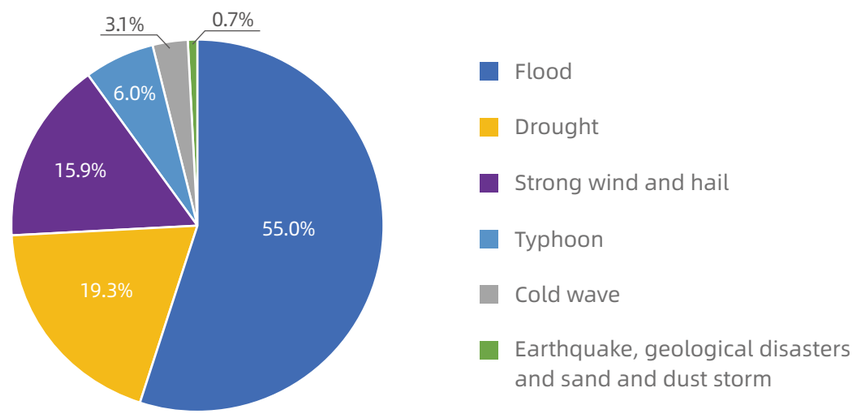


Figure 1 Pie chart of affected population by hazard type in 2021

2.The original report provided by: National Disaster Reduction Center of China.

1.2 Death and missing toll by hazard type

In 2021, flood accounted for the highest proportion (68.1%) of death and missing toll in China, followed by strong wind and hail (14.9%) and geological disasters (11.9%). Proportions of forest and grassland fires, cold wave, earthquake, typhoon, sand and dust storm, marine disasters and other disasters were relatively low.

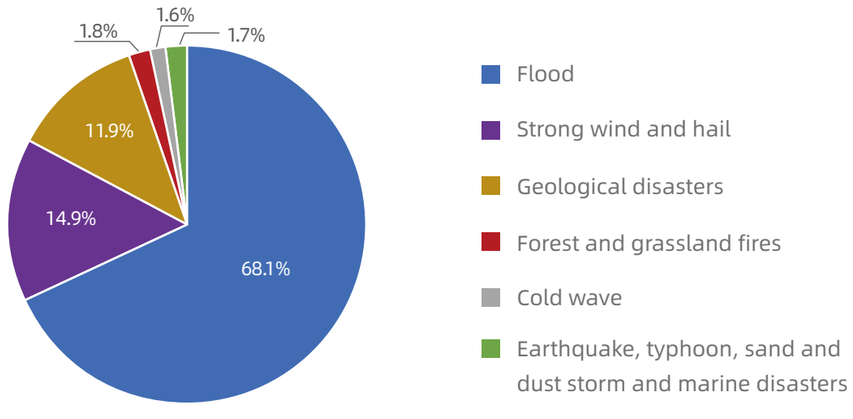


Figure 2 Pie chart of death and missing toll by hazard type in 2021

1.3 Direct economic losses by hazard type

In 2021, flood caused the most direct economic losses, accounting for as high as 73.6% of the total statistics in China. Strong wind and hail (8.0%), drought (6.0%), typhoon (4.6%), cold wave and snow (4.0%) and earthquake (3.2%) followed. Geological disasters, sand and dust storm and other disasters accounted for relatively low proportions.

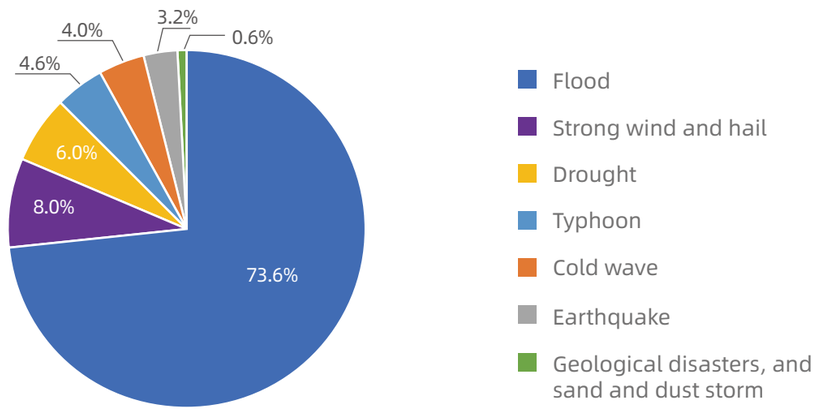


Figure 3 Pie chart of direct economic losses caused by hazard type in 2021

1.4 Death and missing toll by province

Henan, Shanxi, Shaanxi, Hubei, Yunnan, Jiangsu and Sichuan had more than 30 deaths and missing people due to disasters in 2021, ranking in the top seven. Henan was the only province with a death and missing toll of more than 100 people. Compared with annual means from 2001 to 2020, except for Henan, Shanxi Jiangsu and Tianjin where the death and missing toll increased, all the rest provinces had decreases on these statistics.

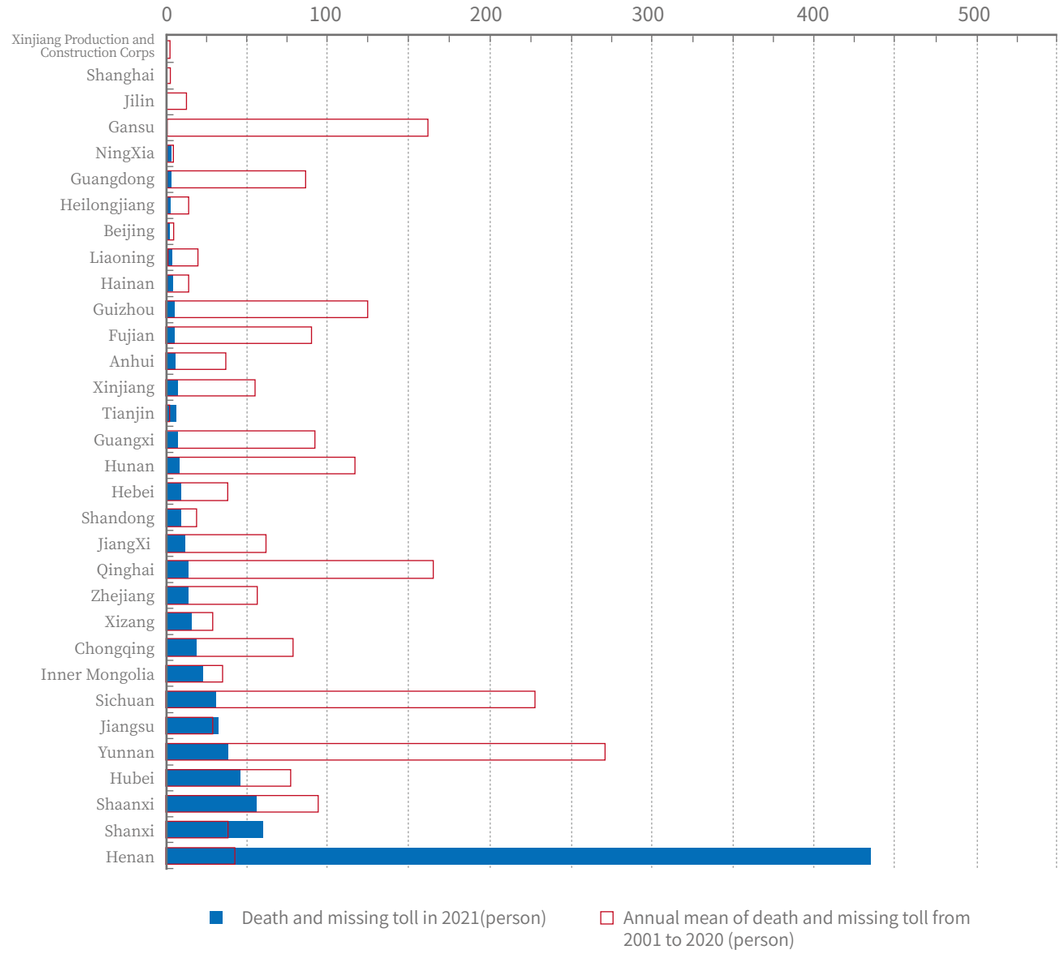


Figure 4 Statistics of death and missing toll by province in 2021[3]

3.Note: The statistics of 2008 is not included in the mean death and missing toll in Sichuan province from 2001 to 2020.

1.5 Direct economic losses by province

Seven provinces, including Henan, Shaanxi, Sichuan, Shanxi, Zhejiang, Yunnan and Hebei, all suffered direct economic losses of over CNY 10 billion in 2021, ranking in the top places in China. Henan suffered direct economic losses of over CNY 100 billion. Compared with annual means from 2001 to 2020 (annual data were converted to baseline 2021 according to gross regional products (GRP) indices), direct economic losses in Henan, Shaanxi, Shanxi and Shanghai increased while loss statistics in other provinces decreased.

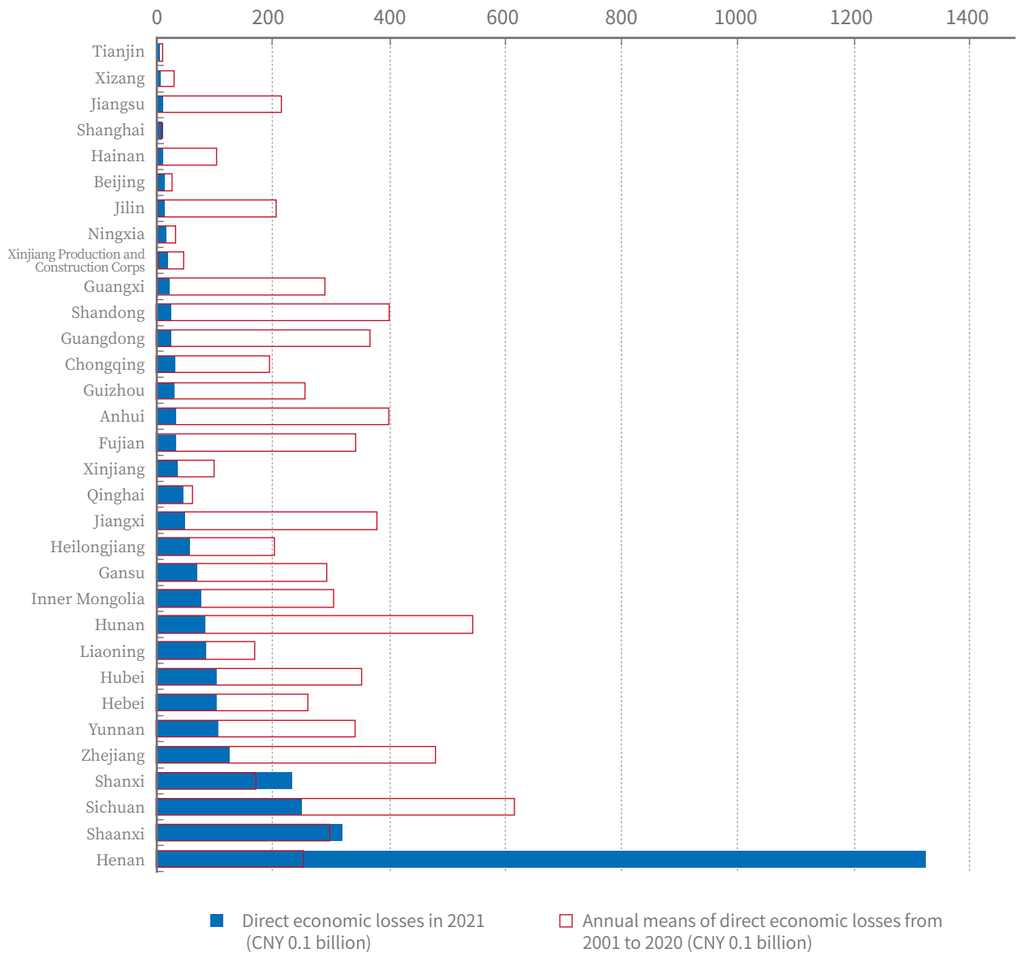


Figure 5 Statistics of direct economic losses from disasters by province in 2021[4]

4.Note: Annual data in each province were converted to baseline 2020 according to the GRP indices; the statistics of 2008 is not included in the mean value of the converted direct economic losses in Sichuan province from 2001 to 2020.

Table 1 Top ten natural disaster events in China, 2021[5]

Natural disaster event	Affected population (10,000 people)	Death and missing toll (person)	Direct economic losses (CNY 0.1 billion)
(1) Extraordinarily heavy rain and floods in Henan	1478.6	398	1200.6
(2) Serious autumn floods in the middle and lower reaches of the Yellow River	666.8	41	153.4
(3) Typhoon In-Fa (2106)	481.9	0	132
(4) Heavy rain and floods in Hubei	158.0	28	31.2
(5) Heavy rain and floods in Shaanxi	107.2	21	91.8
(6) Heavy rain and floods in Shanxi	61.2	35	82.8
(7) Snowstorms in Northeast China and North China	35.1	7	69.4
(8) Yangbi earthquake of MS. 6.4 in Yunnan	16.5	3	33.2
(9) Maduo earthquake of MS. 7.4 in Qinghai	11.4	0	41
(10) Strong wind and hail in Nantong and other places in Jiangsu	2.7	28	1.6
Total losses of the top ten natural disaster events	**3019.4**	**561**	**1837**
Percentage of the top ten natural disaster events	**28.1%**	**64.7%**	**55.0%**

5.Note: In descending order of affected population.

2 Temporal and spatial characteristics of disasters in 2021

2.1 The natural disasters showed obvious periodic and regional characteristics with the disasters that occurred in the first half year generally not as severe as those in the second half year, and those that occurred in southern China generally not as severe as those in northern China

In the first half of the year, an MS. 6.4 earthquake and an MS. 7.4 earthquake successively occurred in Yangbi of Yunnan province and Maduo of Qinghai province, tornados occurred in Jiangsu, Hubei, and other provinces, and local areas in Northeast China encountered rare floods. These disasters were generally not severe. In the second half of the year, heavy rainfall and severe floods successively hit Henan, Sichuan, Shanxi, Hebei, Hubei, Shaanxi and other provinces, an MS. 6.0 earthquake occurred in Luxian county of Sichuan province, severe flash flooding and debris flows took place in Tianquan county of Sichuan province, rare autumn floods occurred in Shanxi, Shaanxi, Henan and other provinces, and the extreme cold waves in North China, Northeast China and other northern regions caused freezing rains and snows. The disasters that occurred in the second half of the year were generally more severe, with the number of dead and missing, the number of collapsed houses and direct economic losses accounting for 82%, 92% and 88% of the total losses respectively. The disasters that occurred in the northern part of China were obviously more severe than those in the south. In particular, the disasters in Henan, Shaanxi and Shanxi provinces were obviously more severe.

82 %

Proportion of the number of deaths and missing persons due to disasters in the second half of 2021 to the total loss

88 %

Proportion of the number of direct economic losses due to disasters in the second half of 2021 to the total loss

2.2 Extremely heavy rainfalls occurred frequently, and the floods in North China and Northwest China were rare in history

In 2021, a total of 42 large-scale heavy rainfalls occurred in China, with an average precipitation of 659 mm, which was 6% more than the annual normal. The extreme rainstorms during the flooding season were highly intense and caused severe disasters. Four extremely heavy rainfalls occurred in July. Henan province suffered from extraordinary rainfalls that are rare in history, which caused extraordinary rainstorm and flood disasters in a wide range of areas, resulting in huge casualties and heavy losses. From mid to late July to August, extremely heavy rainfalls occurred in Jincheng city of Shanxi province, Suixian county of Hubei province and Lantian county of Shaanxi province, causing serious urban waterlogging, mountain torrents and geological disasters. In September and October, rare autumn floods occurred successively in the upper reaches of the Yangtze River, the middle and lower reaches of the Hanjiang River and the Yellow River, and the southern part of the Haihe River system. Throughout the year, floods caused a total of 59.01 million people affected, 590 people dead or missing, 152,000 houses collapsed, and direct economic losses of CNY 245.89 billion.

42

The number of large-scale heavy rainfalls occurred in China in 2021

59.01 million

The number of people affected by floods in China in 2021

2.3 Tornadoes and other strong convections took place, and a wide range of territory was affected by strong wind and hail disasters

In 2021, a total of 47 regional severe convections occurred across China, which was basically the same as the average of the last three years. The characteristics of the severe convections included wide ranges of influence, more in the north than the average through the years, and high extremeness. There were fewer and weaker convective weather events before the middle of April. The first large-scale strong convective weather process occurred 15 days later than normal. After mid-April, strong convections increased significantly, mainly in the northern part of the regions south of the Yangtze River, Jianghan Plain, the region between the lower reaches of the Yangtze River and the Huaihe River, North China, the region between the lower reaches between the Yellow River and the Huaihe River, and Northeast China. In terms of the scope, 1,363 counties (cities, districts) across the country were affected by strong wind and hail disasters which was the most widespread. Shanxi, Inner Mongolia, Liaoning, Jiangsu, Shandong, Shaanxi and Xinjiang were severely affected. In terms of the intensity, severe convections, such as extreme winds and tornadoes, hit significantly more. Jiangsu, Hubei and Inner Mongolia successively experienced extreme convective weather which caused rare tornado disasters, resulting in heavy casualties and economic losses.

47

The number of regional severe convections across China in 2021

1,363

The number of counties (cities, districts) affected by strong wind and hail disasters in China in 2021

2.4 Drought across China was generally less severe, with obvious periodic and regional characteristics

In 2021, drought disasters across China occurred in a periodic manner, and the main climate events included the winter-spring drought in the south, the summer drought in the northwest, and the autumn-winter drought in Guangdong province. At the beginning of the year, Yunnan province, regions south of the Yangtze River and South China experienced severe droughts. From March to April, meteorological droughts occurred again in Yunnan province, the southern part of regions south of the Yangtze River, and South China. In May, several strong rainfalls in southern China significantly improved soil moisture, and most of the droughts were relieved. From July to August, a severe drought occurred in the east part of the northwest region. Later, the drought eased up as more rainfall occurred in the region. In September, droughts occurred in South China. After that, Typhoon Lionrock, Typhoon Kompasu and Typhoon Rai successively brought rains, easing the drought in Guangdong province and other places to a certain extent. Overall speaking, the disaster impact of drought in 2021 were significantly lighter than previous year, affecting 20.689 million people in 24 provinces (autonomous regions and municipalities) including Shanxi, Shaanxi, Gansu, Yunnan, and Inner Mongolia, and 3,426.2 thousand hectares of crops, with direct economic losses of CNY 20.09 billion.

20.689 million

The number of people affected by drought disasters in 2021

20.09 billion CNY

Direct economic losses from drought disasters in China in 2021

2.5 Relatively few typhoons made landfalls in China, and Typhoon In-Fa had a major impact on East China

In 2021, five typhoons made landfalls in China, which was two less than the annual mean level. Tropical Storm Cempaka (2107), made landfall on July 20. As the first typhoon to land in China in 2021, it made landfall more than a month later than the first typhoon did in a normal year, and the affected areas included Guangdong, Guangxi and Hainan. On July 25 and 26, Typhoon In-Fa (2106), made successive landfalls in Zhoushan and Pinghu, Zhejiang province. The severe typhoon affected 4.82 million people in eight provinces (autonomous regions, municipalities) including Zhejiang, Shanghai and Jiangsu, with direct economic loss of CNY 13.2 billion, making it the typhoon with the heaviest loss in 2021. Typhoon Lionrock (2117) and Typhoon Kompasu (2118) made landfalls in Hainan province successively in October, with overlapping rainfalls causing heavy damage to some areas of the province. In late December, Super Typhoon Rai affected the South China Sea. Overall speaking, the annual losses from typhoon disasters were the lowest in the last five years, with the number of affected people, the number of deaths and missing due to the disasters and direct economic loss decreasing by 61%, 95% and 72%, respectively.

95%

The number deaths and missing persons due to the typhoons in 2021 decreasing by

72%

The number of direct economic losses due to the typhoons in 2021 decreasing by

2.6 Earthquake intensity increased, with several strong earthquakes in the western region

There were 20 earthquakes of MS 5.0 or higher in the Chinese mainland in 2021, most of which occurred in the western region such as Xinjiang, Xizang, Qinghai, Yunnan and Sichuan. The MS. 6.1 earthquake in Biru county of Xizang autonomous region on March 19, 2021, caused damage to more than 20,000 houses and direct economic loss of CNY 480 million. The MS 5.4 earthquake in Baicheng county of Xinjiang Uygur autonomous region on March 24 killed three people. The MS 6.4 earthquake in Yangbi county of Yunnan province on May 21 affected 165,000 people, killed three people, and damaged transportation, roads, municipal administration, education facilities. The MS 7.4 earthquake in Maduo county of Qinghai province on May 22 affected 113,000 people and damaged some roads, bridges and other infrastructure. The MS 6.0 earthquake in Luxian county of Sichuan province on September 16 killed three people and damaged a large number of houses. Throughout the year, earthquake disasters affected a total of 585,000 people in 14 provinces (autonomous regions, municipalities), killed nine people, caused 64,000 houses collapsed or severely damaged, resulting in direct economic loss of CNY 10.65 billion.

585,000

The number of people affected by earthquake disasters in 2021

10.65 billion CNY

Direct economic losses from earthquake disasters in China in 2021

2.7 Cold waves occurred at the beginning and the end of the year, and local areas in Northeast China were hit by severe snowstorms

In 2021, there were 10 cold waves across China. The number of cold waves was significantly more than the normal level, and the cold waves in January and November were relatively more severe. In early to mid-January, two cold waves successively occurred in the middle and eastern regions of China. The cold waves were characterized by significant extremely low temperatures and long duration of strong winds, which brought great losses to agricultural production, especially cash crops with weak frost resistance. From November to December, China experienced six cold waves , with obvious regional cumulative superposition effects. The cold wave from November 4 to November 9 was the strongest in 2021 and was characterized by big temperature drops, wide range of rain and snow and extreme intensity. Nine provinces (autonomous regions, municipalities) including Inner Mongolia, Liaoning, Jilin and Heilongjiang were severely affected. In general, cold waves were not as severe as usual, causing a total of 3.274 million people and 378.6 thousand hectares of crops affected, with total direct economic loss of CNY 13.31 billion.

3.274 million

Affected population

13.31 billion CNY

Direct economic losses from cold waves across China in 2021

2.8 Forest and grassland fires showed a stable trend of disaster impact, with relatively concentrated distribution in time and space

In 2021, there were 616 forest fires nationwide, with no major or catastrophic forest fires, and 4,292 hectares of forests affected. 18 grassland fires occurred, and affected area was 4,170 hectares. Compared with the average statistics of the last five years, the number of forest and grassland fires, affected area and casualties all decreased significantly. In terms of time distribution, forest fires were mainly concentrated from January to April. During this period, a total of 506 forest fires occurred, which accounted for 82% of the annual total counts. Grassland fires were mainly concentrated from January to May. During this period, a total of 13 grassland fires occurred, which accounted for 72% of the annual total counts. From a regional perspective, forest fires mostly occurred in the provinces (autonomous regions), including Guangdong, Guangxi, Hunan, Yunnan and Fujian, and grassland fires mostly occurred in Inner Mongolia and Qinghai.

616

The number of forest fires

18

The number of grassland fires

3 Trend analysis of disaster indicators from 2001 to 2021

3.1 Affected population

Overall speaking, affected population by various natural disasters across China has demonstrated a downward trend from 2001 to 2021. Affected population in 2021 was 107.3096 million, ranking the lowest since 2001. Compared with the annual mean from 2001 to 2020 (314.82 million, 2008 excluded), these statistics dropped by 65.9%.

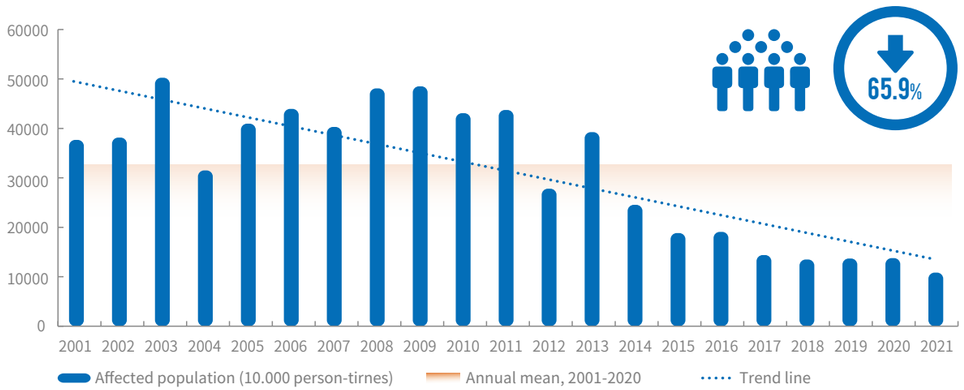


Figure 6 Annual statistic of affected population in China, 2001-2021

3.2 Affected people per 100,000 population

The statistics of affected people per 100,000 population have also shown a decreasing trend from 2001 to 2021. In 2021, the number of affected people per 100,000 population was 7,597, which was the lowest since 2001 and dropped by 67.8%, compared with the annual mean from 2001 to 2020 (23,606 people, 2008 excluded).

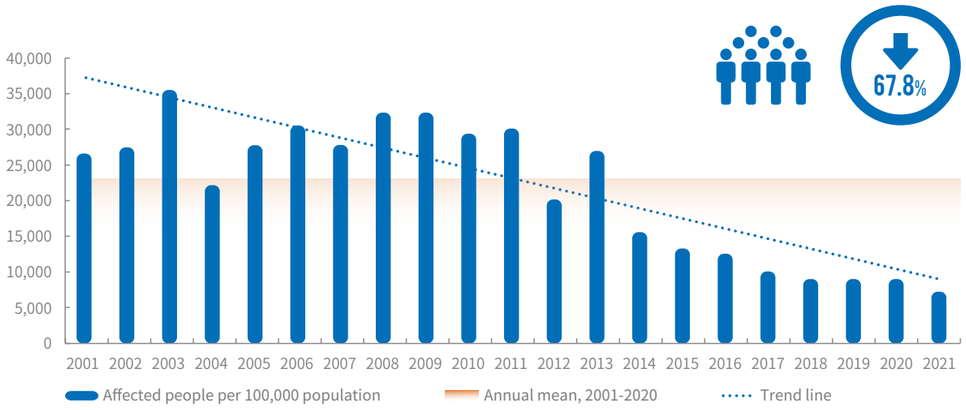


Figure 7 Annual statistics of affected people per 100,000 population in China, 2001-2021

3.3 Death and missing toll

From 2001 to 2021, the annual death and missing toll caused by various natural disasters in China was also declining. The toll in 2021 was 867 (765 deaths and 102 missing people), ranking the third lowest since 2001 (only higher than 2018 and 2020). Compared with the average level from2001 to2020 (2,097 people, 2008 excluded), the decrease was as high as 58.7%.

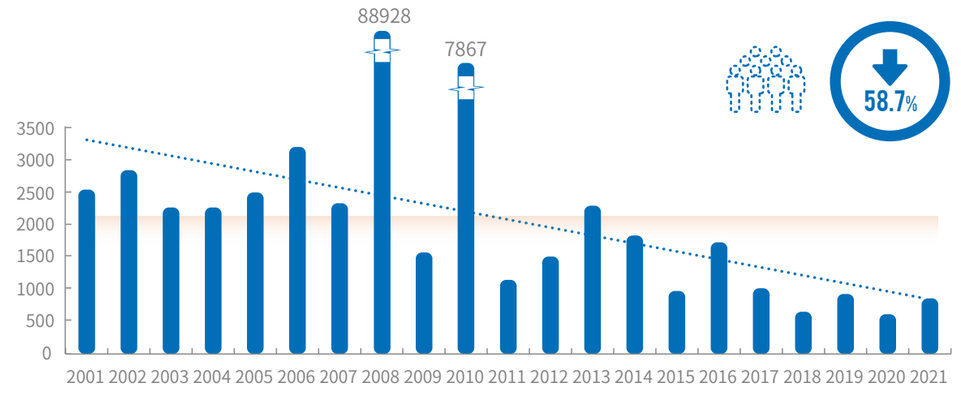


Figure 8 Annual statistics of death and missing toll in China, 2001-2021

3.4 Death and missing toll per 100,000 population

From 2001 to 2021, the death and missing toll per 100,000 population caused by various natural disasters in China went down as well, which was 0.061 in 2021, the third lowest since 2001 (only higher than 2018 and 2020). Compared with the annual mean from 2001 to 2020 (0.16, 2008 excluded), there was a decrease of 61.0%.

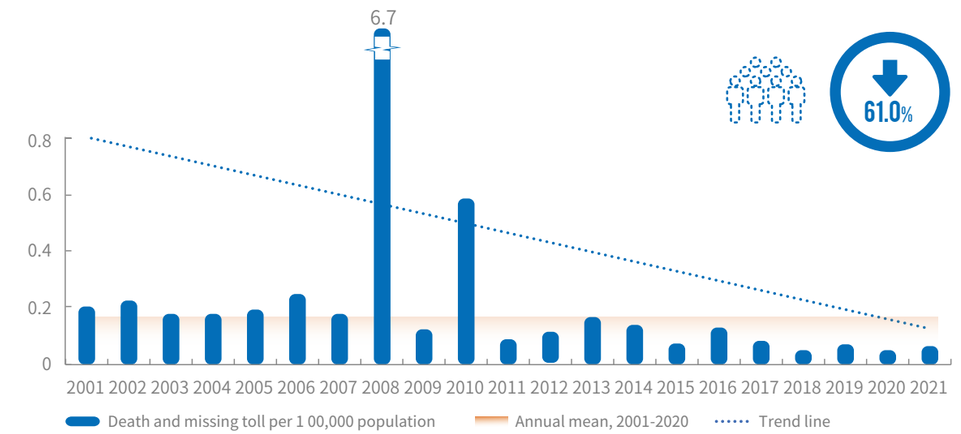


Figure 9 Annual statistics of death and missing toll per 100,000 population in China, 2001-2021

3.5 Direct economic loss

From 2001 to 2021, direct economic losses caused by various natural disasters in China showed a downward trend (annual data were converted to baseline 2021 according to the GDP index). The loss data in 2021 read CNY 334.02 billion, ranking the second lowest since 2001 (only higher than 2018), with a decrease of 49.1% to the annual mean from 2001 to 2020 (CNY 656.67 billion, 2008 excluded).

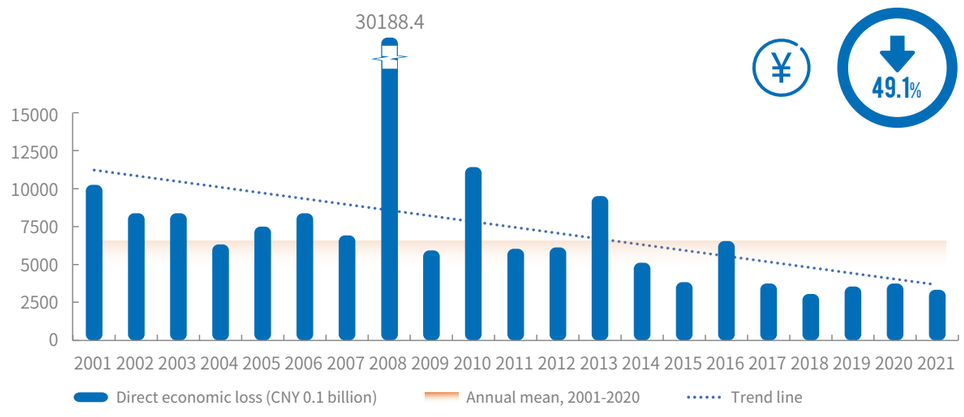


Figure 10 Annual statistics of direct economic losses in China, 2001-2021[5]

3.6 Direct economic losses over GDP

From 2001 to 2021. the ratio of direct economic losses caused by various natural disasters in China over GDP was declining as well. In 2021, this ratio was 0.29%, which was the second lowest since 2001 (only higher than 2018) and decreased by 64.9% to the average level from 2001 to 2020 (0.83%, 2008 excluded).

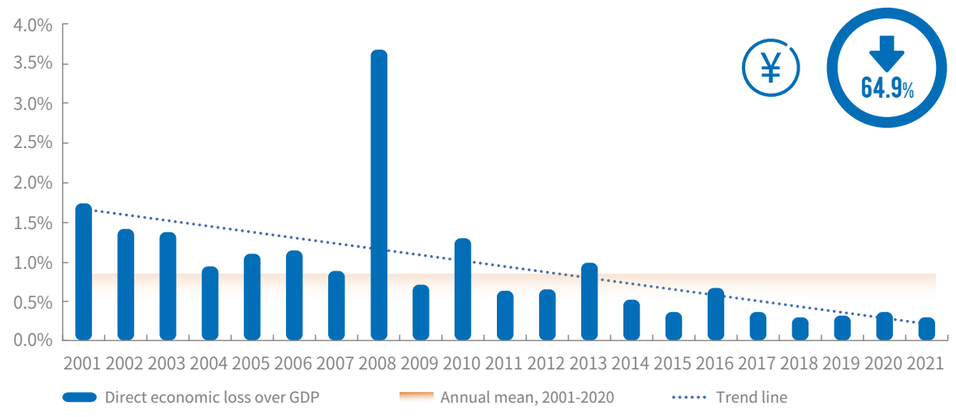


Figure 11 Annual statistics of direct economic losses over GDP in China, 2001-2021

6.Note: Annual data were converted to baseline 2021 according to the GDP index.

03

Special Report 2

Global risk assessment of major meteorological disasters in 2021

1. Global climate summary for 2021
2. Cause analysis of typical catastrophic climate-related events in 2021
3. Conclusion

Special Report 2

Global risk assessment of major meteorological disasters in 2021[7]

1 Global climate summary for 2021

1.1 Surface temperature ranked seventh on record

The year 2021 is an unusual year with a “Bimodal La Nina” phenomenon, which occurred from August 2020 to April 2021 and November 2021 to 2022, respectively. The La Nina phenomenon has an opposite effect on weather and climate compared to the El Nino phenomenon, with a temporary global cooling effect, which is usually strongest in the second year of a La Nina event. In spite of this, 2021 still remained one of the seven warmest years on record according to the statistics of the World Meteorological Organization (WMO). Global warming and other long-term climate change trends were expected to continue since the heat trapped by greenhouse gases in the atmosphere reached the record level. In 2021, the global average temperature was 1.11 (±0.13)°C higher than that before industrialization (1850-1900), which made the year 2021 the seventh year in succession since 2015 when the temperature has been more than 1°C warmer than the levels.

Although 2021 was generally warm globally, temperature anomalies differed around the world (Figure 2). The west and northeast parts of North America and Greenland, the central and north parts of Africa and most regions of the Middle East were significantly warmer, among which the northeast part of North America and some areas of Greenland had a temperature of more than 3°C higher; the west and east parts of Siberia, Alaska, the central and east regions of the Pacific, most regions of Australia and some regions of Antarctica saw a colder-than-normal year, and the lower temperature in the central and east regions of the Pacific corresponds to the La Nina phenomenon. From a regional perspective, the annual mean temperature in Africa was the same as that in 2019 and was the third-highest on record after 2016 and 2010; the annual mean temperature in North America, South America, Europe and Asia was rated among the nine highest on record for each; although Oceania’ s annual mean temperature was higher than that in the climatic reference period, 2021 still remained the coldest year in Oceania since 2012 (NOAA, 2022).

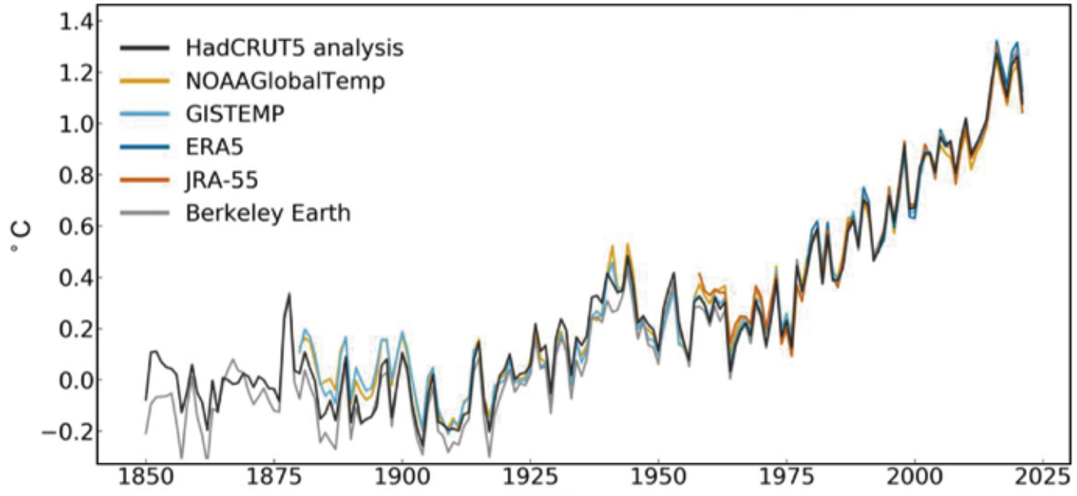


Figure 1 Time series of global annual mean temperature anomaly[8]

7.The special report is provided by National Climate Center, China Meteorological Administration.

8.Compared to the average between 1850-1900.

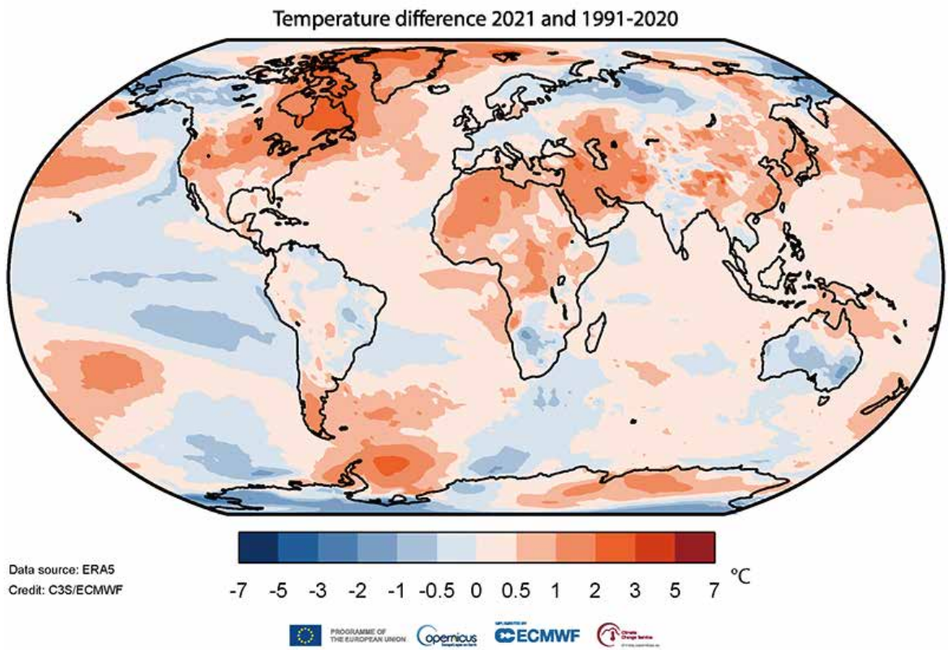


Figure 2 Global annual mean temperature anomaly in 2021[9]

1.2 Ocean heat capacity and sea surface height hit a new record while sea ice extent dropped to its smallest size

The world' s oceans continued to warm up in 2021, while sea temperatures of the Mediterranean, North Atlantic Ocean, Southern Ocean, and North Pacific Ocean all hit a new record, making 2021 the warmest year in the world' s oceans since modern ocean observations began. In 2021, the heat capacity in the upper 2000 meters of the world' s oceans hit a new record again, and the increased heat capacity was equivalent to 500 times China' s annual power output in 2020. The heat capacity of the North Atlantic Ocean, North Pacific and the Mediterranean set a record high as well. From 2013 to 2021, the global sea surface height rose by an average rate of 4.4 mm per year, which was twice the rate of sea surface height rise between 1993 and 2002, and the global mean sea surface height in 2001 even hit a new record. Studies have shown that human activity is most likely the main driver of the observed increase in ocean heat capacity since the 1970s, and industrial and biological aerosols and land use and other factors also contribute to ocean warming.

In 2021, the Arctic sea ice extent was below normal, reaching its annual minimum (4.72 million square kilometers) on September 6 and its annual maximum (14.8 million square kilometers) on March 21, the ninth or tenth smallest on record since 1979. Antarctic sea ice extent was slightly lower than the constant value, with its annual minimum (2.6 million square kilometers) recorded on February 19, and the fifteenth lowest on record; and Antarctic sea ice reached its the maximum extent (18.8 million square kilometers) on August 30, the second time after 2016 that Antarctic sea ice reached its annual maximum extent in August.

Against this backdrop, the year 2021 saw a variety of extreme weather disasters such as flood, drought, tropical cyclone, heat wave and wildfire, winter storm and severe convection across the globe.

9.Compared to the average between 1991-2020, spatial distribution (C3S, 2022).

2 Cause analysis of typical catastrophic climate-related events in 2021

2.1 Torrential rain and flooding in central and western Europe (July 2021)

Central and western Europe has a temperate oceanic climate, with little variation in monthly precipitation and a mild weather. In July 2021, the heavy rainfalls and floods in central and western Europe were mainly caused by the stable atmospheric circulation patterns over central and western Europe that lasts for several days. On July 12-15, affected by the low-pressure system "Bernd", Central Europe was trapped between the high-pressure zones on the east and west sides, forming a "high-low-high" blocking pattern of atmospheric circulation (Figure 3). Figure 4 shows that there was a strong convergence of water vapor flux over central Europe, where the cut-off low pressure "Bernd" was located, and a divergence of water vapor flux in the north and west of the eastern Atlantic Ocean and in the south of the Mediterranean, which suggested that the high-pressure ridge of the eastern Atlantic on the western side of the low-pressure system played a role of a pump, allowing the vapor from Atlantic to cross France into Belgium, the Netherlands and Germany. Then the low-pressure system obtained abundant water vapor and heat from the Mediterranean through cyclonic circulation, transporting water vapor from the depths to central Europe. After July 20, most of the heavy rainfalls in central Europe tended to end as high pressure over the eastern Atlantic extended further into the continent of Europe and pushes the low-pressure area northward and eastward.

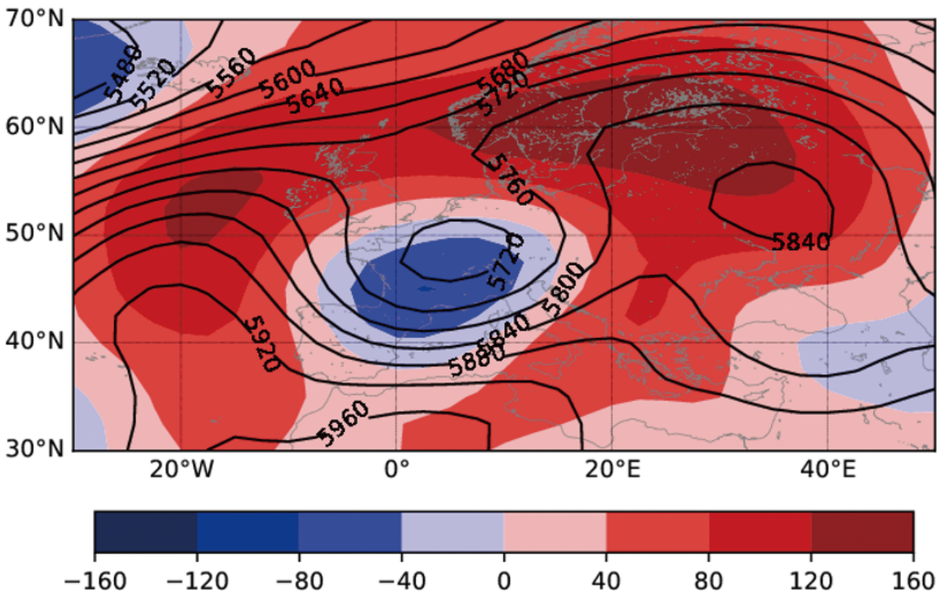


Figure 3 500 hPa geopotential height and anomaly fields during July 12-15[10]

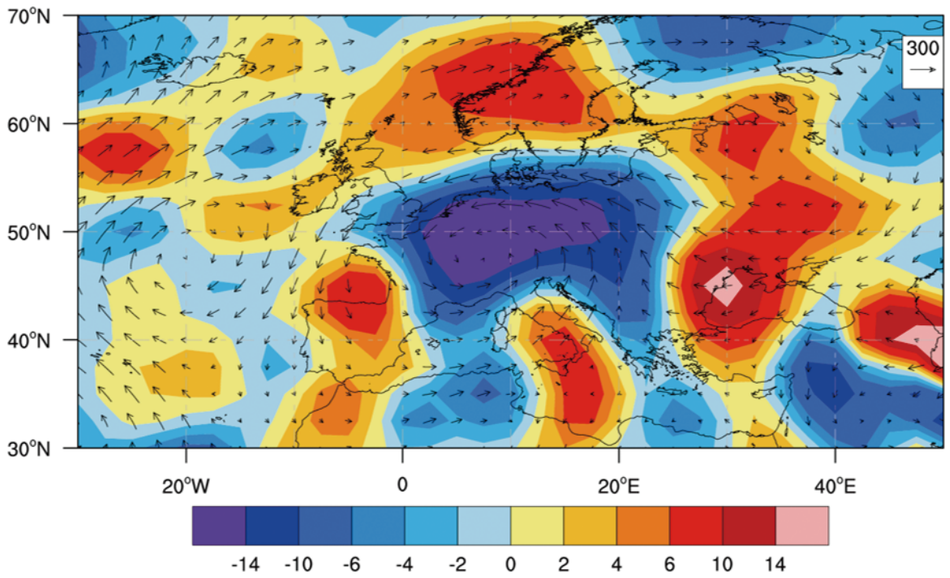


Figure 4 Anomaly field and divergence field of water vapor flux in the whole layer during July 12-15[11]

2.2 Winter storm Uri in North America (February 2021)

From February 12 to 17, 2021, a strong winter storm Uri hit most of North America, bringing heavy snowstorms and extreme low temperatures to almost all across the United States. The temperature in some parts of the central and southern United States was more than 12°C below normal (Figure 5). The immediate cause of this winter storm is that the upper tropospheric polar vortex lingered in southern and central Canada after shifting southward from the Arctic Pole, which caused the cold arctic air to gradually spread southward to Texas.

In addition, the Sudden Stratospheric Warming (SSW) in the Arctic starting from late December 2020 to early January 2021 is also an important cause of this strong snowstorm and low-temperature disaster in North America. A polar vortex is a large area of low pressure and cold air surrounding both of the Earth' s poles, with swirling westerly jet stream winds circulating around them. Typically, those winds are strong enough to constrain the coldest air at the poles in winter. Due to SSW, the stratospheric 10 hPa geopotential height turned from negative to positive at the end of December, reached its strongest in January, and tended to end in mid-February, and the effect of SSW was transmitted downward from the stratosphere to the lower troposphere over time (Figure 6). From December 2020 to mid-February 2021, the strong AO negative phase indicated an atmospheric circulation pattern of "warm Arctic-cold continents". It is against this backdrop that the winter storms and extreme low temperatures hit North America .

10.The colored area is the anomaly field, and the contour line is the mean field, unit: gpm.

11.The vector represents the flux anomaly, unit: kg · m-1 · s-1, and the colored area represents the divergence, unit: 10-5 kg · m-2 · s-1.

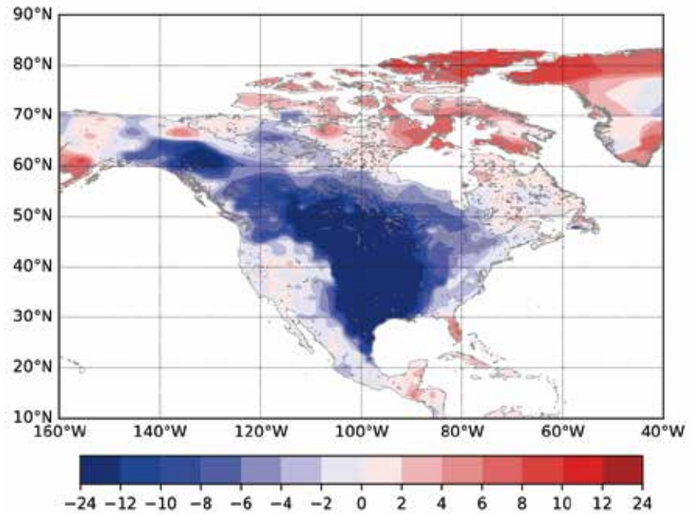


Figure 5 Anomaly distribution of average surface temperature during February 12 - 17, 2021 (Unit: ℃)

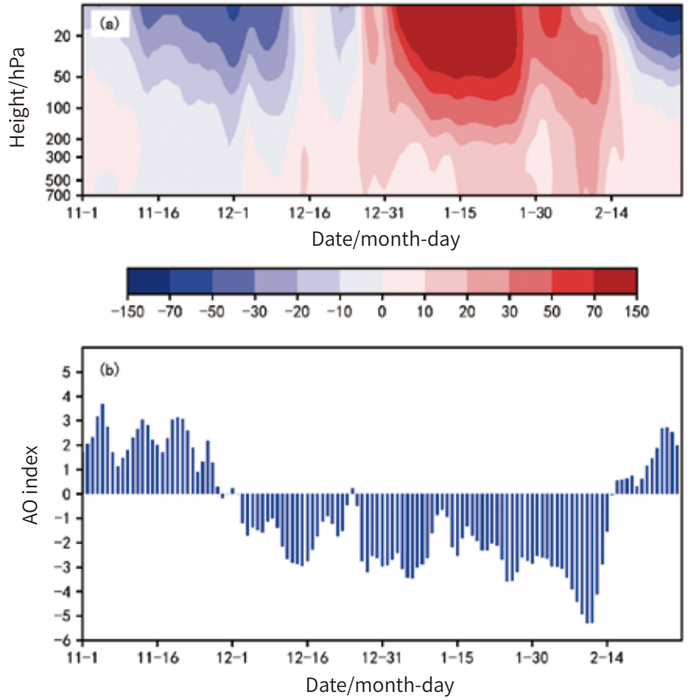


Figure 6 Time-height profile of (a) geopotential height anomaly (unit: gpm) in the Arctic (65 - 90°N) and (b) variability of the AO index during November 1, 2020 - February 28, 2021

3 Conclusion

Under the background of global warming, the summer of 2021 witnessed that Europe and the United States suffered from heatwaves, with record-breaking extreme heat observed in many places. Therefore, the summer of 2021 became the hottest summer on record in Europe and the United States. Heatwaves have left the Mediterranean coast of southern Europe and the western United States dry and rainless, with frequent wildfires and heavy losses. Many places in the world have suffered from torrential rains and severe floods. Record-breaking extreme heavy rainfall occurred in Henan province of China, and Europe also experienced a “once-in-a-century” extremely heavy rainfall, resulting in serious casualties and economic losses; many places in America, Africa and Asia suffered from severe droughts, with the greatest agricultural losses in the United States, Canada, Brazil and Argentina. Tropical cyclones were extremely active in the North Atlantic and the northern Indian Ocean. Ida, a category 4 hurricane, made landfall in Louisiana, the United States, which is the strongest hurricane on record to make landfall in the state. Fierce winds, rainstorms and storm surges caused extensive damage to the coastal states of the southeastern United States, resulting in direct economic losses of tens of billions in USD. At the beginning of the year, North America, Asia and Europe were hit by cold waves and snowstorms. The winter storm Uri struck most of North America, with record-breaking minimum temperatures in many regions, causing traffic paralysis, power failures to millions of households and hundreds of deaths. Strong convections occurred frequently all over the world. In December alone, nearly 70 tornadoes hit several states in the United States, killing nearly 100 people, making it one of the most severe tornado disasters in the history of the United States.

The frequency of extreme weather and climate events increased significantly in 2021, indicating that Continued global warming may lead to more frequent and extreme weather events. With population growth, rapid urbanization and continued wealth accumulation, extreme weather disasters in urban areas will be a major threat to regional sustainable development, which deserves attention from researchers, policymakers and practitioners worldwide.

04

Special Report 3

Global assessment of extreme weather disasters from 2000 to 2021

1. Overview of global extreme weather disasters from 2000 to 2021
2. Losses of global extreme weather disasters from 2000 to 2021
3. Overview of extreme weather disasters in countries (or regions) around the world from 2000 to 2021
4. Comparison of losses and damage from extreme weather disasters between China and the rest of the world from 2000 to 2021

Special Report 3

Global assessment of extreme weather disasters from 2000 to 2021

1 Overview of global extreme weather disasters from 2000 to 2021

1.1 Current situation and criterion

Extreme weather disasters, also known as high-impact weather events or extreme weather and climate events, are one of the seven major scientific challenges of the World Climate Research Program (WCRP) and have always been the focus of the assessment report of the United Nations Intergovernmental Panel on Climate Change (IPCC).

With overall consideration of the intensity of disaster-inducing factors and the extremity of disasters, the identification of the extreme weather events analyzed in this assessment shall meet at least one of the following conditions:

01 They were incorporated into the "Global Major Weather and Climate Events" by China Meteorological Administration from 2000 to 2021

02 More than 50,000 people were affected

03 The economic losses exceeded USD 30 million;

04 They caused heavy casualties (with more than 100 deaths)

1.2 Frequency and regional distribution of extreme weather disasters by hazard type

According to the above criteria and through the screening of disaster events, we statistically concluded that from 2000 to 2021, the number of extreme weather disasters worldwide was 441 (Figure 1), including extreme floods, tropical cyclones, extreme high temperatures, cold waves and winter storms, strong convections, extreme droughts, and other storms.

From 2000 to 2021, the global extreme weather disasters were mainly extreme floods, tropical cyclones, extreme high temperatures, cold waves and winter storms. Strong convections, extreme droughts, and other storms also occurred to varying degrees. Among all these disasters, 221 were caused by extreme floods, with the highest frequency, accounting for 51% of the total number of global extreme weather disasters (the same below); 88 were caused by tropical cyclones (accounting for 20% of the global total); 60 were caused by extreme high temperatures (accounting for 14% of the global total); 41 were caused by extreme cold waves and winter storms (accounting for 9% of the global total); 14 were caused by strong convections (accounting for 3% of the global total); 9 were caused by extreme droughts (accounting for 2% of the global total); 3 were caused by other storms (accounting for 1% of the global total).

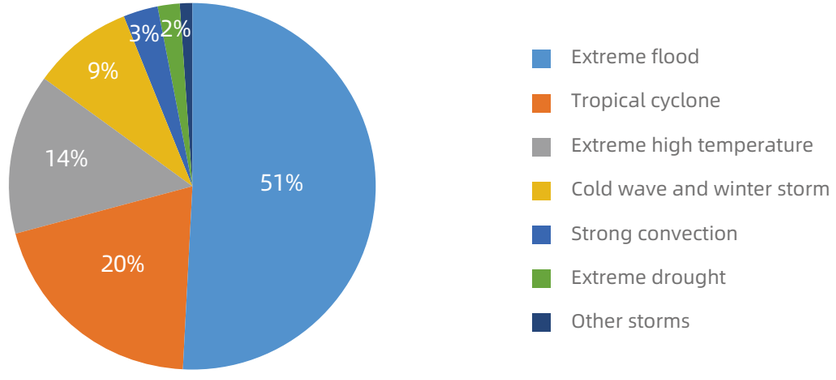


Figure 1 Breakdown of global extreme weather disasters by hazard type 2000-2021

1.3 Regional distribution of extreme weather disasters

Through the classified statistic of these 441 extreme weather disasters, we drew the statistical chart (Figure 2) and spatial distribution map (Figure 3) of global extreme weather disasters by regions from 2000 to 2021.

From 2000 to 2021, extreme weather disasters occurred most frequently in Asia, with the highest frequency of 287 (Figure 4), accounting for 65.1% of the total number of global extreme weather disasters (the same below), which even exceeded the sum of the occurrence frequency of Europe, America, Africa, and Oceania. Among all these disasters, 172 were caused by extreme floods (accounting for 39% of the global total); 60 were caused by tropical cyclones (accounting for 13.6% of the global total); 37 were caused by extreme high temperatures (accounting for 8.4% of the global total); 11 were caused by strong convections; 4 were caused by extreme droughts; 3 were caused by other storms. The frequency of extreme weather disasters in Europe was next only to that in Asia, but the number was far behind, with only 54 disasters; the occurrence frequency in America was similar to that in Europe, with 52 disasters; the occurrence frequency in Africa was slightly less than that in Europe and America, with 45 disasters; the occurrence frequency in Oceania is the lowest, with only 3 disasters.

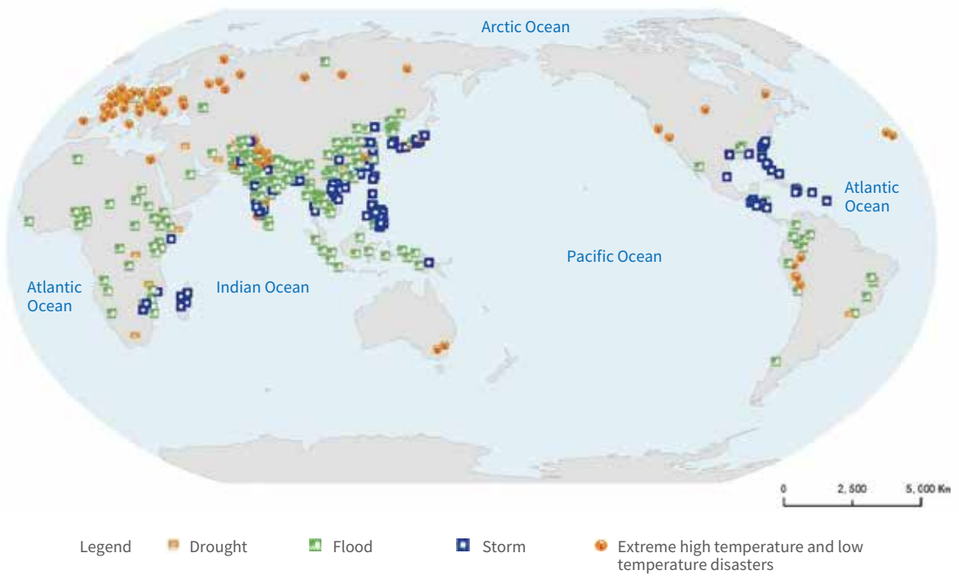
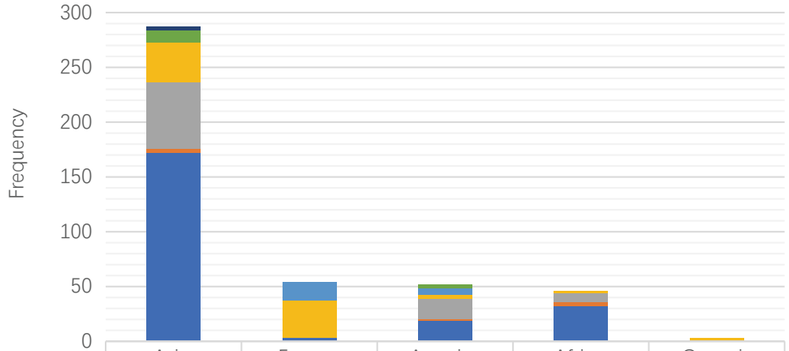


Figure 3 Spatial distribution of 441 global extreme weather disasters (2000-2021)



	Asia	Europe	America	Africa	Oceania
Other storms	3	0	0	0	0
Strong convection	11	0	3	0	0
Cold wave and winter storm	0	17	6	0	0
Extreme high temperature	37	34	4	1	2
Tropical cyclone	60	0	19	8	1
Extreme drought	4	0	1	4	0
Extreme flood	172	3	19	32	0

Figure 2 Statistics of global extreme weather disasters by regions 2000-2021

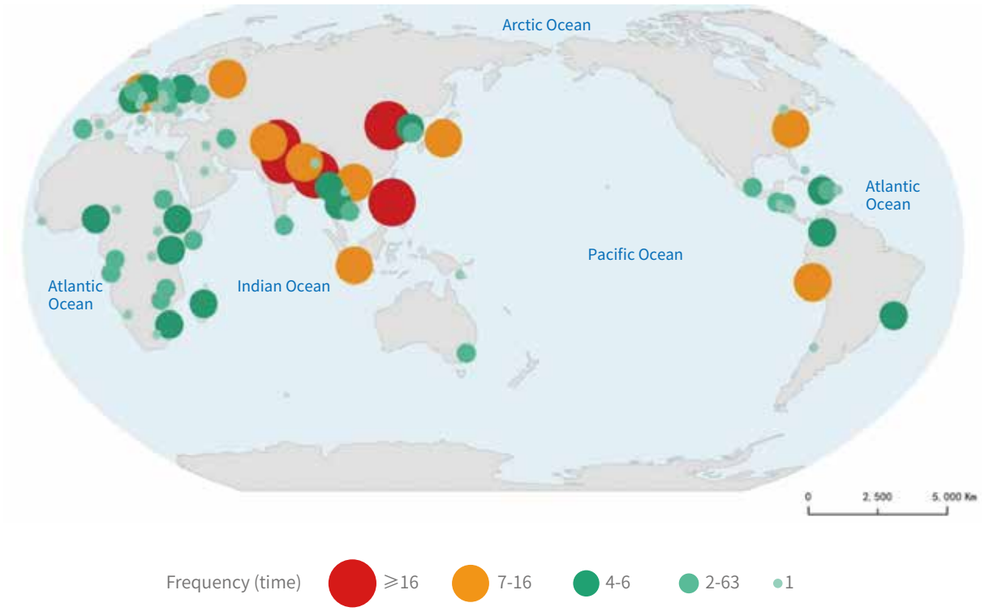


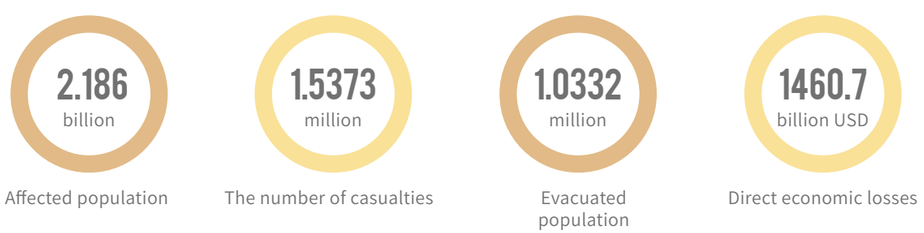
Figure 4 Spatial distribution of the frequency of global extreme weather disasters in countries (or regions) around the world (2000-2021)

2 Losses of global extreme weather disasters from 2000 to 2021

From 2000 to 2021, 441 extreme weather disasters totally caused an affected population of 2.186 billion person-times worldwide, with 1,537,300 casualties (including 454,100 deaths and 1,083,200 injuries), an evacuated population of 1.0332 million people and a direct economic loss of more than USD 1.4607 trillion[12].

From the perspective of disaster types, the affected population caused by extreme floods exceeded 1 billion person-times, which was greater than the sum of the affected population caused by other types of disasters, that is, 1.371 billion person-times (accounting for 62.7% of the total affected population of global extreme weather disasters); tropical cyclones and extreme high temperatures caused the most deaths, with 182,100 and 162,300 deaths (accounting for 40% and 36% of the total number of deaths caused by global extreme weather disasters, respectively), both of which exceeding 150,000 deaths; tropical cyclones caused the highest direct economic losses, with a total of USD 654.55 billion (accounting for 79% of the total direct economic losses from global extreme weather disasters), which far exceeded the sum of direct economic losses from all the other types of disasters.

From a regional perspective, from 2000 to 2021, the affected population in Asia reached 1.864 billion person-times (accounting for 85.3% of the total affected population by global extreme weather disasters), and the total number of deaths was 246,000 (accounting for 54.7% of the total number of deaths caused by global extreme weather disasters), both of which were greater than the sum of the affected population and the sum of deaths in Europe, America, Africa, and Oceania, respectively, thus making Asia the region with the largest affected population and deaths caused by extreme weather disasters worldwide from 2000 to 2021. Americas suffered the maximum economic losses, that is, USD 808.2 billion (accounting for 55.3% of the total direct economic losses from global extreme weather disasters), which was followed by USD 566.7 billion in Asia (accounting for 38.8% of the total direct economic losses from global extreme weather disasters). The direct economic losses of these two continents account for 94.4% of the global total.



12.Note: The direct economic losses from 2000 to 2020 are measured at the price level of 2021, and those of 2021 are measured at the price level of the current year,

3 Overview of extreme weather disasters in countries (or regions) around the world from 2000 to 2021

Table 1 lists the top ten countries in terms of the frequency of extreme weather disasters, deaths, and direct economic losses from 2000 to 2021. It can be seen that the top ten countries in terms of the frequency of extreme weather disasters from 2000 to 2021 were mainly located in the eastern, southern, and southeastern parts of Asia, among which, India had the highest number at 80, followed by China at 47, and Pakistan ranked third with a frequency of 24 times. The countries with a larger number of disaster-related deaths were mainly located in Eurasia and Africa. The top nine countries all had more than 10,000 deaths, of which Myanmar had the largest number of 139,017, followed by Russia at 57,638. China ranked ninth with 10,982 deaths. The countries with higher direct economic losses were mainly distributed in North America, Eastern Asia, and Europe. The top ten countries all had losses of more than USD 5 billion, of which the United States had the most, at USD 203.555 billion, followed by China at USD 127.028 billion.

Table 1 Top ten countries (or regions) in terms of frequency, deaths, and direct economic losses caused by global extreme weather disasters from 2000 to 2021

Ranking	Country	Frequency (time)	Ranking	Country	Deaths (person)	Ranking	Country	Direct economic losses (USD 0.1 billion)
1	India	80	1	Myanmar	139,017	1	The United States	2035.55
2	China	47	2	Russia	57,638	2	China	1270.28
3	Pakistan	24	3	India	40,747	3	Thailand	487.36
4	Philippines	22	4	France	27,512	4	India	272.83
5	Bangladesh	22	5	Somalia	20,162	5	Pakistan	173.53
6	The United States	15	6	Italy	20,089	6	South Korea	129.55
7	Indonesia	14	7	Philippines	17,793	7	Bangladesh	92.56
8	Afghanistan	13	8	Spain	15,090	8	France	64.81
9	Nepal	12	9	China	10,982	9	Italy	64.81
10	Japan	12	10	German	9,552	10	Myanmar	51.35

Note: The direct economic losses in the table are measured at the price level of 2021.

Table 2 lists ten extreme weather disasters with the highest global death toll from 2000 to 2021, which mainly occurred in economically backward developing countries, and most of the disasters were tropical cyclones and extreme high temperatures. The total number of deaths caused by the top ten extreme weather disasters in terms of deaths was 295,768, accounting for 65% of the total number of deaths caused by global extreme weather disasters and exceeding the sum of deaths caused by all the other extreme weather disasters, with an extremely large number of deaths. This is related to the low economic development level of developing countries, weak disaster preparedness and prevention capabilities of their infrastructure, and low level of disaster monitoring and early-warning, emergency rescue, and medical services.

Table 2 Top ten extreme weather disasters in terms of global deaths from 2000 to 2021

Ranking	Time	Country	Event 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	2003.7.16-2003.8.15	Italy	Extreme high temperature	20,089
4	2010.2-2011.11	Somalia	Extreme drought	20,000
5	2003.8.1-2003.8.20	France	Extreme high temperature	19,490
6	2003.8.1-2003.8.11	Spain	Extreme high temperature	15,090
7	2003.8-2003.8	German	Extreme high temperature	9,355
8	2013.11.8-2013.11.8	Philippines	Tropical cyclone	7,354
9	2013.6.12-2013.6.27	India	Extreme flood	6,054
10	2007.11.15-2007.11.19	Bangladesh	Tropical cyclone	4,234

Table 3 lists the world' s top ten extreme weather disasters with the maximum direct economic losses from 2000 to 2021, which mainly occurred in economically developed coastal countries, and most of the disasters were tropical cyclones and extreme high temperatures. The total direct economic losses caused by the top ten extreme weather disasters were USD 777.8 billion, accounting for 53% of the global total direct economic losses, which was roughly equal to the sum of direct economic losses caused by all the other extreme weather disasters.

Table 3 Top ten extreme weather disasters in terms of global direct economic losses from 2000 to 2021

Ranking	Time	Country	Event type	Direct economic losses (USD 0.1 billion)
1	2005.8.29-2005.9.19	The United States	Tropical cyclone	1734
2	2017.8.25-2017.8.29	The United States	Tropical cyclone	1050
3	2021.6.26-2021.7.1	Canada	Extreme high temperature	1000
4	2021.6.26-2021.6.30	The United States	Extreme high temperature	1000
5	2017.9.19-2017.9.21	Puerto Rico	Tropical cyclone	916
6	2017.9.10-2017.9.28	The United States	Tropical cyclone	630
7	2011.8.5-2012.1.4	Thailand	Extreme flood	482
8	2021.7.12-2021.7.15	German	Extreme flood	400
9	2021.2.10-2021.2.20	The United States	Strong convection	300
10	2008.1.10-2008.2.5	China	Cold wave and winter storm	266

Note: The direct economic losses in the table are measured at the price level of 2021.

4 Comparison of losses and damage from extreme weather disasters between China and the rest of the world from 2000 to 2021

4.1 Comparison of extreme weather disaster-related deaths between China and the rest of the world from 2000 to 2021

Figure 5 shows the annual average number of extreme weather disaster-related deaths per million population in major countries and regions around the world from 2000 to 2021.

The average number of extreme weather disaster-related deaths per million population in China from 2000 to 2021 was 0.38; among the 77 countries and regions where extreme weather disasters were recorded, 65 countries and regions had a larger number of disaster-related deaths per million population than China, accounting for 84.42% of the total; when ranked from low to high according to the number of disaster-related deaths per million population, China was among the top 15.58% of the 77 countries and regions where extreme weather disasters occurred. Countries with a similar number of disaster-related deaths to China' s million population included South Korea (0.36), South Sudan (0.39), and Brazil (0.34).

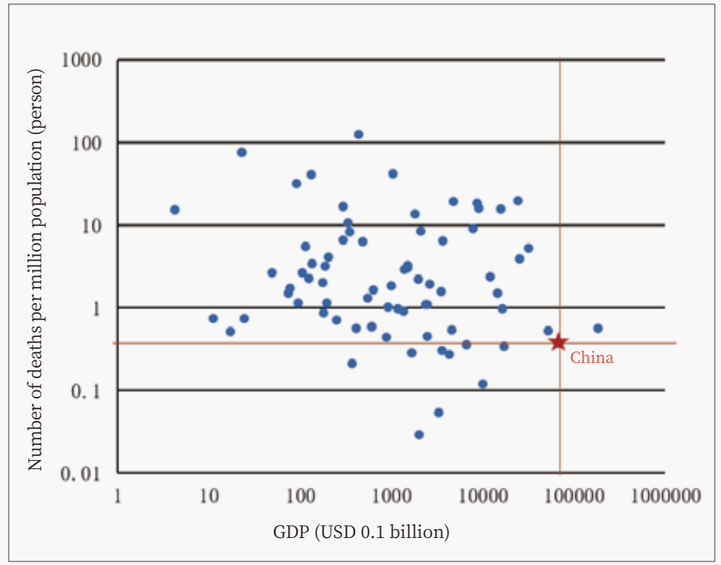
From the perspective of the relationship between the number of extreme weather disaster-related deaths per million population and the economic development level, China' s number of disaster-related deaths per million population was basically consistent with its economic development level from 2000 to 2021, and the count was above-average in the global range in ascending order. Among the countries with economic aggregates comparable to that of China, both the United States (0.57) and Japan (0.53) had a higher number of disaster-related deaths per million population than China. From the perspective of countries with a per capita GDP equivalent to that of China, Peru (3.3) and Columbia (1.1) had a higher number of disaster-related deaths per million population than China.

0.38

The annual average number of extreme weather disaster-related deaths per million population in China, 2000-2021

65

The number of countries and regions that had a larger number of disaster-related deaths per million population than China, 2000-2021



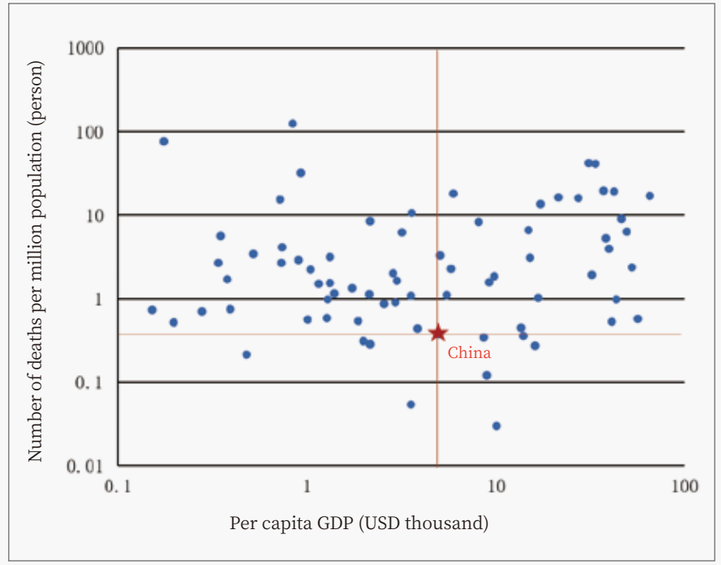


Figure 5 Comparison of annual average deaths caused by extreme weather disasters between China and the rest of the world from 2000 to 2021

Note:
Horizontal comparison between China and 77 countries and regions in the world;
China ranked in the top 15.58% in terms of the number of disaster-related deaths per million population in ascending order, which was in the upper-middle level;
China' s total GDP ranked second; per capita GDP ranked in the top 45%, which was in the upper-middle level;
The number of deaths among China' s millions of people 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 77 countries and regions around the world from 2000 to 2021 by the average number of the million population in the previous year. The population data come from the World Bank (https://data.worldbank.org/), and GDP data come from the GDP (in current USD) in 2020 released by the World Bank)

4.2 Comparison of direct economic losses from extreme weather disasters between China and the rest of the world from 2000 to 2021

Figure 6 shows the annual average direct economic losses from extreme weather disasters as a percentage of GDP in major countries and regions worldwide from 2000 to 2021.

China's annual average direct economic losses from extreme weather disasters accounted for 0.0023 of its GDP; among all the 77 countries and regions recorded, there were 17 countries and regions with a higher proportion of direct economic losses from extreme weather disasters in GDP than China, accounting for 22% of the total; when ranked by the proportion of direct economic losses in GDP in ascending order, China was among the top 72.73% of the 77 countries and regions recorded. Countries with the same proportion of direct economic losses from extreme disasters in GDP as China included Nepal (0.0022) and India (0.0028).

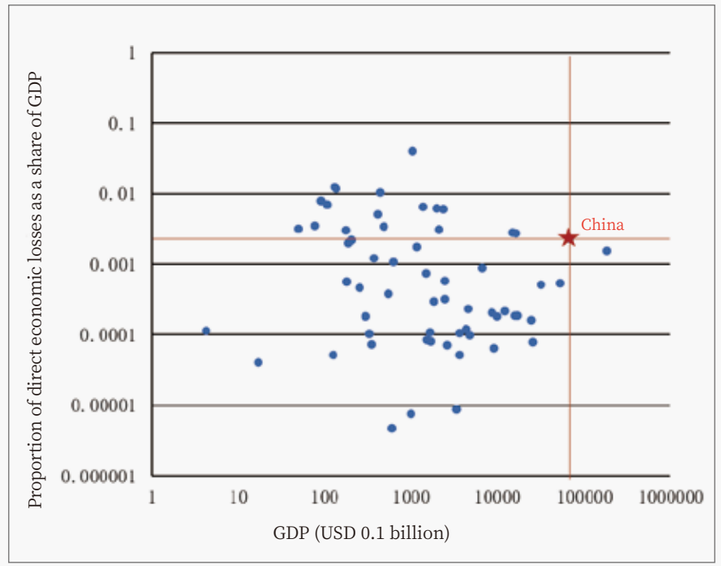
From the perspective of the relationship between the proportion of direct economic losses in GDP and the economic development level from 2000 to 2021, China's direct economic losses from extreme weather disasters were not consistent with its economic development level, and China ranked in the lower middle position of the global range in terms of the proportion of direct economic losses in GDP in ascending order. Among the countries with economic aggregates comparable to that of China, the United States (0.0016) and Japan (0.0005) had a lower proportion of direct economic losses in GDP than China. In terms of countries with a per capita GDP equivalent to that of China, the proportion of direct economic losses in GDP of Peru (0.0007) and Columbia (0.0006) was far lower than that of China.

0.0023

The annual average direct economic losses from extreme weather disasters as a percentage of GDP in China, 2000-2021

17

The number of countries and regions with a higher proportion of direct economic losses from extreme weather disasters in GDP than China, 2000-2021



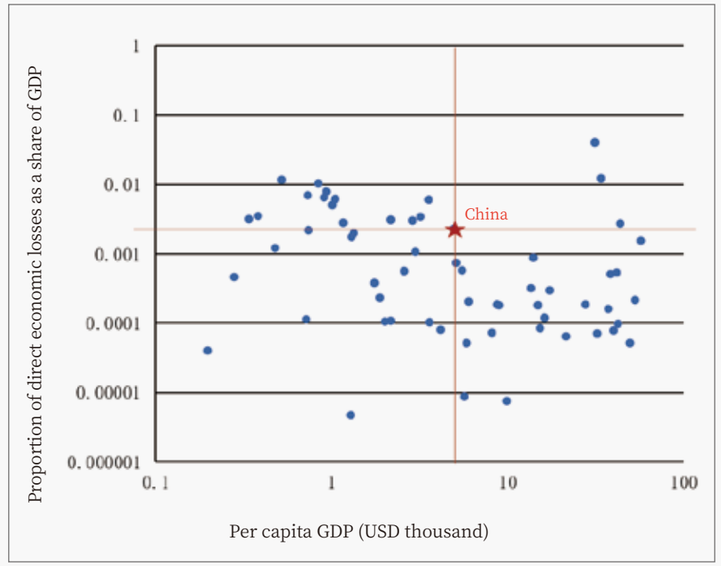


Figure 6 Comparison of annual average direct economic losses from extreme weather disasters as a percentage of GDP between China and the rest of the world from 2000 to 2021

Note:
Horizontal comparison between China and 77 countries and regions in the world;
China ranked in the top 72.73% in terms of direct economic losses as a percentage of GDP in ascending order, which was in the lower middle position;
China's total GDP ranked second; per capita GDP ranked in the top 45%, which was in the upper-middle level;
The proportion of direct economic losses in GDP did not match the economic strength.
(The proportion of direct economic losses in GDP shown in the figure is calculated by dividing the direct economic losses from extreme weather disasters in 77 countries and regions around the world from 2000 to 2021 by the average number of the total GDP of the previous year. The population data, GDP (in current USD), and per capita GDP (in current USD) come from the World Bank (https://data.worldbank.org/)).

05

Appendixes

Appendix I: Top 50 natural disasters in terms of global deaths and direct economic losses from 1991 to 2021
Appendix II: Judging criteria for the severity of disasters
Appendix III: Calculation method for comprehensive disaster index
Appendix IV: Socio-economic data sources and conversion methods

Appendix I Top 50 natural disasters in terms of global deaths and direct economic losses from 1991 to 2021

Top 50 natural disasters worldwide by death toll, 1991-2021

No.	Time	Countries or regions affected	Hazard type	Number of deaths (persons)	Direct economic losses (USD 0.1 billion, current year prices)
1	2010/1/12	Haiti	Earthquake	222570	80
2	2004/12/26	Indonesia	Earthquake	165708	44.516
3	1991/4/29-5/10	Bangladesh	Storm	138866	17.8
4	2008/5/2-3	Myanmar	Storm	138366	40
5	2008/5/12	China	Earthquake	87476	850
6	2005/10/8	Pakistan	Earthquake	73338	52
7	2010/6/-2010/8/	Russia	Extreme high temperature	55736	4
8	2004/12/26	Sri Lanka	Earthquake	35399	13.165
9	1999/12/15-12/20	Venezuela	Flood	30000	31.6
10	2003/12/26	Iran	Earthquake	26796	5
11	2003/7/16-8/15	Italy	Extreme high temperature	20089	44
12	2001/1/26	India	Earthquake	20005	26.23
13	2010/2/-2011/11/	Somalia	Drought	20000	0
14	2011/3/11	Japan	Earthquake	19846	2100
15	2003/8/1-8/20	France	Extreme high temperature	19490	44
16	1999/8/17	Turkey	Earthquake	17127	200
17	2004/12/26	India	Earthquake	16389	10.228
18	2003/8/1-8/11	Spain	Extreme high temperature	15090	8.8
19	1998/10/25-11/8	Honduras	Storm	14600	37.936
20	1999/10/28-10/30	India	Storm	9843	25
21	1993/9/29	India	Earthquake	9748	2.8
22	2003/8/-2003/8/	German	Extreme high temperature	9355	16.5
23	2015/4/25	Nepal	Earthquake	8831	51.74
24	2004/12/26	Thailand	Earthquake	8345	10
25	2013/11/8	The Philippines	Storm	7354	100
26	2020/06-08	United Kingdom, France, Belgium, Netherlands	Extreme high temperature	6340	0
27	2013/6/12-6/27	India	Flood	6054	11
28	1991/11/5-11/8	The Philippines	Storm	5956	1
29	2006/5/26	Indonesia	Earthquake	5778	31
30	1995/1/17	Japan	Earthquake	5297	1000
31	1998/5/30	Afghanistan	Earthquake	4700	0.1
32	2018/9/28	Indonesia	Earthquake	4340	14.5
33	2007/11/15-11/19	Bangladesh	Storm	4234	23
34	1997/11/2-11/4	Vietnam	Storm	3682	4.7
35	1998/7/1-8/30	China	Flood	3656	300
36	1998/10/25-11/8	Nicaragua	Storm	3332	9.877
37	2015/6/29-8/9	France	Extreme high temperature	3275	0
38	2010/4/14	China	Earthquake	2968	5
39	1998/6/9-6/11	India	Storm	2871	4.69
40	1996/6/30-7/26	China	Flood	2775	126
41	2004/9/17-9/18	Haiti	Storm	2754	0.5
42	2003/8/-2003/8/	Portugal	Extreme high temperature	2696	0
43	2004/5/23-6/1	Haiti	Flood	2665	0
44	2021/8/14	Haiti	Earthquake	2575	16.2
45	1998/5/26	India	Extreme high temperature	2541	0
46	1992/12/12	Indonesia	Earthquake	2500	1
47	1998/2/4	Afghanistan	Earthquake	2323	0.1
48	1997/10/19-11/17	Somalia	Flood	2311	0
49	2003/5/21	Algeria	Earthquake	2266	50
50	1999/9/21	China	Earthquake	2264	141

Top 50 natural disasters worldwide by direct economic losses, 1991-2021

No.	Time	Countries or r egions affected	Hazard type	Direct economic losses (USD 0.1 billion, current year prices)	Number of deaths (persons)
1	2011/3/11	Japan	Earthquake	2100	19846
2	2005/8/29-9/19	The United States	Storm	1250	1833
3	1995/1/17	Japan	Earthquake	1000	5297
4	2017/8/25-8/29	The United States	Storm	950	88
5	2008/5/12	China	Earthquake	850	87476
6	2017/9/20	Puerto Rico	Storm	680	64
7	2021/8/28-9/2	The United States	Storm	651	96
8	2017/9/10-9/28	The United States	Storm	570	58
9	2012/10/28	The United States	Storm	500	54
10	2021/7/12-7/15	German	Flood	417	242
11	2011/8/5-2012/1/4	Thailand	Flood	400	813
12	1998/7/1-8/30	China	Flood	300	3656
12	2010/2/27	Chile	Earthquake	300	562
12	2021/2/10-2021/2/20	The United States	Storm	300	235
12	2008/9/12-9/16	The United States	Storm	300	82
12	1994/1/17	The United States	Earthquake	300	60
17	2004/10/23	Japan	Earthquake	280	40
18	1992/8/24	The United States	Storm	265	44
19	2019/10/10-10/17	The United States	Wildfire	250	3
20	2016/6/28-7/13	China	Flood	220	289
21	2008/1/10-2/5	China	Extreme low temperature	211	129
22	1999/8/17	Turkey	Earthquake	200	17127
22	2016/4/16	Japan	Earthquake	200	49
22	2012/6/-2012/12/	The United States	Drought	200	0
25	2010/5/29-8/31	China	Flood	180	1691
25	2004/9/15-9/16	The United States	Storm	180	52
27	2019/10/12-10/17	Japan	Storm	170	99
27	2020/5/21-7/30	China	Flood	170	280
29	2021/6/1-2021/8/30	China	Flood	165	352
29	2018/11/8-11/16	The United States	Wildfire	165	88
31	2014/9/	India	Flood	160	298
31	2018/10/10-10/11	The United States	Storm	160	45
31	2005/9/23-10/1	The United States	Storm	160	10
31	2004/8/13	The United States	Storm	160	10
35	2012/5/20	Italy	Earthquake	158	7
36	2011/2/22	New Zealand	Earthquake	150	181
36	2020/5/20	India, Bangladesh	Storm	150	116
36	1995/8/1-9/8	South Korea	Flood	150	68
39	2005/10/24	The United States	Storm	143	4
40	1999/9/21	China	Earthquake	141	2264
41	2011/5/20-5/25	The United States	Storm	140	176
41	2018/9/12-9/18	The United States	Storm	140	53
43	1994/1/-1994/12/	China	Drought	138	0
44	2020/8/27-8/28	The United States	Storm	130	33
44	2017/10/8-10/20	The United States	Wildfire	130	30
46	2013/5/28-6/18	German	Flood	129	4
47	1996/6/30-7/26	China	Flood	126	2775
48	2018/9/4-9/5	Japan	Storm	125	17
48	2007/7/16	Japan	Earthquake	125	9
50	1993/6/24-8/23	The United States	Flood	120	48

Appendix II Judging criteria for the severity of disasters

1. Judging criteria for disaster indicators. The definition of overall mild disaster situation and overall significantly mild disaster situation are as follows:

Overall mild disaster situation: More than 50% of the major disaster indicators are lower than the average for the last 10 years (2011-2020).

Overall significantly mild disaster situation: The major disaster indicators are lower than the average for the last 10 years (2011-2020), with the decrease exceeding 30%.

2. Judging criteria for disaster index. The standard definition for the comparison of the disaster index is as follows:

The fluctuation of the disaster index within 10% of the multi-year average , is on the same level as the average year; 10%-30% up from the multi-year average, more severe than that of the average year; more than 30% up, significantly more severe; 10%-30% down from the multi-year average, lower than that of the average year; more than 30% down, significantly lower.

Appendix III Calculation method for comprehensive disaster index

The comprehensive disaster index has both temporal and spatial attributes, allowing for a quantitative assessment of the comprehensive disaster situation in a region in both temporal and spatial dimensions. The index is calculated based on the historical disaster data of various regions over a multi-year period, which takes into account both time-series variability and inter-regional diversity. In this report, the disaster index is mainly used to provide a quantitative assessment of the overall disaster situation at the national and provincial levels. The national-level disaster index is used to evaluate the overall disaster situation of a nation by year, and the provincial-level disaster index is used to evaluate the overall disaster situation of a province by year. The calculation methods are briefly described as follows. The comprehensive disaster index has both temporal and spatial attributes, allowing for a quantitative assessment of the comprehensive disaster situation in a region in both temporal and spatial dimensions. The index is calculated based on the historical disaster data of various regions over a multi-year period, which takes into account both time-series variability and inter-regional diversity. In this report, the disaster index is mainly used to provide a quantitative assessment of the overall disaster situation at the national and provincial levels. The national-level disaster index is used to evaluate the overall disaster situation of a nation by year, and the provincial-level disaster index is used to evaluate the overall disaster situation of a province by year. The calculation methods are briefly described as follows.

(I) Calculation method for national-level disaster index

1. Pretreatment of disaster indicators

The disaster indicators are divided into four dimensions of population, agriculture, housing, and economy. Among them, the indicators of the population dimension include affected population, deaths and missing persons, evacuated population, and the number of people who need assistance due to drought and drinking water difficulties; the indicators of the agriculture dimension include area of affected crops and area of destroyed crops; the indicators of housing dimension include the number of destroyed and damaged dwellings; the indicator of the economy dimension includes direct economic losses. First, normalize each disaster indicator in the three dimensions of population, agriculture and housing; convert the indicator of economy dimension by the GDP index and then normalize it. Refer to Part III of the Appendix for the conversion method. The normalization formula is (take the affected population as an example)

$$P_a^* = \frac{P_a}{\max P_a}$$

In this formula, P_a is the indicator of the affected population, max P_a is the maximum value of this indicator in the time series, and P_a^* is a normalized indicator.

2. Calculation of the dimension index

For each year in the historical series, calculate separately the index of each dimension of the overall national disaster situation in each year, namely the geometric mean of the normalized disaster indicators within the dimension, and the calculation formula is

$$I_P = (P_a^*)^{W_{pa}} (P_d^*)^{W_{pd}} (P_t^*)^{W_{pt}} (P_w^*)^{W_{pw}}$$
$$I_C = (C_a^*)^{W_{ca}} (C_d^*)^{W_{cd}}$$
$$I_H = (H_c^*)^{W_{hc}} (H_d^*)^{W_{hd}}$$
$$I_E = E^*$$

Refer to Attachment 1 and Attachment 2 for the meaning and weight of each symbol.

3. Calculation of the comprehensive disaster index

For a given year, the comprehensive disaster index for that year (denoted by I) is the geometric mean of the normalized indicators of its four dimensions, and the formula is

$$I = (I_P^*)^{W_P} (I_C^*)^{W_C} (I_H^*)^{W_H} (I_E^*)^{W_E}$$

Among them, I_P^*, I_C^*, I_H^* and I_E^* are respectively the values of I_P, I_C, I_H and I_E normalized using the method in the first step, and W_P, W_C, W_H and W_E are respectively the weights of the corresponding dimension indexes (Attachment 2).

Attachment 1 Disaster indicators and dimension index symbols for the calculation of national-level comprehensive disaster index

Dimension index	Symbol	Normalized symbol	Disaster indicator	Symbol	Normalized symbol
Dimension index of population	I_P	I_P^*	Affected population	P_a	P_a^*
			Number of deaths and missing persons	P_d	P_d^*
			Evacuated population	P_t	P_t^*
			Number of people who need assistance due to drought and drinking water difficulties	P_w	P_w^*
Dimension index of agriculture	I_C	I_C^*	Area of affected crops	C_a	C_a^*
			Area of destroyed crops	C_d	C_d^*
Dimension index of housing	I_H	I_H^*	Number of collapsed dwellings	H_c	H_c^*
			Number of damaged dwellings	H_d	H_d^*
Dimension index of economy	I_E	I_E^*	Direct economic losses	E	E^*

Attachment 2 Weight symbols and assignment for the calculation of national-level comprehensive disaster index

Dimension index	Weight symbol	Weight assignmen
Dimension index of population	W_P	0.35
Dimension index of agriculture	W_C	0.20
Dimension index of housing	W_H	0.35
Dimension index of economy	W_E	0.10

Dimension indicator	Weight symbol	Weight assignment
Affected population	W_{pa}	0.20
Number of deaths and missing people	W_{pd}	0.40
Evacuated population	W_{pt}	0.20
People who need assistance due to drought and drinking water difficulties	W_{pw}	0.20
Area of affected crops	W_{ca}	0.30
Area of destroyed crops	W_{cd}	0.70
Number of collapsed dwellings	W_{hc}	0.70
Number of damaged dwellings	W_{hd}	0.30

(II) Calculation method for provincial-level disaster index

The provincial-level disaster index is used to provide a quantitative assessment of the overall disaster situation of each year since 2000 in each province, and a single assessment object is the overall disaster situation of a given year in a given province. The calculation process of the provincial-level disaster index is the same as that of the national-level disaster index, and the distinctions in each step are briefly described as follows.

1. Pretreatment of disaster indicator

Since the disaster indicators of some provinces in some years are zero (not affected), in order to ensure that zeros are not used in the geometric mean in the index calculation, the normalization of provincial-level disaster indicators adopts the following formula (take the affected population as an example)

$$P_a^* = 1 + \ln\left(1 + \frac{P_a}{\max P_a}\right)$$

2. Calculation of the dimension index

The calculation formulas of the provincial-level dimension indexes of agriculture, housing, and economy are the same as those of the national level. The calculation of the dimension index of the population does not include the population that needs assistance due to drought and drinking water difficulties. The formula is as follows

$$I_P = (P_a^*)^{W_{pa}} (P_d^*)^{W_{pd}} (P_t^*)^{W_{pt}}$$

3. Calculation of the comprehensive disaster index

The calculation formula of the provincial-level comprehensive disaster index is

$$I = (I_P^*)^{W_P} (I_C^*)^{W_C} (I_H^*)^{W_H} (I_E^*)^{W_E} - 1$$

The meaning of each symbol and the normalization method of each dimension indicator in the calculation of the provincial-level disaster index are the same as those of the national-level disaster index. Except for the indicators of the population dimension, the weights of all dimension indicators and disaster indicators are also calculated in the same way as the national-level disaster index. Refer to Attachment 3 for the weight assignment for the calculation of the indicators of the population dimension.

Attachment 3 Weight assignment of the population dimension for the calculation of provincial-level comprehensive disaster index

Dimension indicator	Weight symbol	Weight assignment
Affected population	W_{pa}	0.25
Number of deaths and missing persons	W_{pd}	0.50
Evacuated population	W_{pt}	0.25

Appendix IV Socio-economic data sources and conversion methods

1. Total population (year-end), gross domestic product (GDP) and the permanent resident population by province (year-end), and gross regional product (GRP) from 2001 to 2020 are sourced from annual data on the website of the National Bureau of Statistics of China.

2. The national total population at the end of 2021 is 1.4126 billion according to the preliminary statistics published by the National Bureau of Statistics of China on January 17, 2022. The total population of each province (autonomous region and municipality directly under the central government) at the end of 2021 is calculated by using the national natural population growth rate of 0.34‰ in the above-mentioned data.

Total population of a region at the end of 2021 = Total population of a region at the end of 2020 × (1 + 0.34‰)

3. GDP for 2021 is CNY 114.367 trillion according to the preliminary data from the National Bureau of Statistics of China on January 17, 2022. GRP for 2021 is calculated by using the national growth rate of 8.1% in the above-mentioned data.

GRP for 2021 = GRP for 2020 × (1+8.1%)

4. The GDP for 2001-2020 and the direct economic losses from various disasters in the country in that year are converted according to the GDP index published by the National Bureau of Statistics of China and based on the 2021 price level. It is calculated as follows:

Converted value of GDP for that year= GDP for that year × (1 + the cumulative value of GDP index for that year relative to 2021)

In the formula, “the cumulative value of the GDP index for that year relative to 2021” is the continued products of the GDP indexes (the value for the previous year is 1) from the year following that year to 2021. No need to convert GDP for 2021; the cumulative value of conversion for 2020 is the GDP index for 2021 (in this report data of 2020 was used instead); in other years, take the year 2010 as an example, the cumulative value of conversion is the continued products of the GDP indexes from 2011 to 2020.

The GRP of each province in China from 2001 to 2020 and the direct economic losses of various disasters in each province in that year are converted by using the above method and replacing the GDP index with the GRP index of that province.

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