2023 GLOBAL NATURAL DISASTER ASSESSMENT REPORT

October 2024

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Integrated Research on Disaster Risk

Executive Summary

Compared with the average for the last 30 years (1993-2022), the frequency of global natural disasters was 3% less in 2023, the affected population was 53% less, the death population was 73% more, but the direct economic loss was 32% higher. Flood disasters were the most frequent with a total of 152 times, 3.5% more than the historical average, affecting the largest number of people at 32,392,800, 66% less than the historical average. The direct economic losses caused by storm disasters were the largest, at about USD 100.845 billion, 50% more than the historical average. Seismic activities increased, causing the largest number of deaths at 62,451, 140% more than the historical average. The number of deaths from wildfire disasters increased and the direct economic losses were 41% higher than the historical average. The occurrence of landslides increased, resulting in 30% fewer deaths, 35% less affected population than the historical average, and 100% lower direct economic loss. Regionally, Asia had the highest frequency of natural disasters in 2023, followed by South America and Africa. Asia was the continent with the largest number of deaths due to disasters, followed by Africa. Asia had the highest economic losses due to disasters, followed by North America. Developing countries were more affected by natural disasters than developed countries, mainly by floods, storms and earthquakes.

The Special Report found that natural disasters in China in 2023 were mainly floods, typhoons and geological disasters, while droughts, hailstorms, freezing and snow disasters, earthquakes, sandstorms and forest and grassland fires also occurred to varying degrees. Disaster losses throughout the year read an affected population of over 95 million, death and missing toll of 691 people, an evacuated population of 3.343 million; collapsed housing of 209,000 rooms, with another 2.06 million rooms damaged to varying degrees; affected crops of 10,539.3 thousand hectares; and direct economic losses of CNY 345.45 billion.

The Special Report found that under the combined influence of heat wave hazard and population exposure, the population heat wave risk in areas such as the Gangetic Plain of the Indian Peninsula is relatively high, with most areas exceeding 5×10^4 person-days; the population heat wave risk in central and western Africa, eastern and western Asia is slightly higher, with some areas exceeding 2×10^4 person-days; the population heat wave risk in Europe, southeastern North America, and southeastern South America is relatively low, with most areas less than 0.5×10^4 person-days. This not only reflects the characteristics of the impact of heat waves on different regions around the world, but also highlights the urgency and necessity of the world's joint response to heat wave disasters.

The Special Report assessed the earthquake that struck Türkiye in February 2023 and found that this typical and rare “twin shock” earthquake and its frequent and high magnitude aftershocks have become one of the world’ s deadliest and most economically damaging earthquake disasters in the past two decades. Due to the fact that there were a large number of bricks and concrete buildings and few frame structures in the earthquake area, and the buildings were not designed to adequately resist seismic forces during earthquakes, the 2023 earthquake leads to the collapse of a large number of buildings that were claimed to “meet the seismic standards”, which increased the probability of casualties.

The frequency of global natural disasters was 3% less

The affected population was 53% less

The death population was 73% more

The direct economic loss was 32% higher

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General Report Global Natural Disasters in 2023

1 Overview of global natural disasters in 2023

A total of 326 major natural disasters (excluding epidemics and infestations) occurred worldwide in 2023, affecting 117 countries and regions. Among all these disasters, 152 were caused by floods, with the highest frequency, accounting for 46.63% of the total; 88 caused by storms (typhoons, hurricanes), accounting for 26.99%; 27 by earthquakes, accounting for 8.28%; 19 by landslides, accounting for 5.83%; 16 by wildfires, accounting for 4.91%; 9 by droughts, accounting for 2.76%; 8 by extreme temperatures, accounting for 2.45%; 4 by volcanic eruptions, accounting for 1.23%; and 3 by avalanches, accounting for 0.92% (Table 1 and Figure 1).

Table 1 The Frequency and losses of natural disasters worldwide in 2023

Type of disaster	Frequency (time)/%	Deaths (persons)/%	Population affected (tens of thousands)/%	Direct economic losses (USD 0.1 billion)/%
Flood	152/46.63	7763/8.98	3239.28/34.81	203.69/10.05
Storm	88/26.99	14666/16.96	1731.25/18.61	1008.45/49.76
Earthquake	27/8.28	62451/72.22	2024.67/21.76	519.38/25.63
Drought	9/2.76	247/0.29	2175.81/23.38	221/10.91
Landslide	19/5.83	604/0.7	15.03/0.16	0/0
Wildfire	16/4.91	263/0.3	11.74/0.13	68.5/3.38
Extreme temperatures	8/2.45	406/0.47	103.21/1.11	5.5/0.27
Volcanic eruption	4/1.23	23/0.03	4.24/0.05	0/0
Avalanche	3/0.92	50/0.06	0.01/0.00	0/0
Total	**326/100**	**86473/100**	**9305.24/100**	**2026.52/100**

*Note: The global natural disaster data come from the EM-DAT of the Université catholique de Louvain (UCLouvain), Belgium; and the time period is from January 1, 2023 to December 31, 2023, and the data was download on 25 March, 2024, the same hereinafter. Data of 0 indicates low or missing values, the same hereinafter.

A total of 86,473 people were killed by major natural disasters worldwide in 2023, of which 62,451 died from earthquakes, accounting for the most proportion of the total number at 72.22%; 14,666 from storms, accounting for 16.96%; 7,763 from floods, accounting for 8.98%; 604 from landslides, accounting for 0.7%; 406 from extreme temperatures, accounting for 0.47%; 263 from wildfires, accounting for 0.3%; 247 from droughts, accounting for 0.29%; 50 from avalanches, accounting for 0.06%; and 23 from volcanic eruptions, accounting for 0.03%.

A total of 93.0524 million people were affected by major natural disasters globally in 2023, of which 32.3928 million were affected by floods, accounting for the most proportion of the total number at 34.81%; 21.7581 million by droughts, accounting for 23.38%; 20.2467 million by earthquakes, accounting for 21.76%; 17.3125 by storms, accounting for 18.61%; 1.0321 million by extreme temperatures, accounting for 1.11%; 150,300 by landslides, accounting for 0.16%; 117,400 by wildfires, accounting for 0.13%; 42,400 by volcanic eruptions, accounting for 0.05%; and 100 by avalanches.

A total of USD 202.652 billion in direct economic losses were caused by major natural disasters worldwide in 2023, of which 49.76% were caused by storms, reaching USD 100.845 billion, accounting for the most proportion of the total amount; 25.63% by earthquakes, reaching USD 51.938 billion; 10.91% by droughts, reaching USD 22.1 billion; 10.05% by floods, reaching USD 20.369 billion; 3.38% by wildfires, reaching USD 6.85 billion; and 0.27% by extreme temperatures, reaching USD 550 million.

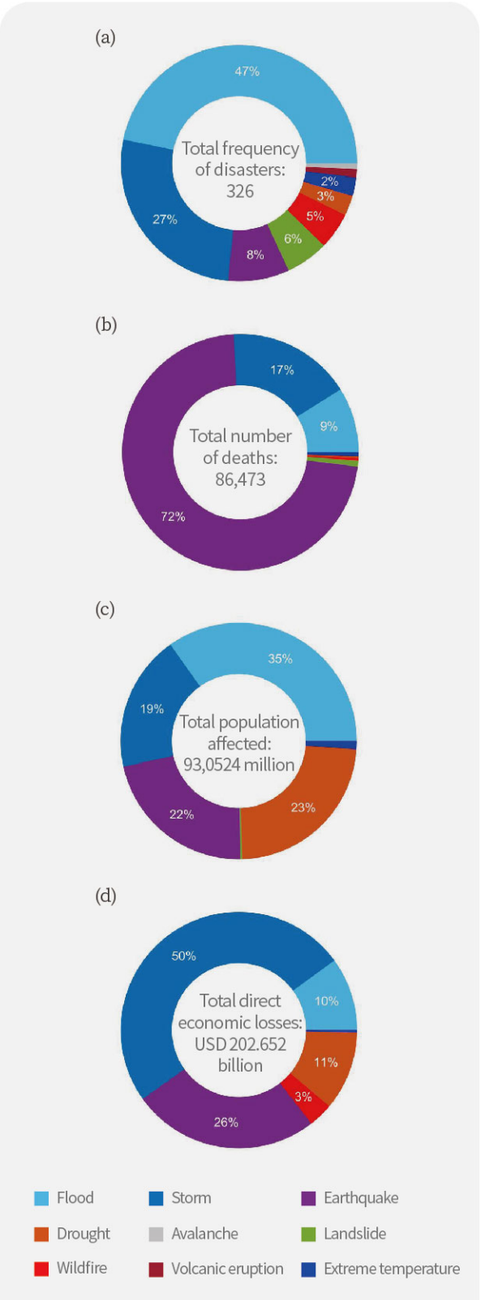


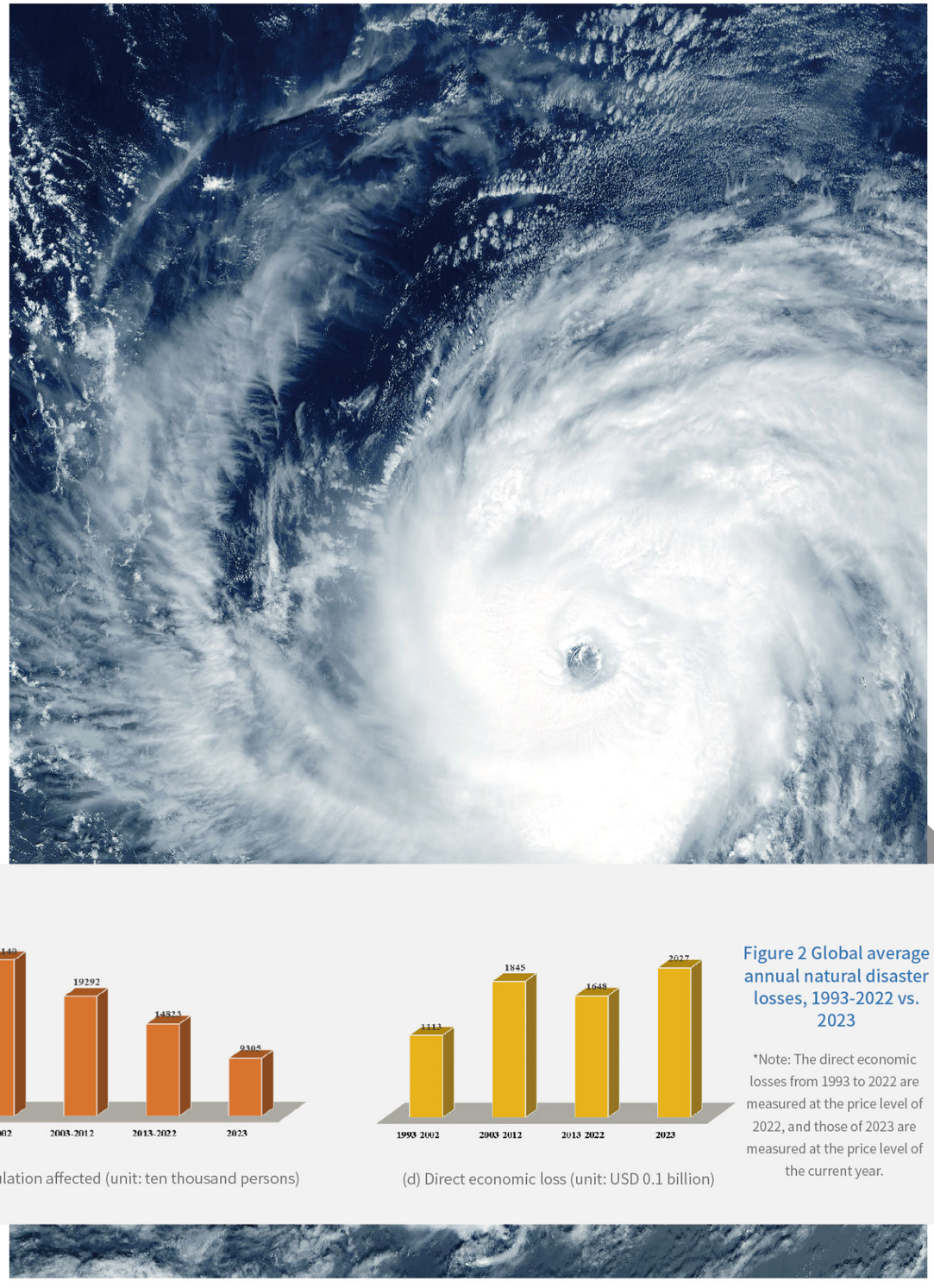
Figure 1 Breakdown of frequency and losses per disaster type worldwide in 2023

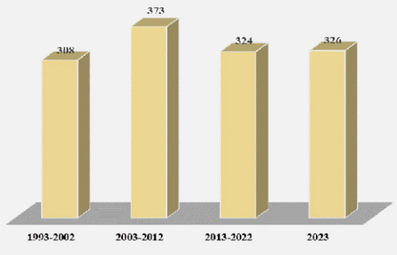
2 Characteristics of global natural disasters in 2023

2.1 The overall economic losses from natural disasters were relatively large, and the death toll increased

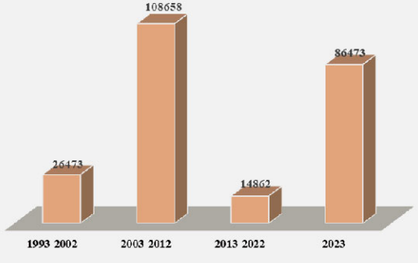
In 2023, a total of 326 major natural disasters occurred worldwide, killing 86,473 people, affecting 93.05 million people, and causing direct economic losses of USD 202.65 billion. Compared with the average for the last 30 years (1993-2022), the frequency of major natural disasters was 3% less in 2023, the death toll was 73% more, and the affected population was 53% less but the direct economic loss was 32% larger. Compared with the average for the last 10 years (2013-2022), the frequency of major natural disasters was 1% higher in 2023, the death toll was 482% higher, the affected population was 37% less and the direct economic loss was 23% larger (Figure 2).

In 2023, catastrophes occurred with about the same frequency and at an overall lower level compared with the averages for the last 10 years and 30 years, but caused greater direct economic losses. In 2023, there were six natural disasters with more than 1,000 deaths caused per disaster globally, more than the annual average for the last 30 years, and there was one natural disaster with more than 10,000 deaths (while 20 such natural disasters were recorded in the last 30 years). In 2023, there were three natural disasters worldwide with direct economic losses of more than USD 10 billion per disaster worldwide, slightly higher than the annual average for the last 30 years, and no disaster that caused direct economic losses exceeding USD 50 billion. There have been eight disasters exceeding USD 50 billion at a time in the past 30 years, three of which exceeded USD 100 billion.





(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)

(c) Population affected (unit: ten thousand persons)

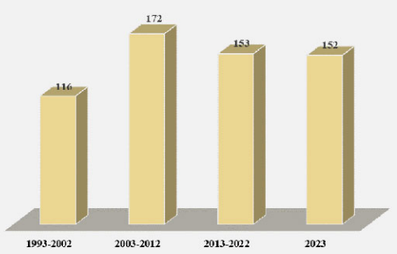
(d) Direct economic loss (unit: USD 0.1 billion)

Figure 2 Global average annual natural disaster losses, 1993-2022 vs. 2023

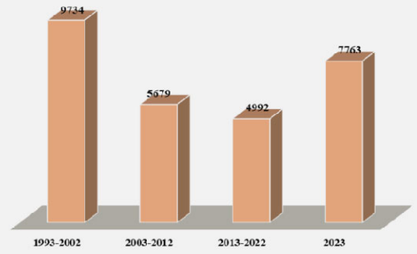
*Note: The direct economic losses from 1993 to 2022 are measured at the price level of 2022, and those of 2023 are measured at the price level of the current year.

2.2 Floods were the most frequent, resulting in many deaths

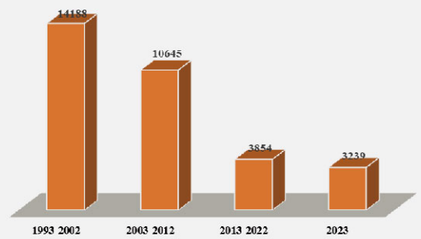
In 2023, a total of 152 major floods occurred worldwide, accounting for 47% of the total number of major disasters of the year; killed 7,763 people, accounting for about 9% of the death toll; affected 32.39 million people, accounting for 35% of the total population affected by disasters, a decrease of about 44% from 57.53 million in 2022; and caused direct economic losses of USD 20.4 billion, accounting for about 10% of the total direct economic losses. Compared with the average for the last 30 years (1993-2022), the frequency of floods was 4% higher in 2023, the death toll was 14% higher, the affected population was 66% less, and the direct economic loss was 46% less. Compared with the average for the last 10 years (2013-2022), the frequency of floods was 1% less in 2023, the death toll was 56% higher, the affected population was 16% less, and the direct economic loss was 50% less (Figure 3). In 2023, there were two floods with more than 1,000 deaths caused per disaster globally, one of which killed 2,970 people. Countries such as India in Asia suffered severe flooding, with thousands of lives lost in floods or heavy rains during the monsoon period.



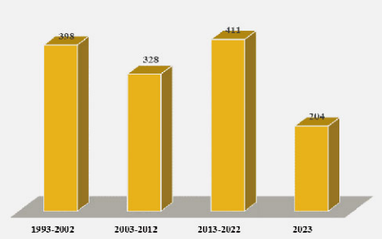
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



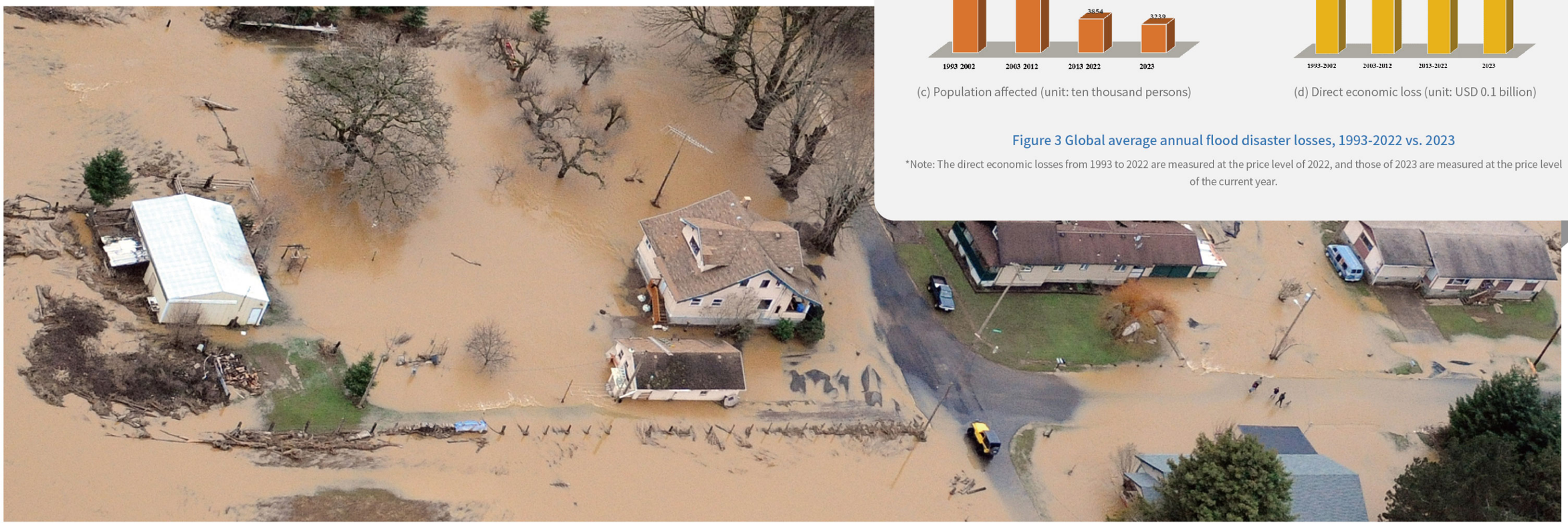
(c) Population affected (unit: ten thousand persons)



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

Figure 3 Global average annual flood disaster losses, 1993-2022 vs. 2023

*Note: The direct economic losses from 1993 to 2022 are measured at the price level of 2022, and those of 2023 are measured at the price level of the current year.



2.3 Storms resulted in large direct economic losses and high death toll

In 2023, a total of 88 major storms occurred worldwide, accounting for 27% of the total number of major disasters of the year; killed 14,666 people; affected 17.31 million people; and caused direct economic losses of USD 100.8 billion, accounting for 50% of the total direct economic losses caused by disasters. Compared with the average for the last 30 years (1993-2022), the frequency of storms was 6% less in 2023, the death toll was 67% larger, the affected population was 45% less, but the direct economic loss was 50% larger. Compared with the average for the last 10 years (2013-2022), the frequency of storms was 1% higher in 2023, the death toll was 513% larger, the affected population was 45% less, and the direct economic loss was 6% larger (Figure 4).

88

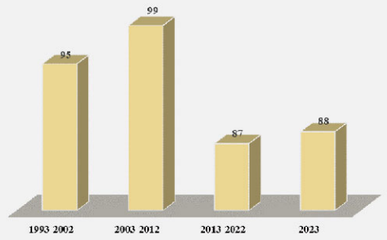
In 2023, a total of 88 major storms occurred worldwide

14,666

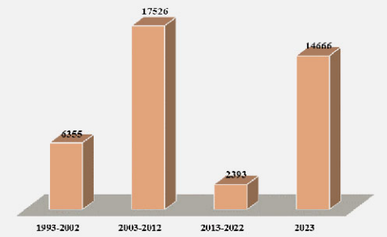
Killed 14,666 people

100.8

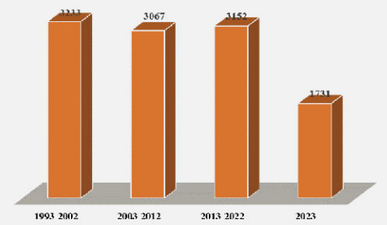
Caused direct economic losses of USD 100.8 billion



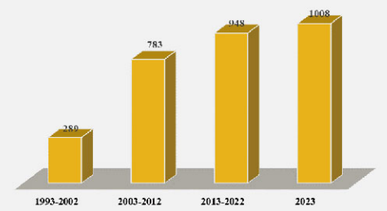
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand persons)



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

Figure 4 Global average annual storm disaster losses, 1993 -2022 vs. 2023

*Note: The direct economic losses from 1993 to 2022 are measured at the price level of 2022, and those of 2023 are measured at the price level of the current year.

2.4 More seismic activities and larger disaster losses

In 2023, there were 27 major earthquakes worldwide, accounting for 8% of the total number of major disasters of the year. Deaths from earthquakes accounted for about 72% of the total deaths from natural disasters; the affected people accounted for about 22%; and the direct economic losses accounted for about 26%. Compared with the average for the last 30 years (1993-2022), the frequency of earthquakes was 8% higher in 2023, the death toll was 140% larger, the affected population was 325% larger, and the direct economic loss was 53% larger. Compared with the average for the last 10 years (2013-2022), the frequency of earthquakes was 8% higher in 2023, the death toll was 2,627% larger, the affected population was 613% larger, and the direct economic loss was 358% larger (Figure 5). In 2023, there were two earthquakes with a magnitude of 7.8, causing heavy damage.

27

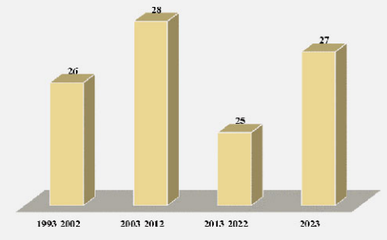
In 2023, there were 27 major earthquakes worldwide

72 %

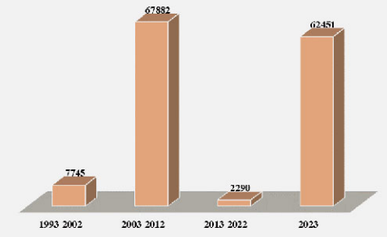
Deaths from earthquakes accounted for about 72% of the total deaths from natural disasters

26%

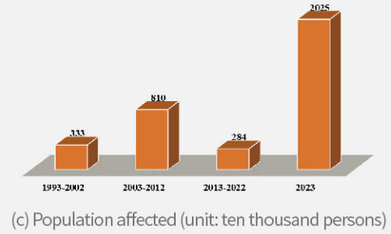
The direct economic losses accounted for about 26%



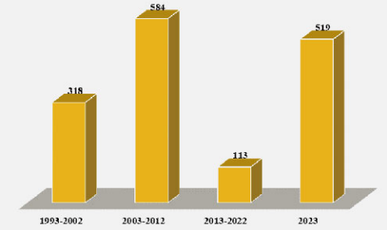
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand persons)



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

Figure 5 Global average annual earthquake disaster losses, 1993-2022 vs. 2023

*Note: The direct economic losses from 1993 to 2022 are measured at the price level of 2022, and those of 2023 are measured at the price level of the current year.

2.5 More frequent wildfires with larger death toll

There were 16 wildfires that caused large losses in 2023, slightly higher than the level of recent years (an average of 12 times a year for the last 30 years and an average of 11 times a year for the last 10 years). Compared with the average for the last 30 years (1993-2022), the death toll from wildfires in 2023 was 195% larger, the affected population was 54% less, and the direct economic loss was 41% larger. Compared with the average for the last 10 years (2013-2022), the death toll from wildfires in 2023 was 118% larger, the affected population was 45% less, and the direct economic loss was 18% less (Figure 6). On August 9, 2023, a large-scale wildfire disaster broke out in Maui, Hawaii, and other places, resulting in 128 deaths, making the death toll from wildfires in 2023 higher than the annual average of the past 30 years and the annual average of the past 10 years.

16

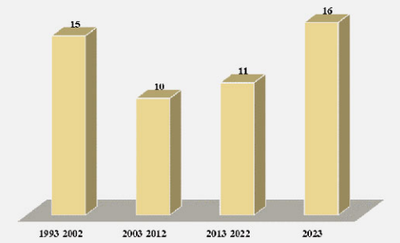
There were 16 wildfires that caused large losses in 2023

195 %

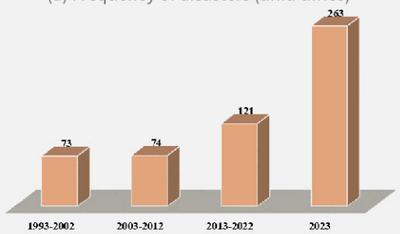
The death toll from wildfires in 2023 was 195% larger

54 %

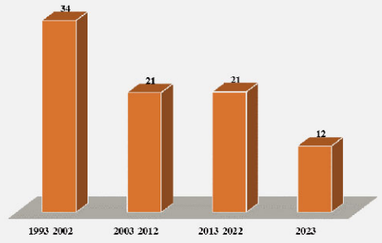
The affected population was 54% less



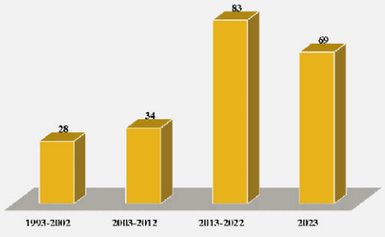
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand persons)



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

Figure 6 Global average annual wildfire losses, 1993-2022 vs. 2023

*Note: The direct economic losses from 1993 to 2022 are measured at the price level of 2022, and those of 2023 are measured at the price level of the current year.

2.6 Less frequent landslides and less death toll

A total of 19 major landslides occurred in 2023, accounting for about 6% of the total number of major disasters. Compared with the average for the last 30 years (1993-2022), the frequency of landslides increased by 4% in 2023, the number of deaths from landslides was 30% less, the number of affected people was 35% less, and the direct economic losses were 100% less. Compared with the average for the last 10 years (2013–2022), the frequency of landslides was 16% more in 2023, the number of deaths from landslides was 13% less, the number of affected people was 44% more, and the direct economic losses were 100% less (Figure 7).

19

A total of 19 major landslides occurred in 2023

4 %

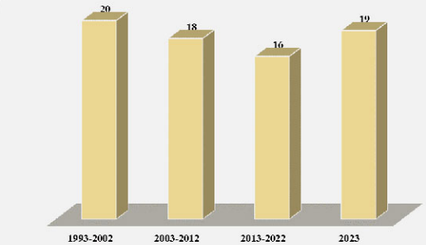
The frequency of landslides increased by 4% in 2023

30 %

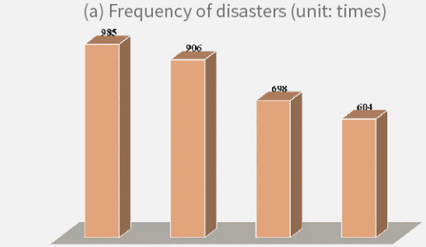
The number of deaths from landslides was 30% less

100 %

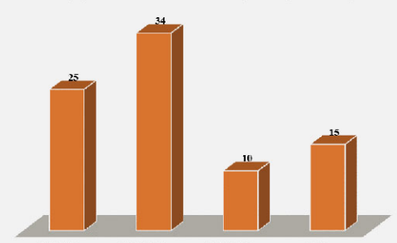
The direct economic losses were 100% less



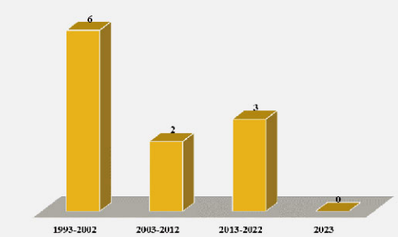
(a) Frequency of disasters (unit: times)



(b) Number of deaths (unit: persons)



(c) Population affected (unit: ten thousand persons)



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

Figure 7 Global average annual landslide losses, 1993-2022 vs. 2023

*Note: The direct economic losses from 1993 to 2022 are measured at the price level of 2022, and those of 2023 are measured at the price level of the current year.

3 Global patterns of natural disasters in 2023

3.1 Spatial pattern of global natural disasters in 2023

In 2023, the major types of natural disasters occurring globally were 1) meteorological and hydrological disasters, such as floods and storms, and 2) geohazards, including earthquakes and geological disasters (Figure 8). Flood was the most frequent of all types of natural hazards around the world in 2023. There were 152 floods in total that cumulatively affected 76 countries and regions, mainly in Asia, the Americas, and Africa. Storm was the second with a total of 88 occurrences, which cumulatively affected 70 countries, mainly in Asia, Europe, and the Americas. 27 earthquakes were registered, cumulatively affecting 17 countries, mainly in Asia. 22 landslides were recorded with 16 countries cumulatively affected, mainly in Asia. 16 wildfires occurred and cumulatively affected 13 countries, mainly in the Americas and Europe. Nine droughts occurred and cumulatively affected 10 countries, mainly in the Americas. Eight extreme temperature disasters cumulatively affected eight countries, mainly in Asia. Four volcanic eruptions occurred and cumulatively affected three countries, mainly in South-East Asia.

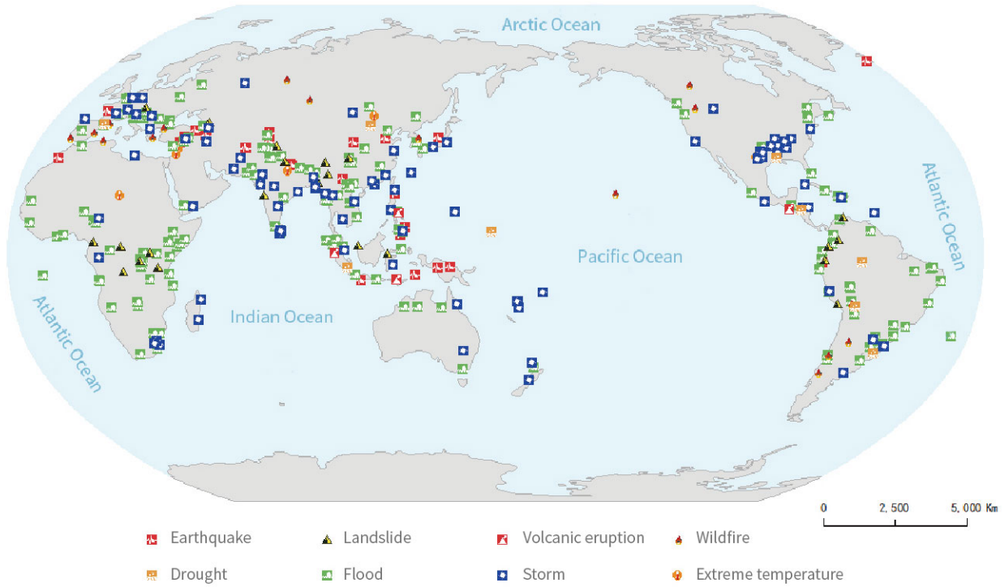


Figure 8 Spatial pattern of global natural disasters, 2023

3.2 Natural disasters by continent in 2023

Figure 9 shows the statistical results of the frequency of disasters, the number of deaths attributed to disasters, and the direct economic losses in all continents from January 1 to December 31, 2023. Among the 326 natural disasters included in the statistics, Asia had the largest number of disaster events, with 138 occurrences, accounting for 42.33%. This was followed by South America and Africa, with 63 and 54 events (19.33% and 16.56%, respectively). Europe and South America had a similar number of disasters, with 33 and 28 events (10.12% and 8.59%, respectively). Oceania had the least number of disasters. In terms of the number of deaths attributed to disasters, Asia had the largest number with 63,445 in total, accounting for 73.37% of the global total, and Africa ranked second, with 21,304 deaths, accounting for 24.64% of the total. Among all major disasters, 21 caused more than 100 deaths each (10 in Asia, 8 in Africa, 2 in North America, and 1 in South America). There were 7 catastrophic events that caused more than 1,000 deaths each. The most serious one was the earthquake in Syria and Türkiye in Asia in February, with a total of 56,683 deaths (as of 25 March, 2024). In terms of economic losses, Asia suffered the largest direct disaster economic losses (USD 75.917 billion), accounting for 37.46% of the global economic losses caused by natural disasters. This is followed by North America with economic losses of USD 68.525 billion, accounting for 33.81% of the total global economic losses. The direct economic losses caused by disasters in Asia and North America summed up to nearly 71.3% of the global total. The disaster events that caused direct economic losses of more than USD 0.1 billion at a time occurred mostly in North America (25), South America (13), and Asia (12). In addition, 13 such disaster events occurred in other parts of the world (7 in Europe, 3 in Oceania, and 3 in Africa). The biggest loss was caused by the earthquake that struck Syria and Türkiye in Asia in February, resulting in total direct economic losses of USD 42.9 billion.

326

Among the 326 natural disasters included in the statistics

138

Asia had the largest number of disaster events, with 138 occurrences

63,445

Asia had the largest number with 63,445 in total

73.27 %

Accounting for 73.37% of the global total

75.917 USD billion

Asia suffered the largest direct disaster economic losses (USD 75.917 billion)

37.46 %

Accounting for 37.46% of the global economic losses caused by natural disasters

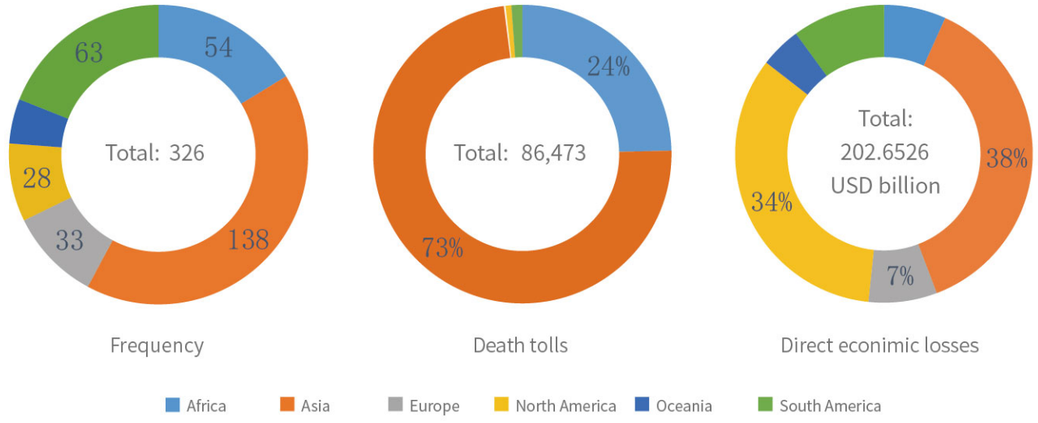


Figure 9 Statistics on the frequency of natural disasters, death tolls and direct economic losses by continent, 2023

*Note: The data come from the EM-DAT of the Université catholique de Louvain (UCLouvain), Belgium; and the time period is from January 1, 2023 to December 31, 2023. Five hurricane events occurred across continents (one in Oceania-Asia, three in Asia-Europe, and one in North America-South America) and one flood event occurred across continents (Europe-Asia). Each was counted as one event for the two hit continents when we counted up the number of disasters by continent; and was counted as a single disaster when we counted up the total number of disasters across the world.

3.3 Natural disasters in countries or regions in 2023

Figures 10, 11 and 12 show the spatial distribution of the frequency of natural disasters[1], the number of deaths, and direct economic losses for each country or region in the year of 2023 respectively. Tables 2 and 3 respectively list the top 10 countries in terms of the frequency of disasters, the death toll and mortality rates, direct economic losses, and loss rates. The top 10 countries with the highest frequency of disasters were mainly located in Southern and Southeastern Eurasia. Among them, the United States had the highest number at 25, followed by China and India both at 17. Brazil ranked fourth at 16. The countries with a larger number of disaster-related deaths were mainly located in West, South, and Southeast Asia. The death tolls in the top 10 countries all surpassed 300. Among them, Türkiye had the largest number at 50,840, followed by Libya at 12,352. Among the top ten countries with the largest number of deaths per million people, Libya ranked the first with 181,318 deaths; and Guatemala ranked the tenth, with 9.45 deaths. The number of deaths per million people in China was 0.27. The countries with higher direct economic losses were mainly located in East and West Asia and Southern North America. The top ten countries all had direct economic losses of more than USD 4 billion, of which the United States had the most, at USD 68.16 billion, followed by Türkiye and China at USD 34.025 billion and USD 29.55 billion respectively. In terms of the proportion of direct economic losses in GDP of the previous year, all countries were below 1% except Libya, Morocco, Malawi, Türkiye, Myanmar, Haiti, and New Zealand. Among the top 10 countries with the highest share of economic losses, Libya accounted for the most direct economic losses, reaching 13.55%, and Italy had the lowest proportions, at 0.48%.

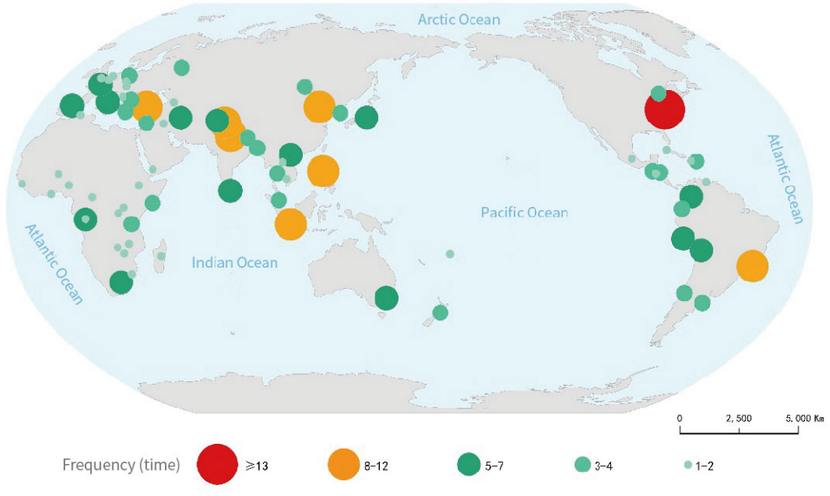


Figure 10 Spatial distribution of the frequency of natural disasters by country/region globally in 2023

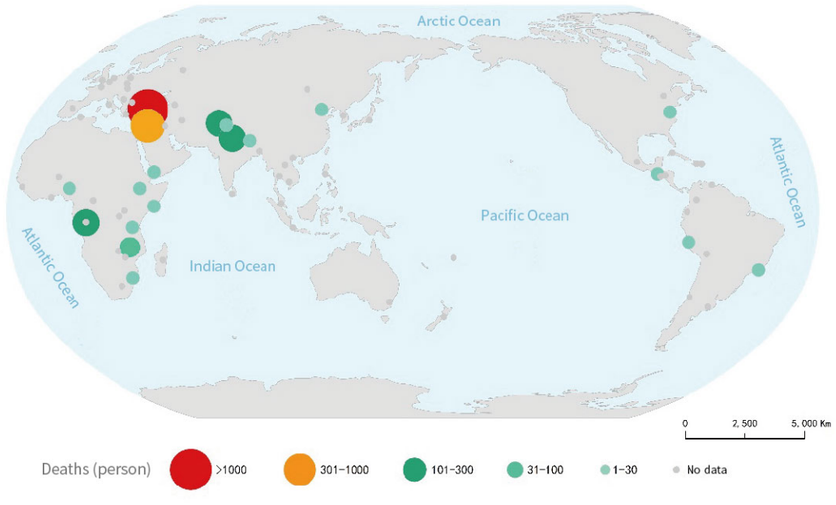


Figure 11 Spatial distribution of the death toll from natural disasters by country/region globally in 2023

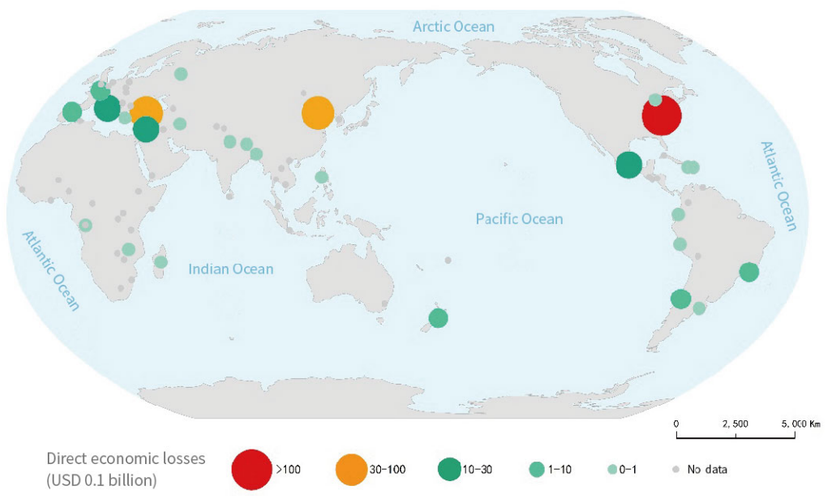


Figure 12 Spatial distribution of direct economic losses from natural disasters by country/region globally in 2023

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

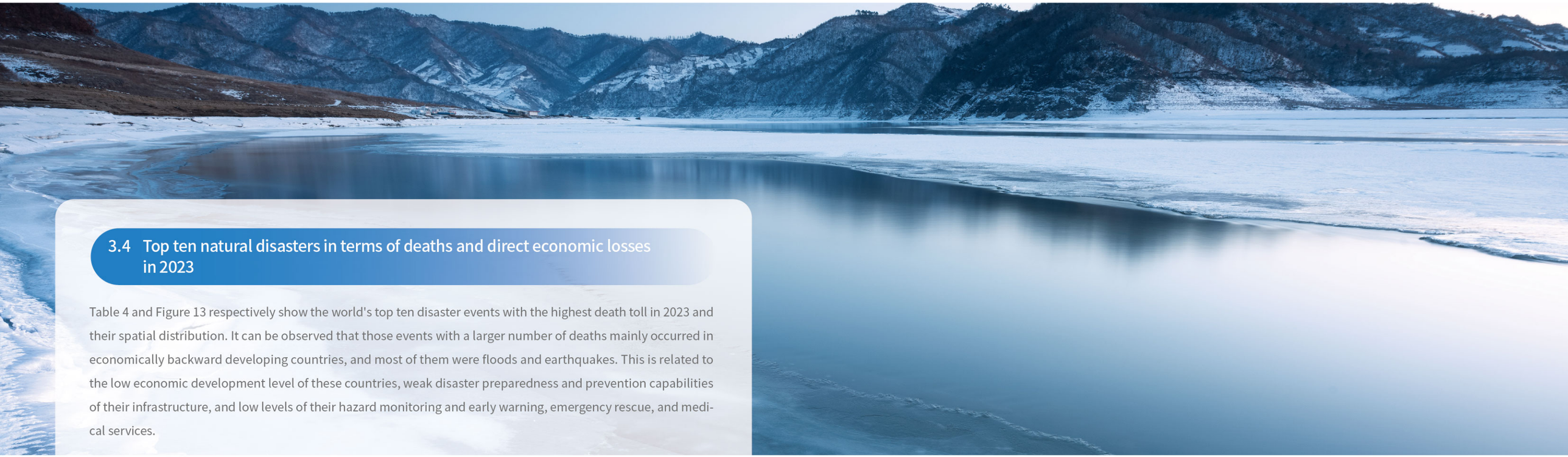
Table 2 Top ten countries (or regions) in terms of disaster frequency and losses globally in 2023

Country	Frequency	Country	Deaths (persons)	Country	Direct economic losses (USD 0.1 billion)
The United States	25	Türkiye	50,840	The United States	681.6
China	17	Libya	12,352	Türkiye	340.25
India	17	Syrian Arab Republic	5,900	China	295.5
Brazil	16	Democratic Republic of the Congo	3,086	Mexico	120
The Philippines	15	Morocco	2,946	Italy	98.5
Indonesia	15	Afghanistan	2,698	Syrian Arab Republic	89
Pakistan	13	India	2,135	Morocco	70
Türkiye	8	Malawi	1,209	Libya	62
Italy	7	The United States	539	New Zealand	47
Democratic Republic of the Congo	7	China	386	Guam	43

Table 3 Top ten countries (or regions) in terms of disaster loss rates globally in 2023

Country	Deaths per million population	Country	Percentage of direct economic losses (%)
Libya	1,813.18	Libya	13.55%
Türkiye	598.26	Morocco	5.35%
Syrian Arab Republic	266.66	Malawi	3.85%
Morocco	78.65	Türkiye	3.75%
Afghanistan	65.60	Myanmar	3.60%
Malawi	59.25	Haiti	2.07%
Democratic Republic of the Congo	31.17	New Zealand	1.89%
Guam	11.64	Chile	0.92%
Rwanda	9.51	Mexico	0.82%
Guatemala	9.45	Italy	0.48%

*Note: The number of deaths per million population in Table 3 refers to the proportion of deaths in 2023 in the total population in 2022 (expressed as deaths per million population), and the percentage of direct economic losses refers to the total direct disaster economic losses in 2023 as a share of GDP in 2022. The population and GDP (in current USD) data for 2022 are sourced from the World Bank (https://data.worldbank.org/).



3.4 Top ten natural disasters in terms of deaths and direct economic losses in 2023

Table 4 and Figure 13 respectively show the world's top ten disaster events with the highest death toll in 2023 and their spatial distribution. It can be observed that those events with a larger number of deaths mainly occurred in economically backward developing countries, and most of them were floods and earthquakes. 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 their hazard monitoring and early warning, emergency rescue, and medical services.

Table 4 Top ten natural disasters by death toll globally in 2023

Ranking	Time	Country	Type of disaster	Deaths (persons)	Deaths per million population
1	February 6-February 6	Türkiye	Earthquake	56,683*	2,440.3913
2	September 10-September 11	Libya	Storm	12,352	1,793.1626
3	May 2-May 5	Congo	Flood	2,970	486.3376
4	September 8-September 8	Morocco	Earthquake	2,946	77.8540
5	October 7-October 7	Afghanistan	Earthquake	2,445	57.8837
6	June 25-September 7	India	Flood	1,746	1.2222
7	March 11-March 13	Malawi	Storm	1,412	67.4573
8	October 15-October 19	Nigeria	Flood	275	1.2157
9	May-June	Yemen	Flood	248	7.1989
10	April 1-September 30	The United States	Drought	247	0.7265

* Note: As of 25 March, 2024.

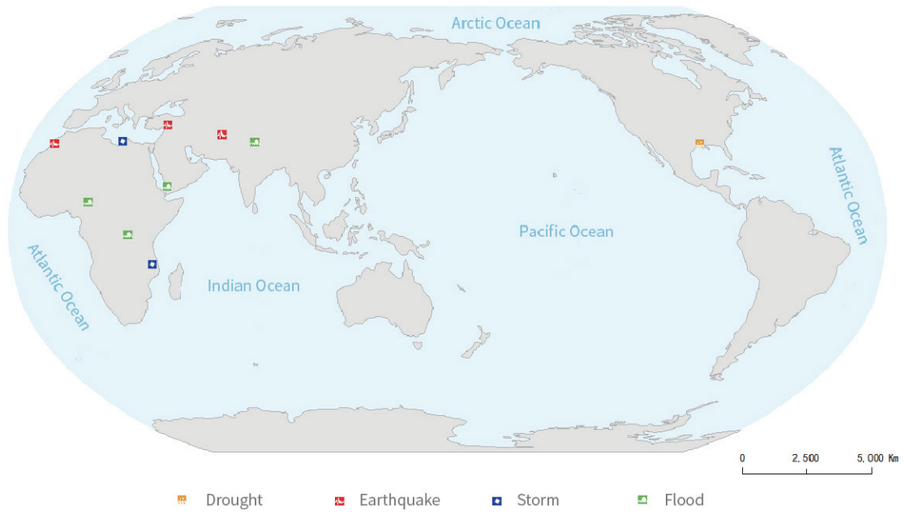


Figure 13 Spatial distribution of the world' s top ten natural disasters in death toll in 2023

Table 5 and Figure 14 list the world's top ten disaster events with the most directly economic losses in 2023 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 storms and earthquakes.

Table 5 Top ten natural disasters in direct economic losses globally in 2023

Ranking	Time	Country	Type of disaster	Direct economic losses (USD 0.1 billion)
1	February 6-February 6	Türkiye	Earthquake	429
2	July 27-August 2	China	Storm	253
3	April 1-September 30	The United States	Drought	145
4	October 22-October 25	Mexico	Storm	120
5	May 16-May 20	Italy	Flood	97.5
6	September 8-September 8	Morocco	Earthquake	70
7	September 10-September 11	Libya	Storm	62
8	March 1-March 3	The United States	Storm	60
9	March 30-April 3	The United States	Storm	55
10	August 9-August 10	The United States	Wildfire	55

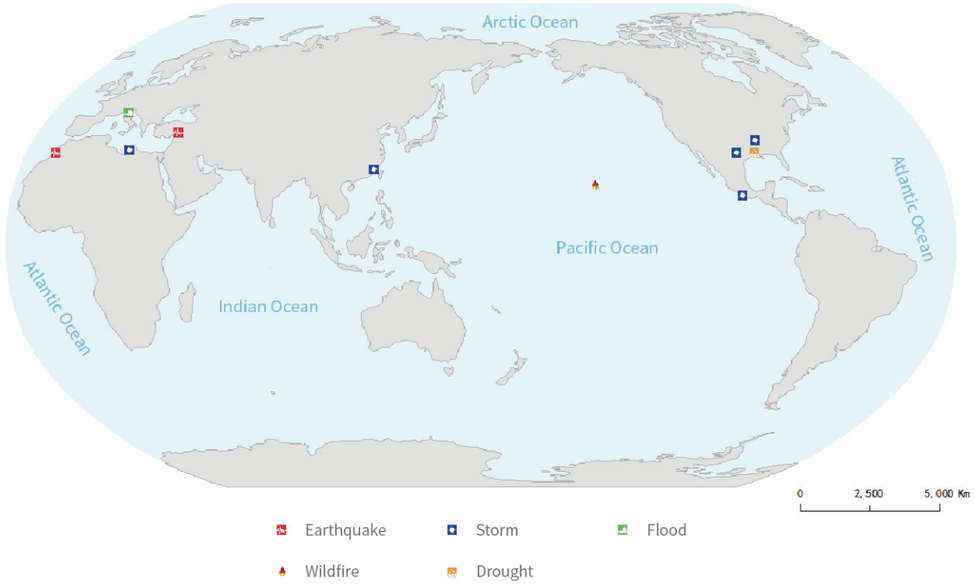


Figure 14 Spatial Distribution of the world' s top ten natural disasters in direct economic losses in 2023

02

Special Report 1

Natural Disasters in China in 2023

1. Overall review of natural disasters
2. Temporal and spatial characteristics of disasters
3. Trend analysis of disaster indicators
4. Comparison of natural disasters in China and the rest of the world in 2023

Special Report 1 Natural Disasters in China in 2023[2]

1 Overall review of natural disasters

In 2023, China's natural disaster situation is complex and severe, mainly including floods, typhoons and geological disasters, while droughts, hailstorms, freezing and snow disasters, earthquakes, sandstorms and forest and grassland fires occurred to varying degrees. Affected by extreme disaster weather, major natural disasters occurred successively in China, such as rainy wheat harvest season in Henan at the end of May, the Typhoon Doksuri（2305）, the “23.7” flooding in the Haihe River basin, the torrential rain and floods in Northeast China in early August, the “8.21” flash flood and debris flow in Jinyang, Sichuan, and the 6.2-magnitude earthquake in Jishishan County, Gansu Province on December 18. All localities and relevant departments have conscientiously implemented the spirit of General Secretary Xi Jinping's important instructions and the arrangements of the Party Central Committee and the State Council. The Ministry of Emergency Management has strengthened overall planning and coordination, and made every effort to effectively carry out emergency rescue and disaster relief, so as to minimize casualties and property losses. Disaster losses throughout the year reached an affected population of over 95 million, death and missing toll of 691 people, an evacuated population of 3.343 million; collapsed housing of 209,000 rooms, with another 2.06 million rooms damaged to varying degrees; affected crops of 10,539.3 thousand hectares; and direct economic losses of CNY 345.45 billion. Compared with the annual average of the last ten years, the affected population, death and missing toll, collapsed housing and direct economic losses saw a decrease of 46%, 39%, 25% and 2% respectively. Compared with 2022, the 2023 the affected population decreased by 15%, while the death and missing toll, collapsed housing and direct economic losses saw an increase of 25%, 347%, and 45% respectively.

95+

Disaster losses throughout the year reached an affected population of over 95 million

691

Death and missing toll of 691 people

3.343

An evacuated population of 3.343 million

10,539.3

Affected crops of 10,539.3 thousand hectares

345.45

Direct economic losses of CNY 345.45 billion

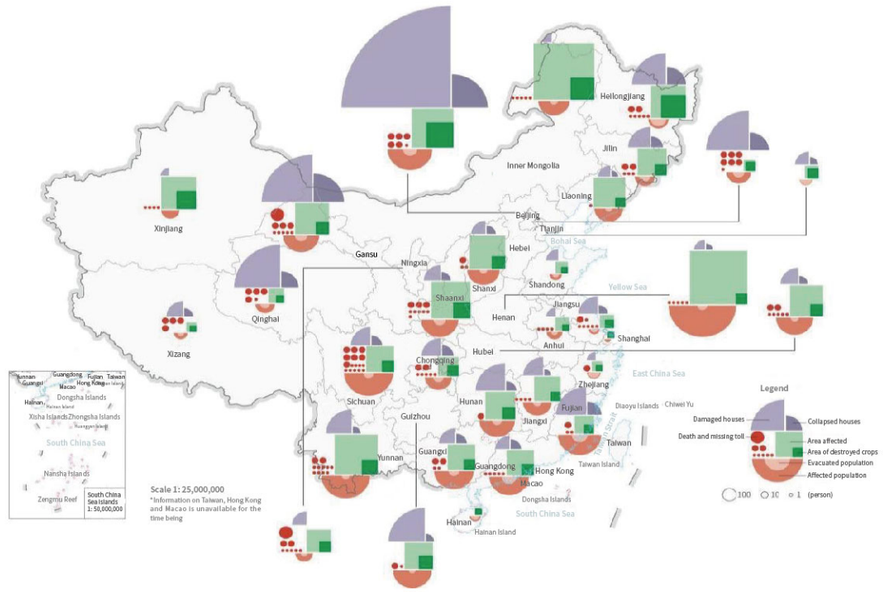


Figure 1 Spatial distribution of natural disasters in China in 2023

Figure 2 Spatial distribution of direct economic losses caused by natural disasters in China by hazard type in 2023

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

1.1 Affected population by hazard type

In 2023, with regard to the population affected by natural disasters in China, floods accounted for the highest proportion (55.3%), followed by drought (22.0%), typhoons (11.9%), hailstorms (6.3%), freezing and snow disasters (3.4%), while other disasters such as earthquakes, geological disasters, and sandstorms accounted for a relatively low proportion.

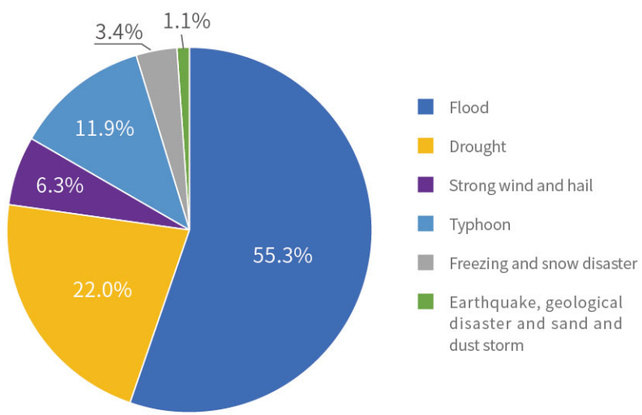


Figure 3 Pie chart of affected population by hazard type in 2023

1.2 Death and missing toll by hazard type

In 2023, floods accounted for the highest proportion of death and missing tolls from natural disasters in China (44.7%), followed by earthquake disasters (21.9%), geological disasters (18.7%), hailstorms (8.2%), and freezing and snow disasters (4.3%), while other disasters such as typhoons and wildfires accounted for a relatively low proportion.

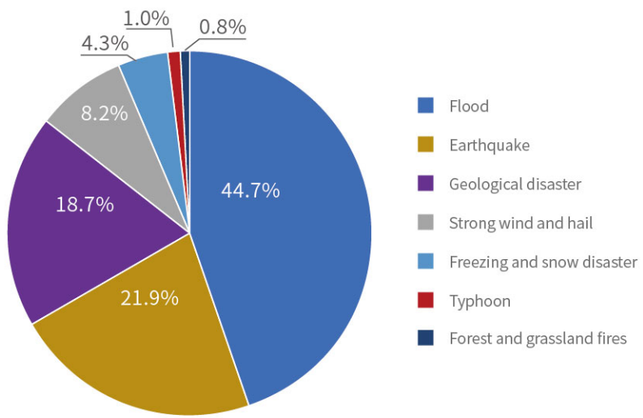


Figure 4 Pie chart of death and missing toll by hazard type in China, 2023

Floods, geological disasters, earthquakes, collapse of houses or structures, avalanches, and lightning strikes were the main causes of the death and missing toll. Specifically, 32.4% of the death and missing were caused by floods, 21.9% due to earthquakes, 28.5% and 6.1% were killed and missing due to secondary geological disasters caused by landslides and debris flows, rockslides and floods, and the collapse of buildings or structures, 3.9% by avalanches, 2.9% by lightning strikes, and 4.3% by falling objects from heights, forest fires, etc., and in the process of disaster relief.

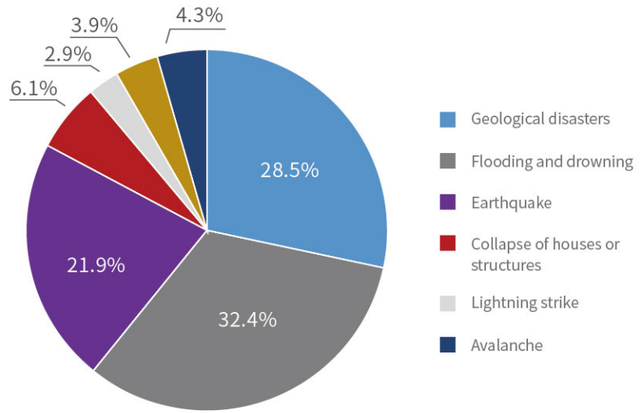


Figure 5 Pie chart of causes to death and missing toll in 2023

1.3 Direct economic losses

In 2023, floods accounted for the highest proportion of direct economic losses caused by natural disasters in China (70.8%), followed by typhoons (13.7%), droughts (5.9%), hailstorms (3.4%), earthquakes (4.4%), freezing and snow disasters (1.4%), while other disasters such as geological disasters and sandstorms accounted for relatively low proportions.

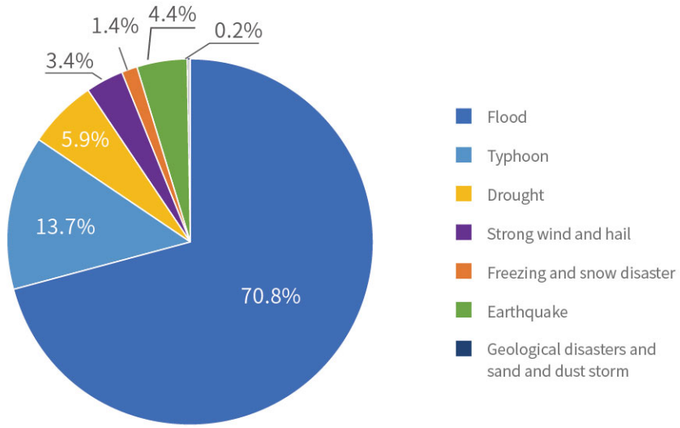


Figure 6 Pie chart of direct disaster economic losses by hazard type in 2023

1.4 Death and missing toll by province

Gansu, Sichuan, Beijing, and Hebei had the largest deaths and missing people due to disasters in 2023 with more than 50 persons, ranking among the top four in China. Gansu was the only province that suffered a death and missing toll of more than 100 people. Compared to the average from 2003 to 2022, the number of death and missing tolls in 2023 increased in Beijing, Hebei, Jilin, Heilongjiang and Xizang, while all other provinces saw a decrease.

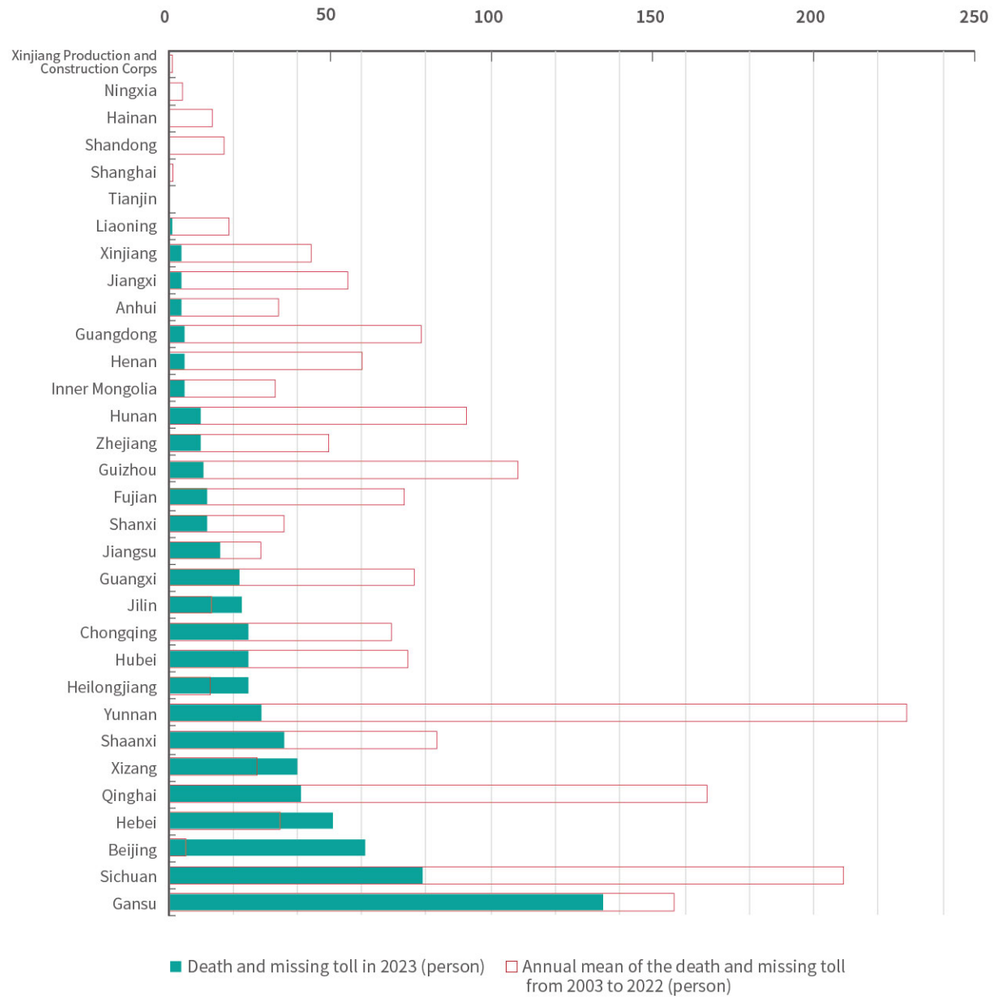


Figure 7 Statistics of death and missing toll by province in 2023

*Note: The statistics of 2008 is not included in the mean death and missing toll in Sichuan Province from 2003 to 2022.

1.5 Direct economic losses by province

In 2023, the direct economic losses of Hebei Province and Beijing Municipality due to disasters (The data of each province, autonomous region and municipality were based on 2003 and converted according to the GDP index, the same below.) exceeded CNY 30 billion, and the direct economic losses of Fujian, Heilongjiang and Guangdong all exceeded CNY 10 billion. Compared with annual mean from 2003 to 2022, direct economic losses of Beijing, Tianjin, Hebei, Heilongjiang, Fujian and Qinghai increased while loss statistics in other provinces decreased.

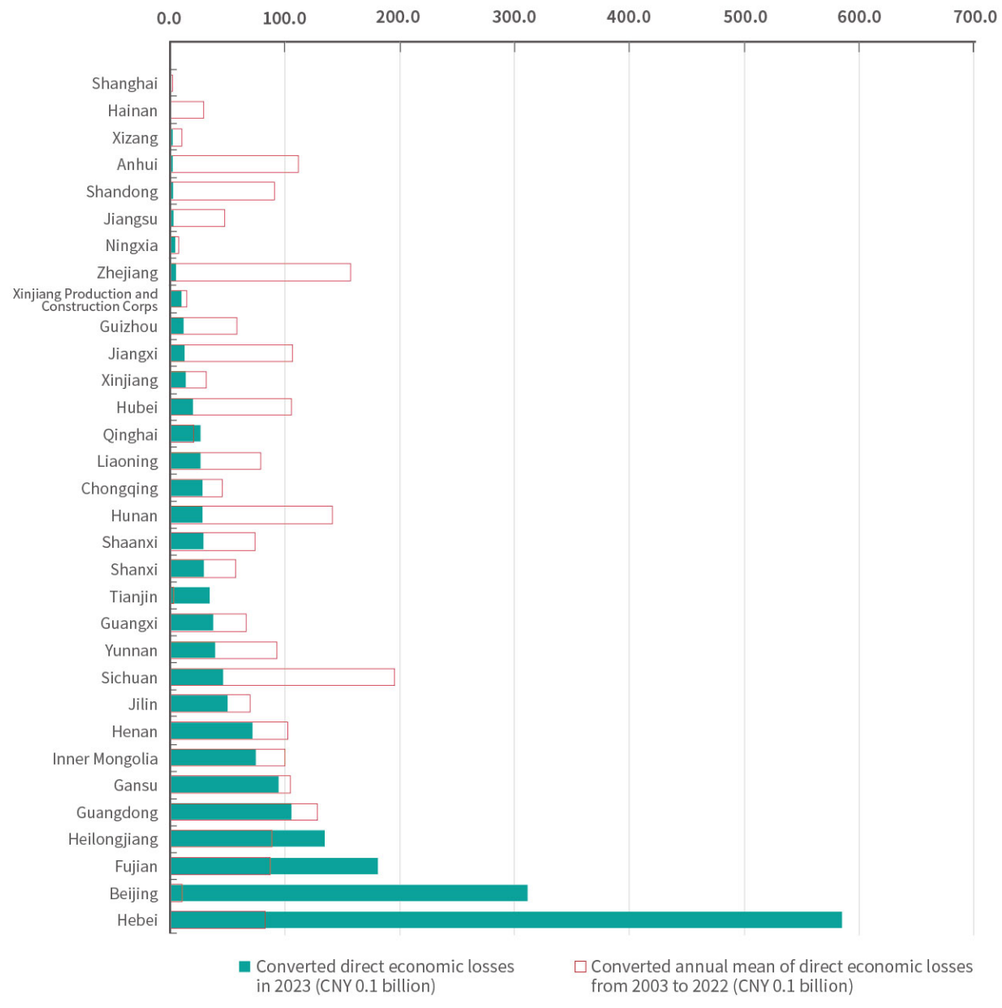


Figure 8 Statistics of direct economic losses from disasters by province in 2023

*Note: Annual data in each province were converted on the basis of comparable prices in 2003 according to the GDP indices. The statistics of 2008 is not included in the mean value of the converted direct economic losses in Sichuan province from 2003 to 2022.

Table 1 Top ten natural disaster events in China, 2023

Natural disaster event	Affected population (10,000 persons)	Death and missing toll (persons)	Direct economic losses (CNY 0.1 billion)
Avalanche in the Paimo Highway in Nyingchi, Xizang on January 17	-	28	-
Heavy rain, floods, and geological disasters in Chongqing in late June and early July	35.8	25	13.1
Typhoon Doksuri in 2023	295	0	149.5
Heavy rain and flooding in the Beijing-Tianjin-Hebei region at the end of July and early August	551.2	107	1657.9
Heavy rain and flooding in northeast China in early August	119.4	47	215.2
Flash flood and debris flow in Chang' an District, Xi' an, Shaanxi on August 11	-	27	-
"8.21" flash flood in Jinyang, Sichuan	-	52	-
Typhoon Haikui in 2023	312	6	166.6
Strong wind and hail in Yancheng and other places in Jiangsu in mid-September	2	10	4.8
Magnitude 6.2 earthquake in Jishishan County, Gansu Province	77.2	151	146.12
Total losses of top 10 natural disaster events	1392.6	453	2353.22
National annual total losses	9544.43	691	3454.52
Percentage of top 10 natural disaster events	14.6%	65.6%	68.1%

*Note: Blank spaces in Table 1 indicate missing data.

2 Temporal and spatial characteristics of disasters

2.1 Natural disasters in China were unevenly distributed in time and space with obviously more disasters in the north than in the south

From January to March, except for the winter and spring drought in Southwest China and the major avalanche disaster in Nyingchi in Xizang, the disaster situation in China was relatively stable. In early summer, there was continuous rainy weather in Henan and other places, which adversely affected the summer harvest. In the main flood season, major disasters such as super typhoon Doksuri, catastrophic floods in the Haihe River Basin, and severe rainstorms and floods in the Songliao River Basin have occurred one after another. In mid-December, low temperature, rain, snow and freezing disasters occurred in Shanxi and other places, which had a great impact on the production and livelihoods. On December 18, the Magnitude 6.2 earthquake in Jishishan County, Gansu Province, caused heavy casualties in Gansu and Qinghai provinces. The number of houses collapsed due to disasters in the north and south accounted for 92.2% and 7.8% of China's total losses, respectively, and the direct economic losses accounted for 73.7% and 26.3%, respectively.

92.2 %
The number of houses collapsed due to disasters in the north accounted for 92.2% of China' s total losses

7.8 %
The number of houses collapsed due to disasters in the south accounted for 7.8% of China' s total losses

73.7 %
The direct economic losses from natural disaster in the north accounted for 73.7% of the total

2.2 North China and Northeast China suffered severe rainstorms and floods, and local flash floods and geological disasters broke out

In 2023, the average precipitation in China was 612.9 mm, 3.9% less than normal, and there were 35 regional rainstorm processes. From late May to early June, there was a wide range of continuous rainy weather in Henan, which coincided with the maturity and harvest period of wheat, resulting in a large range of crop losses. From late July to early August, under the influence of the remnants of Typhoon Doksuri, extreme rainstorms successively occurred in North China and Northeast China. Major floods occurred in the Haihe River, causing heavy casualties and property losses in Beijing, Tianjin and Hebei. Serious floods occurred in the Songhua River Basin, entailing severe damages in Heilongjiang, Jilin and other places. Local flash floods and geological disasters occurred in many different places in the southwest and northwest. Sichuan, Chongqing, Shaanxi and other places suffered relatively large casualties. A total of 52.789 million people were affected by floods throughout the year, with 309 people dead and missing, 130,000 houses collapsed, and direct economic losses of CNY 244.57 billion. In addition, a total of 3,666 geological disasters such as landslides, collapses, and debris flows occurred in China, most of which were small-scale in North China, Southwest China and other regions.

612.9
The average precipitation in China was 612.9 mm

3.9%
3.9% less than normal

35
There were 35 regional rainstorm processes

2.3 The number of typhoons generated and landed was relatively small, with strong landfall intensity, bringing many extremely heavy rainfalls

In 2023, a total of 17 typhoons formed in the Northwest Pacific and the South China Sea, significantly less than normal, and 6 of them made landfall in China, slightly less than normal. During the landfall of Typhoon Doksuri, it brought heavy rainfall to Zhejiang and Fujian, causing local flash floods and waterlogging in some cities. After landfall, it moved northward, and the circulation was maintained on land for a long time, resulting in extremely heavy rainfall in North China, Huang Huai area, Northeast China and other places, causing severe rainstorms and floods. The landfall of Typhoon Sula, together with cold air, brought a wide range of heavy rains to Guangdong and Guangxi. After the landfall of Typhoon Haikui, the residual vortex affected South China for a long time, and the precipitation in many places and stations in Fujian and Guangdong exceeded the historical extreme. In 2023, a total of 11.316 million people were affected by typhoons to varying degrees, 12 people were dead and missing, more than 7,000 houses collapsed, and the direct economic loss registered CNY 47.49 billion.

17
A total of 17 typhoons formed in the Northwest Pacific and the South China Sea

11.316
A total of 11.316 million people were affected by typhoons to varying degrees

12
12 people were dead and missing

2.4 Strong earthquakes in Chinese mainland have lower intensity, and the magnitude 6.2 earthquake in Jishishan County in Gansu Province caused heavy damage

In 2023, a total of 11 earthquakes of magnitude 5.0 or higher occurred in Chinese mainland, a significant decrease from the annual average level of previous years, two of which measured magnitude 6.0 or higher, lower than the annual average level of previous years. The 5.5-magnitude earthquake in the Shandong Plain caused damage to more than 2,900 houses and some certain infrastructures, and caused direct economic losses of CNY 240 million. The 6.2-magnitude earthquake in Jishishan County, Gansu Province, caused 151 people dead in Gansu and Qinghai provinces, 983 people injured, 70,000 houses collapsed, 99,000 houses seriously damaged, and 252,000 houses generally damaged, with direct economic losses of CNY 14.612 billion.

151
Caused 151 people dead in Gansu and Qinghai provinces

983
983 people injured

14.612
Direct economic losses of CNY 14.612 billion

2.5 Periodic droughts occurred in the southwest, north, and northwest China, less destructive than normal

In 2023, China experienced winter and spring droughts in the southwest, local summer droughts in the north, and autumn droughts in the northwest, which were less destructive than normal. At the beginning of the year, precipitation was low in most parts of Southwest China, especially in Yunnan, where the average precipitation from January to May was 50% lower than normal. From May to June, there were many extremely high temperature processes in North China and Huang-Huai area, and the precipitation in the western part of Northeast China was 20-30 percent less. From June to August, the precipitation in western Inner Mongolia, Ningxia, most of Gansu and southern Qinghai and the amount of water from rivers in the corresponding region were relatively low, and there were temporary difficulties in drinking water for people and livestock and agricultural irrigation in some areas. In 2023, 20.974 million people were affected by droughts to varying degrees, with 3,803.7 thousand hectares of crops affected and direct economic losses of CNY 20.55 billion.

20.974
20.974 million people were affected by droughts to varying degrees

3,803.7
3,803.7 thousand hectares of crops affected

20.55
Direct economic losses of CNY 20.55 billion

2.6 Hailstorms occurred in many different places, and Jiangsu and other places were affected by strong convective weather

In 2023, there was a total of 33 severe convective weather processes in China, less than the average of the same period in the past five years, mainly in spring and summer. A total of more than 1,100 counties (cities and districts) in North China, Huang-Huai area, Northwest and Southwest China were affected by hailstorms. A total of 26 tornadoes were observed and recorded throughout the year, of which 9 were strong tornadoes, significantly higher than the multi-year average. Tornadoes in Yancheng, Suqian, Nantong and other places in Jiangsu Province caused 14 people dead. In 2023, a total of 6.053 million people were affected by hailstorms to varying degrees, resulting in 57 people dead, 1,174.5 thousand hectares of crops damaged, and direct economic losses registered CNY 11.73 billion. In addition, China had 17 sand and dust storms throughout the year.

33
A total of 33 severe convective weather processes in China

6.053
A total of 6.053 million people were affected by hailstorms to varying degrees

57
Resulting in 57 people dead

2.7 Northeast and North China suffered from freezing and snow disasters, and severe avalanche disasters occurred in Nyingchi, Xizang

In 2023, China was affected by 31 cold air processes, including 8 cold waves. On 5-7 and 21-24 November, cold waves entailed heavy snowfalls in Inner Mongolia and Northeast China. From December 13 to 16, a total of 18 stations in Hebei, Shanxi, Beijing, Tianjin and other places had daily minimum temperatures falling below the historical extreme value in December since the establishment of the stations. The cold waves entailed a wide range of rain and snow in the central region, impacting Hebei, Shanxi, Shandong, Henan and other places. In addition, an avalanche on January 17 on the Paimo Highway in Nyingchi, Xizang, killed 28 people, making it the deadliest avalanche event in China in recent years. In 2023, a total of 3.225 million people were affected by freezing and snow disasters, 30 people died in these disasters, 519.2 thousand hectares of crops were affected, and the direct economic loss was CNY 4.92 billion.

31
China was affected by 31 cold air processes

3.225
A total of 3.225 million people were affected by freezing and snow disasters

30
30 people died in these disasters

2.8 The number of forest and grassland fires was at a historical low, with generally stable situation

In 2023, a total of 328 forest fires occurred in China, mainly in the four provinces (regions) of Inner Mongolia, Heilongjiang, Guangxi, and Yunnan, killing 2 people. A total of 15 grassland fires occurred, mainly in Inner Mongolia, killing one person. The number of forest and grassland fires was at a historical low, and the number of forest fires and grassland fires decreased by 77.5% and 46.8%, respectively, compared with the average values of the past five years.

328
A total of 328 forest fires occurred in China

2
Killing 2 people

15
A total of 15 grassland fires occurred

3 Trend analysis of disaster indicators

3.1 Affected population

Overall, affected population by various natural disasters across China has demonstrated a downward trend from 2003 to 2023. The affected population in 2023 was 954.443 million, ranking the lowest since 2003. Compared with the annual mean from 2003 to 2022 (286.80 million, 2008 excluded), these statistics dropped by 66.7%.

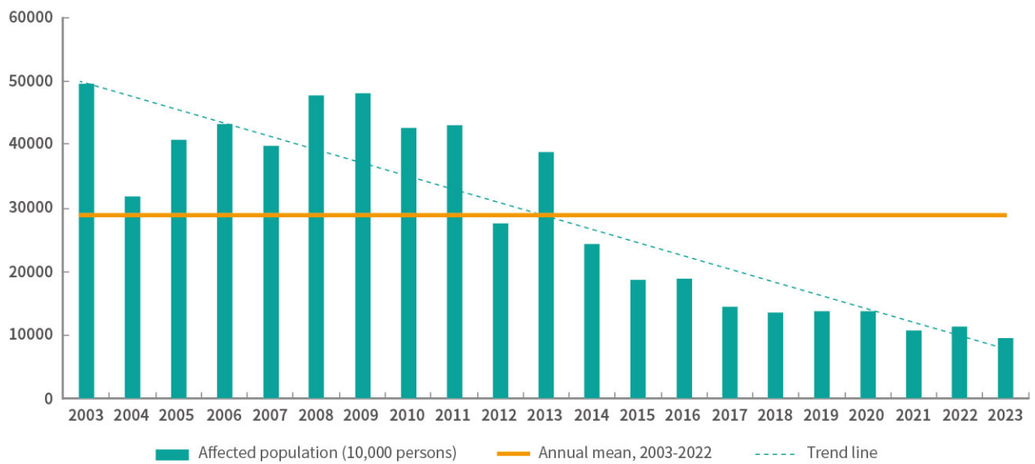


Figure 9 Annual statistic of affected population in China, 2003-2023

3.2 Affected people per 100,000 population

The statistics of affected people per 100,000 population have also shown a decreasing trend from 2003 to 2023. In 2023, the number of affected people per 100,000 population in China was 6,765, which was the lowest since 2003 and dropped by 68.3% compared with the annual mean from 2003 to 2022 (21,339, 2008 excluded).

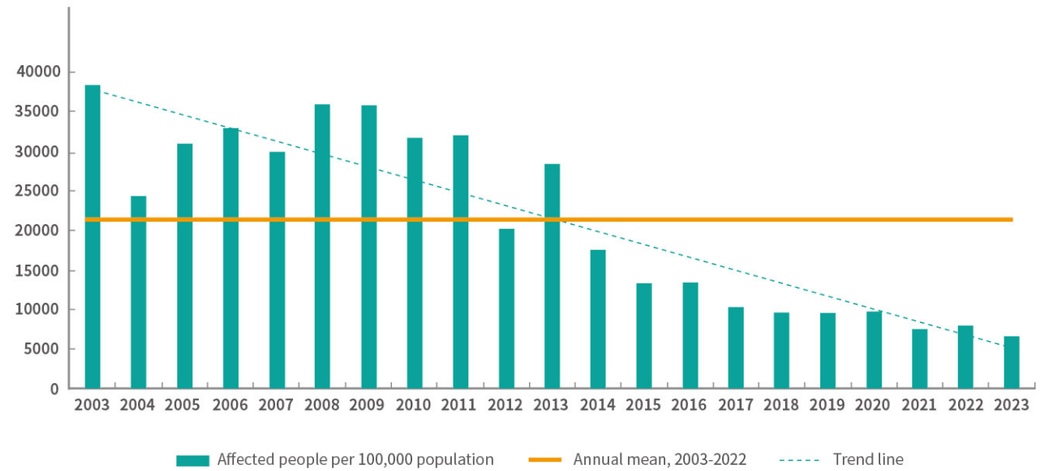


Figure 10 Annual statistics of affected people per 100,000 population in China, 2003-2023

3.3 Death and missing toll

From 2003 to 2023, the annual death and missing toll caused by various natural disasters across China was also declining. In 2023, the death and missing toll in China was 691, ranking the fourth lowest since 2003. Compared with the average level from 2003 to 2022 (1,889 people, the year 2008 was excluded), the decrease was as high as 63.4%.

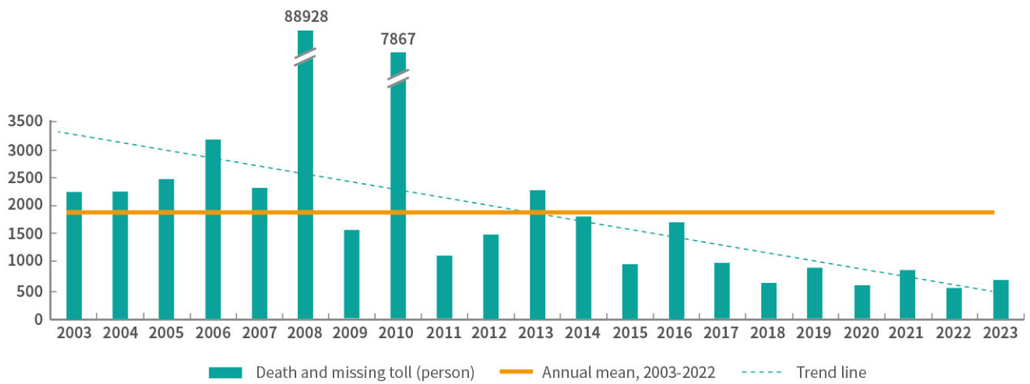


Figure 11 Annual statistics of death and missing toll in China, 2003-2023

3.4 Death and missing toll per 100,000 population

From 2003 to 2023, the death and missing toll per 100,000 population caused by various natural disasters in China went down as well, which was 0.049 in 2023, the third lowest since 2003. Compared with the annual average from 2003 to 2022 (0.14, 2008 excluded), there was a decrease of 65.1%.

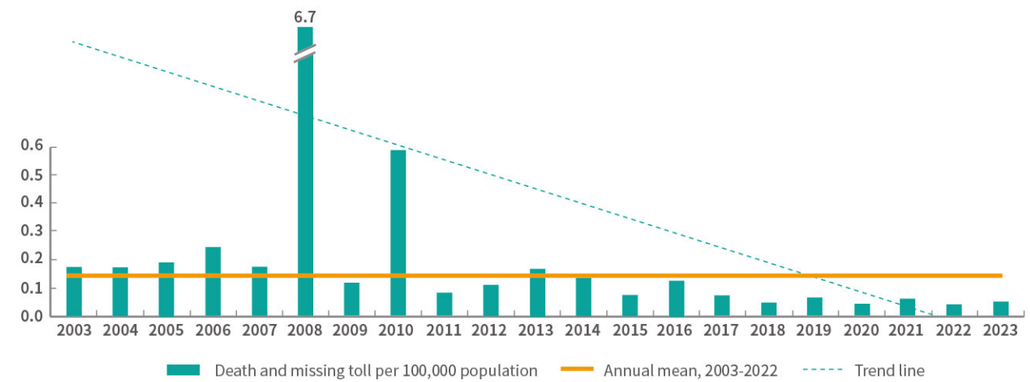


Figure 12 Annual statistics of death and missing toll per 100,000 population in China, 2003-2023

3.5 Direct economic losses

From 2003 to 2023, direct economic losses caused by various natural disasters in China showed a downward trend (annual data were converted to comparable prices in 2003 as a baseline according to the GDP index). The loss data in 2023 was CNY 173.71 billion, down 16.4% from the annual average from 2003 to 2022 (CNY 207.70 billion, 2008 excluded).

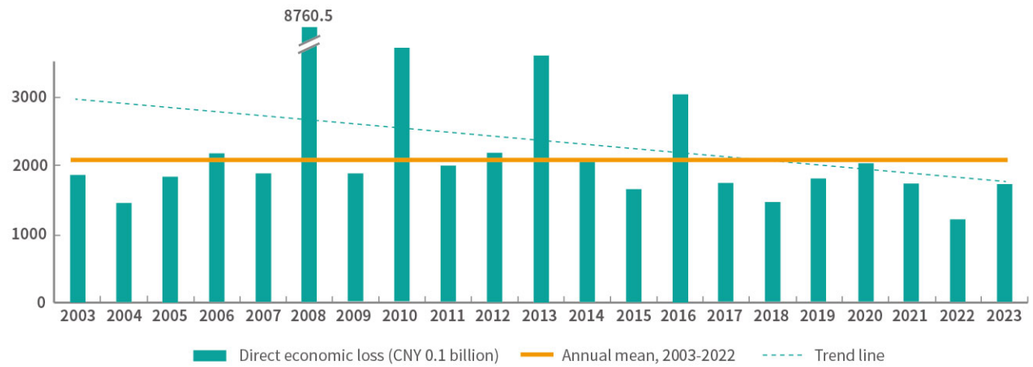


Figure 13 Annual statistics of direct economic losses in China, 2003-2023

*Note: Annual data were converted to comparable prices in 2003 as a baseline according to the GDP index.

3.6 Direct economic losses over GDP

From 2003 to 2023, the ratio of direct economic losses caused by various natural disasters in China over GDP was declining as well. In 2023, this ratio was 0.27%, which was the second lowest since 2003, and decreased by 60.8% from the average level from 2003 to 2022 (0.69%, 2008 excluded).

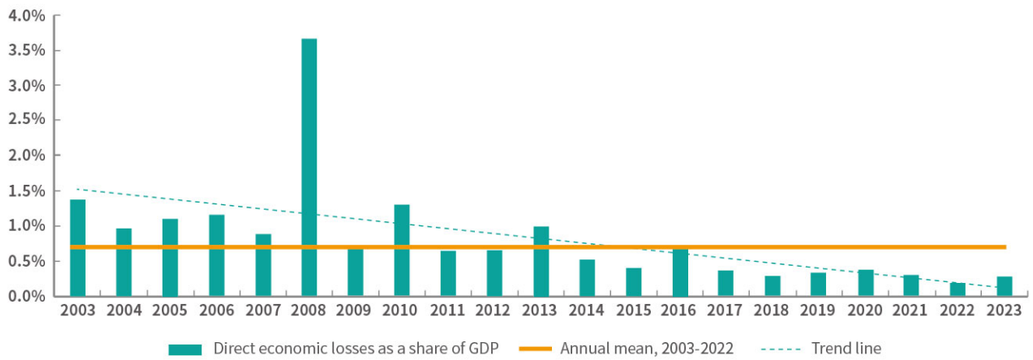


Figure 14 Annual statistics of direct economic losses over GDP in China, 2003-2023

4 Comparison of natural disasters in China and the rest of the world in 2023

4.1 Comparison of natural disaster deaths in China and the rest of the world in 2023

Figure 15 shows the number of deaths per million population due to natural disasters in major countries and regions around the world in 2023.

The number of disaster-related deaths per million population in China was 0.27 in 2023; among all the 91 countries and regions in the statistics, 73 countries and regions had a larger number of deaths per million than China, accounting for 80.22% of the total; when ranked from low to high according to the number of deaths per million population, China was among the top 19.78% of the 91 countries and regions in the statistics. Countries on the same level as China included Canada (0.26), Croatia (0.26) and Vietnam (0.31), etc.

In terms of the number of disaster-related deaths per million population in relation to the level of economic development, China's number of disaster-related deaths per million was basically consistent with the level of its economic development in 2023, and the count was relatively low in the global range. Among the countries with economic aggregates comparable of China, the United States (1.62) had a higher number of deaths per million population than China, while Japan (0.12) and Germany (0.05) had a lower number. Among the countries with per capita GDP equivalent to that of China, Bulgaria (1.24), Mexico (0.9), and Argentina (0.32) both had a lower number of deaths per million population than China, while Malaysia (0.18) had a higher number.

0.27

The number of disaster-related deaths per million population in China was 0.27 in 2023

73

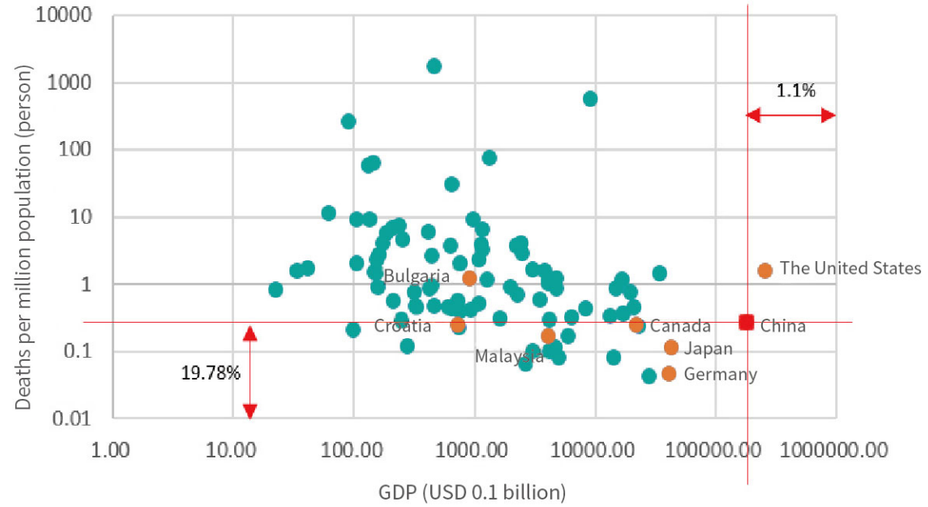
73 countries and regions had a larger number of deaths per million than China

80.22 %

Accounting for 80.22% of the total

19.78 %

China was among the top 19.78% of the 91 countries and regions in the statistics



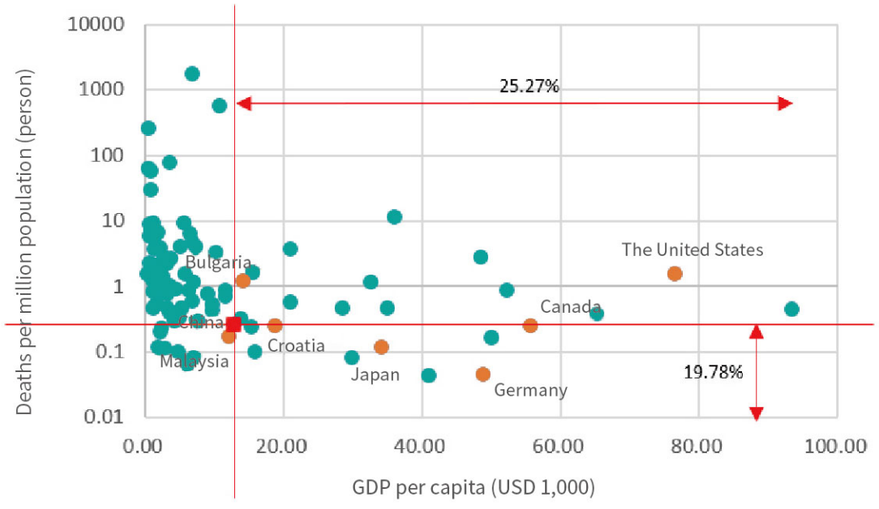


Figure 15 Comparison of natural disaster deaths in China and the rest of the world in 2023

*Note:
Horizontal comparison between China and the other 90 countries and regions in the world;
China ranked in the top 19.78% in terms of the number of disaster-related deaths per million population, which was in the lower level;
China' s total GDP ranked the second; its per capita GDP ranked in the top 27.37%, which was in the upper-middle level;
The number of disaster-related deaths per million population in China was basically consistent with the level of its economic development.
(The number of deaths per million population shown in the figure is calculated by dividing the number of deaths from disasters in 91 countries and regions around the world in 2023 by the number of million population in 2022. The population data come from the World Bank (https://data.worldbank.org/), and the GDP data are from the GDP figures (in current USD) in 2022 released by the World Bank).

4.2 Comparison of direct economic losses from natural disasters in China and the rest of the world in 2023

Figure 16 shows the direct economic losses as a share of GDP in major countries and regions worldwide in 2023.

China's direct natural disaster economic losses accounted for 0.16% of its GDP. Among all the 30 countries and regions in the statistics, there were 17 countries and regions with a higher economic loss ratio than China, accounting for 56.7% of the total; when ranked by the proportion of direct economic losses in GDP in ascending order, China was among the top 43.3% of the 30 countries and regions in the statistics. Countries at the same level as China included Madagascar (0.13%), Ecuador (0.18%), and Spain (0.20%), etc. In terms of the relationship between the proportion of direct economic losses in GDP and the level of economic development in 2023, China's direct natural disaster economic losses were roughly consistent with the level of its economic development, and China ranked in the middle position of the global range in terms of the proportion of direct economic losses in GDP. Among the countries with economic aggregates comparable to that of China, the United States (0.27%) had a higher share of direct economic losses in GDP than China. Among the countries with per capita GDP equivalent to that of China, Argentina (0.02%) had a lower share of direct economic losses in GDP than China, while Mexico (0.82%) had a higher share.

0.16 %

China's natural disaster direct economic losses accounted for 0.16% of its GDP

17

There were 17 countries and regions with a higher economic loss ratio than China

56.7 %

Accounting for 56.7% of the total

43.3 %

China was among the top 43.3% of the 30 countries and regions in the statistics

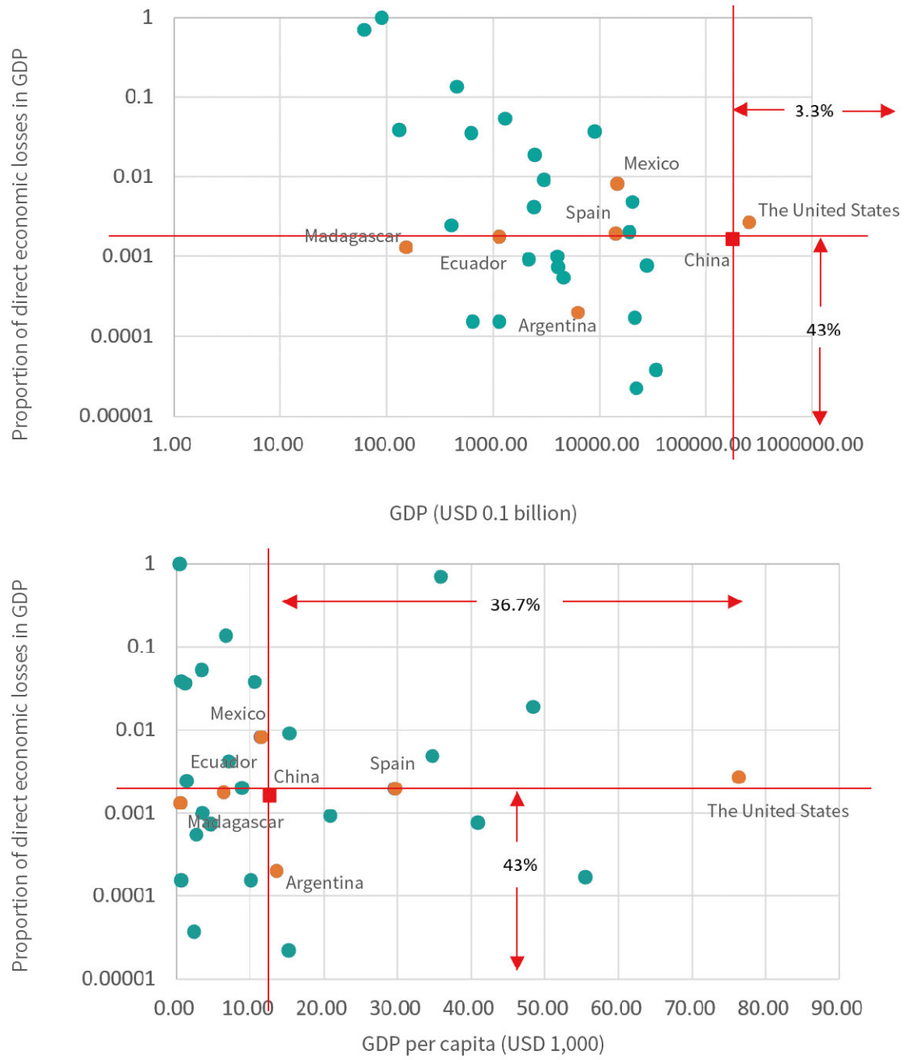


Figure 16 Comparison of direct economic losses from natural disasters as a share of GDP in China and the rest of the world in 2023

*Note:
Horizontal comparison between China and the other 29 countries and regions in the world;
China ranked in the top 43.3% in terms of the annual average direct economic losses as a percentage of GDP in ascending order, which was at the middle level;
China' s total GDP ranked the second; its per capita GDP ranked in the top 40%, which was in the upper-middle level;
China' s proportion of direct economic losses in GDP was basically consistent with the level of its economic development.
(The proportion of direct economic losses in GDP shown in the figure is calculated by dividing the direct economic losses from natural disasters in 30 countries and regions around the world in 2023 by the total GDP in 2022. The population data, GDP (in current USD) and GDP per capita (in current USD) come from the World Bank (https://data.worldbank.org/)).

03

Special Report 2

Temporal and spatial characteristics of global high temperatures from 2014 to 2023

1. Temporal and spatial characteristics in general
2. Temporal variation
3. Spatial variation
4. High temperature risks and insights

Special Report 2 Temporal and spatial characteristics of global high temperatures from 2014 to 2023

1 Temporal and spatial characteristics in general

The Synthesis Report for the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) pointed out that since 1850, the global surface temperature in each decade of the last 40 years has been warmer than in any previous decade. Since the 1950s, extreme heat events such as heatwaves have intensified and increased over land areas around the world. Heatwaves are a pervasive meteorological phenomenon that amplifies many risks. This report adopts the high temperature and heatwave standards recommended by the World Meteorological Organization (WMO) (daily maximum temperature > 32°C and lasting more than 3 days) to analyze the spatial and temporal characteristics of global heatwaves in the decade from 2014 to 2023 based on the ERA5 reanalysis dataset of the European Centre for Medium-Range Weather Forecasts (ECMWF). The data used include daily maximum temperatures from 2014 to 2023 with a spatial resolution of 1° , and the global population distribution data, LandScan Global 2022, released by the Oak Ridge National Laboratory (ORNL) of the United States Department of Energy.

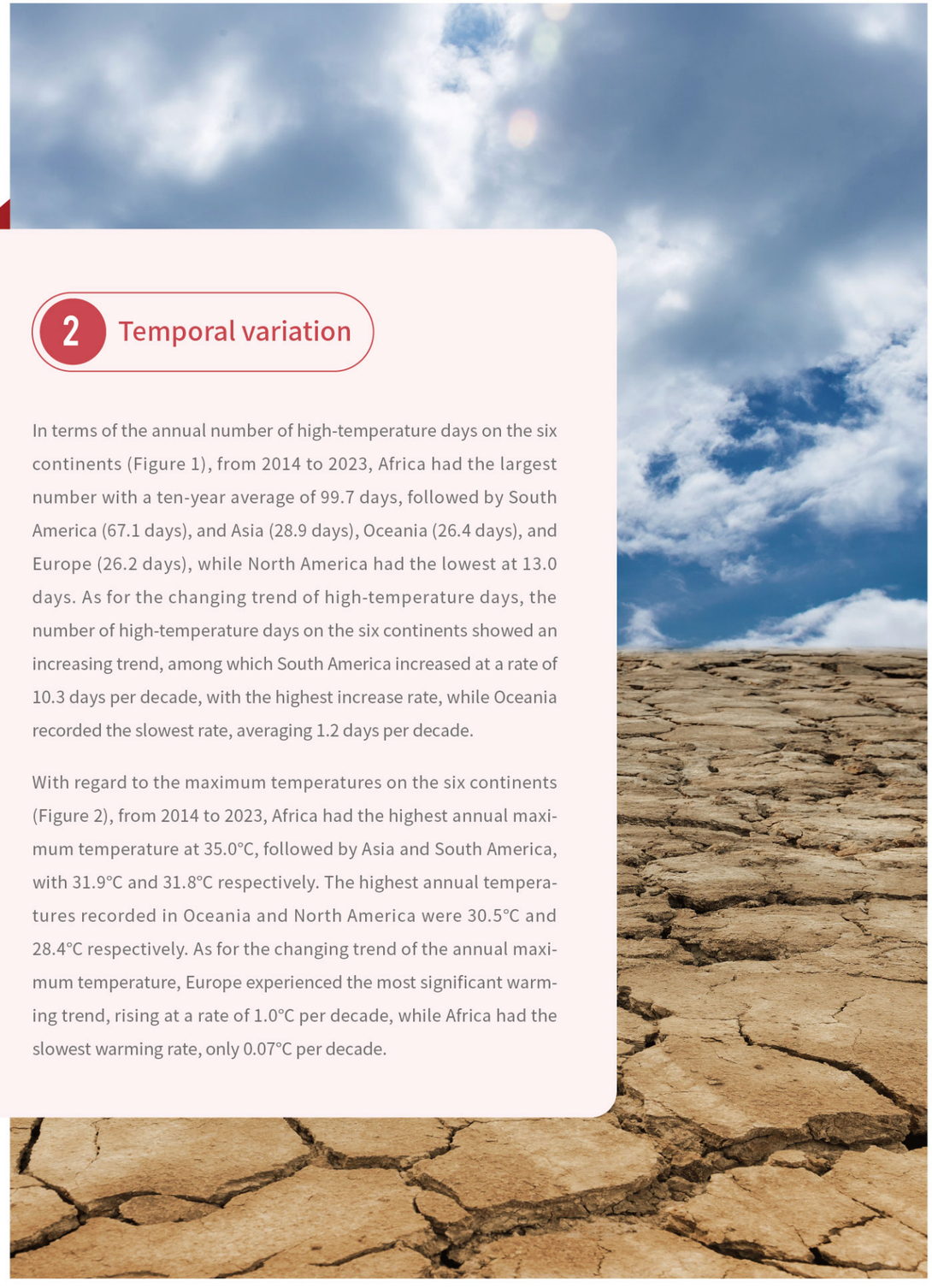
In general, from 2014 to 2023, Africa had the largest number of high-temperature days, with the highest maximum temperature, but the slowest warming rate. North America had the smallest number of high-temperature days with the lowest maximum temperature. South America experienced the fastest increase in the number of high-temperature days, while Oceania had the slowest increase. Europe had the fastest maximum temperature increase. Except for Antarctica, northern Eurasia, the Qinghai-Xizang Plateau, northern North America, and mountainous areas in western South America, the rest of the world experienced high temperatures. The number of high-temperature days in the middle and lower reaches of the Yangtze River Basin in China, the Congo Basin, the coastal areas of the Gulf of Guinea in Africa and central South America showed a significant increasing trend. The daily maximum temperature rose fastest in northeastern Asia, borders between Europe and Asia, central North America and northwestern Antarctica. The frequency of high-temperature processes increased rapidly in northwestern Africa, the Congo Basin, the surrounding areas of the Qinghai-Xizang Plateau, the Mississippi River Basin in North America and the western Amazon Plain in South America.

Africa had the largest number of high-temperature days

North America had the smallest number of high-temperature days

South America experienced the fastest increase in the number of high-temperature days

Europe had the fastest maximum temperature increase



2 Temporal variation

In terms of the annual number of high-temperature days on the six continents (Figure 1), from 2014 to 2023, Africa had the largest number with a ten-year average of 99.7 days, followed by South America (67.1 days), and Asia (28.9 days), Oceania (26.4 days), and Europe (26.2 days), while North America had the lowest at 13.0 days. As for the changing trend of high-temperature days, the number of high-temperature days on the six continents showed an increasing trend, among which South America increased at a rate of 10.3 days per decade, with the highest increase rate, while Oceania recorded the slowest rate, averaging 1.2 days per decade.

With regard to the maximum temperatures on the six continents (Figure 2), from 2014 to 2023, Africa had the highest annual maximum temperature at 35.0°C, followed by Asia and South America, with 31.9°C and 31.8°C respectively. The highest annual temperatures recorded in Oceania and North America were 30.5°C and 28.4°C respectively. As for the changing trend of the annual maximum temperature, Europe experienced the most significant warming trend, rising at a rate of 1.0°C per decade, while Africa had the slowest warming rate, only 0.07°C per decade.

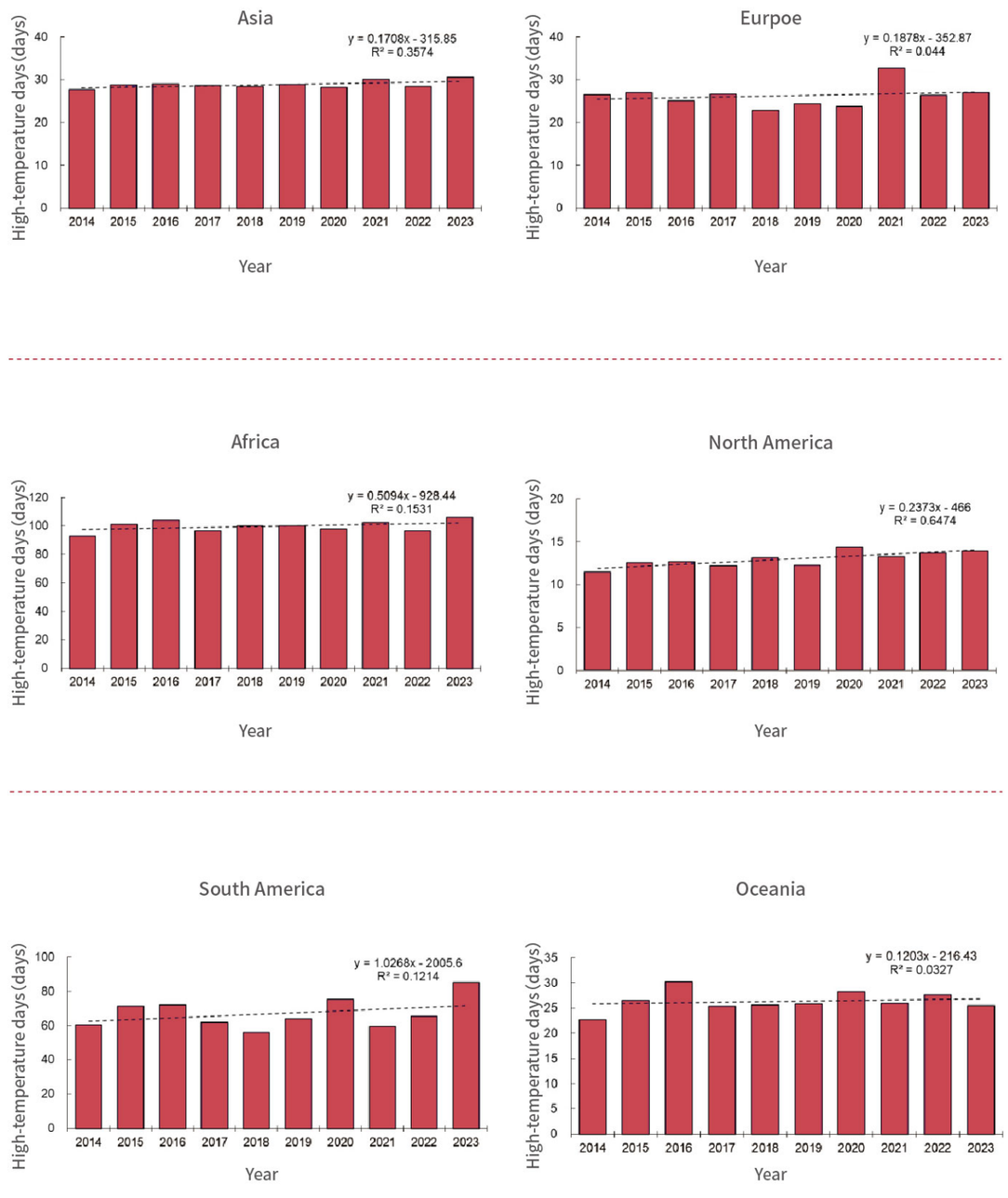


Figure 1 Annual high-temperature days and linear (trend) on each continent 2014-2023

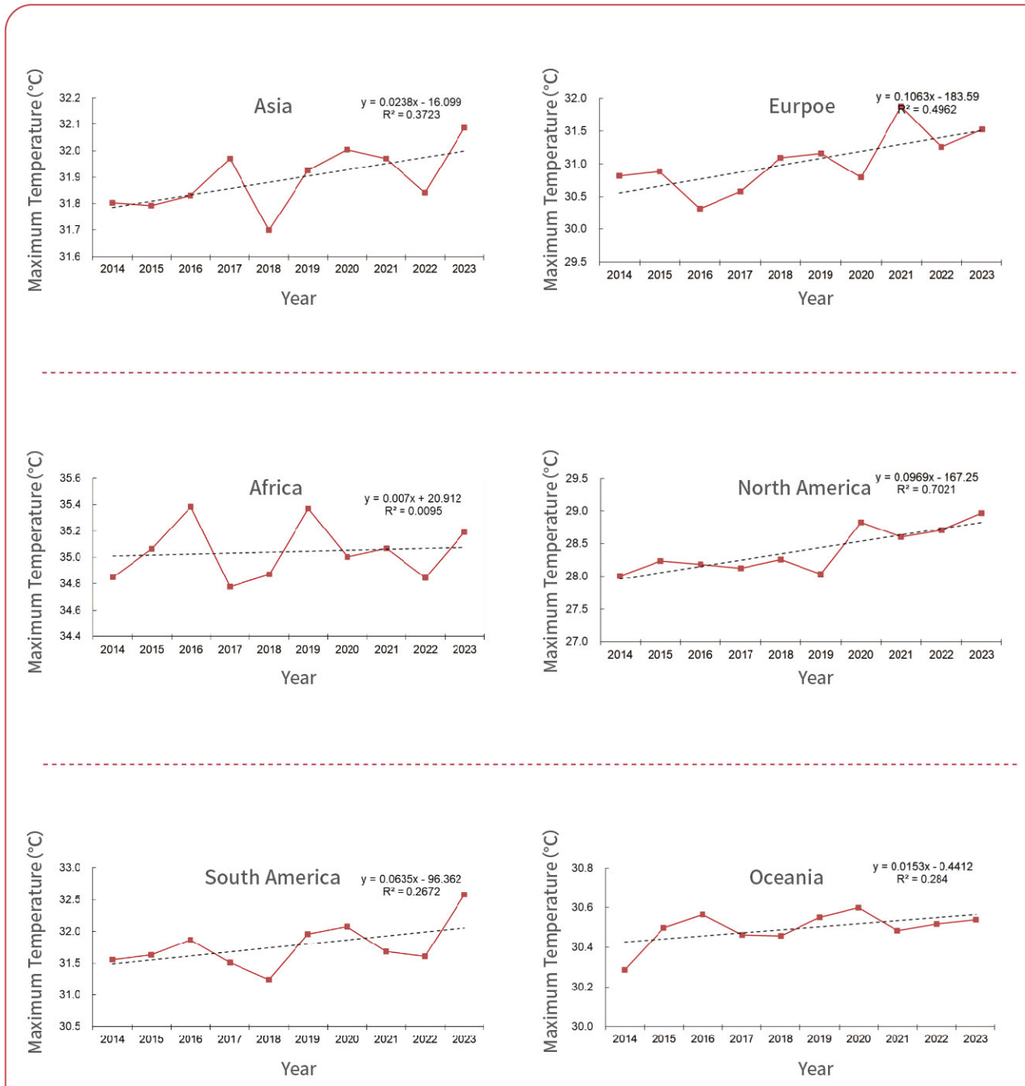


Figure 2 Annual daily maximum temperature and linear (trend) on each continent 2014-2023

3 Spatial variation

From the perspective of the global spatial distribution of high-temperature days (Figure 3), except for Antarctica, northern Eurasia, the Qinghai-Xizang Plateau, northern North America and mountainous areas in western South America, all other parts of the world experienced high temperatures. The Sahara Desert in Africa, the southern Arabian Peninsula, the Indian Peninsula, northern Oceania, the Paraguay Basin and Campos Grasslands in South America had the largest number of high-temperature days in average (from 2014 to 2023, the same below), exceeding 210 days; while the most parts of Europe, northern Asia, the eastern plains of North America and other regions had the least number in average, less than 15 days.

210+ days

The Sahara Desert in Africa, the southern Arabian Peninsula, the Indian Peninsula, northern Oceania, the Paraguay Basin and Campos Grasslands in South America had the largest number of high-temperature days in average (from 2014 to 2023, the same below), exceeding 210 days

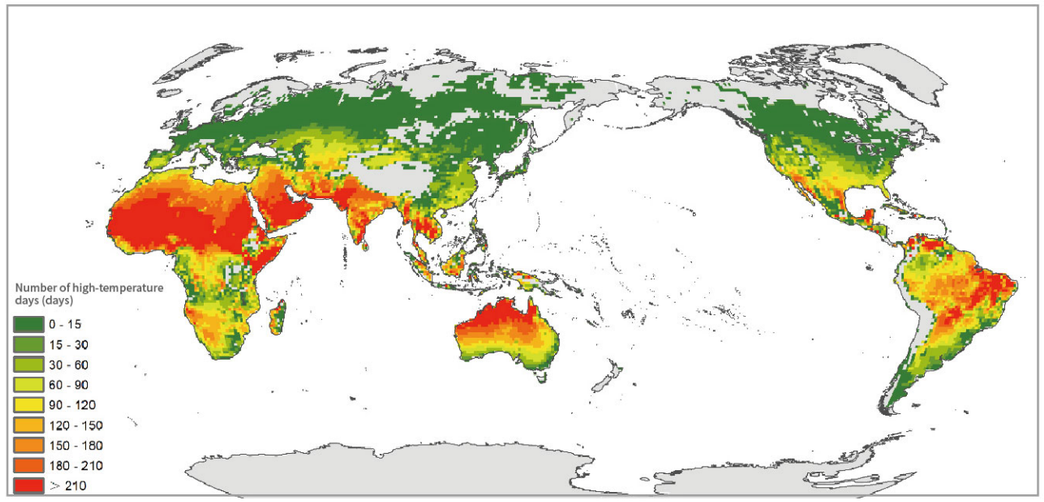


Figure 3 Spatial distribution of global high-temperature days

When it comes to the five-year changes in the average number of high-temperature days (Figure 4), the five-year average number of high-temperature days from 2019 to 2023 in western and eastern Europe, eastern East Asia, Southeast Asia, most of Africa, southwestern Oceania, most of North America and central South America increased compared with that from 2014 to 2018. Europe and northern North America increased by less than 10 days, while parts of central Africa and central South America increased by more than 30 days.

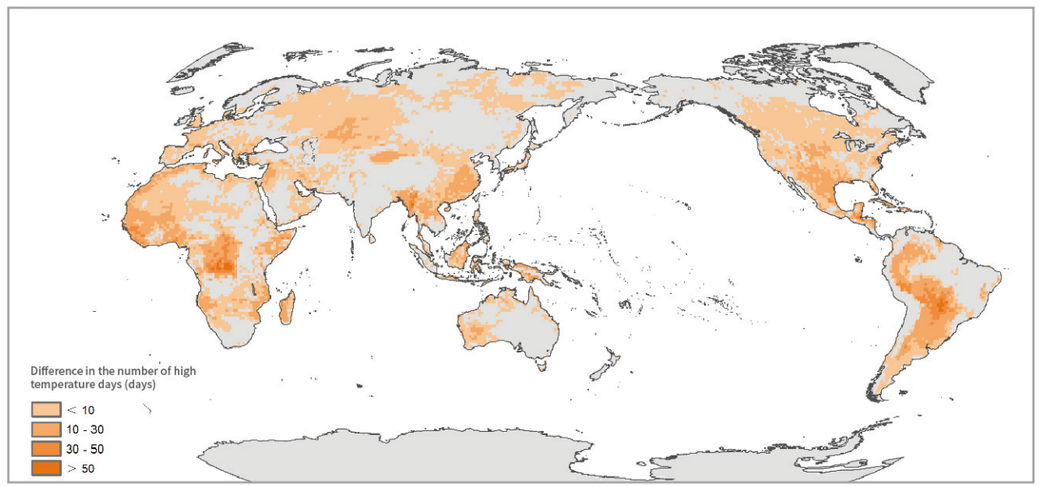


Figure 4 The difference between the average number of high-temperature days from 2019 to 2023 and that from 2014 to 2018

As for the increasing trend of high-temperature days in the world (Figure 5), with the exception of Antarctica, most of Oceania, northern and central Europe, northern Asia and the Qinghai-Xizang Plateau, the Indian Peninsula, northern North America, the western coastal mountains and eastern mountainous areas of South America, most parts of the world saw an increasing number of high-temperature days. The middle and lower reaches of the Yangtze River Basin in China, the Congo Basin and the coastal areas of the Gulf of Guinea in Africa, and central South America saw an increase at a rate of 3-6 days per decade, and certain African areas had an increased rate of over 6 days per decade.

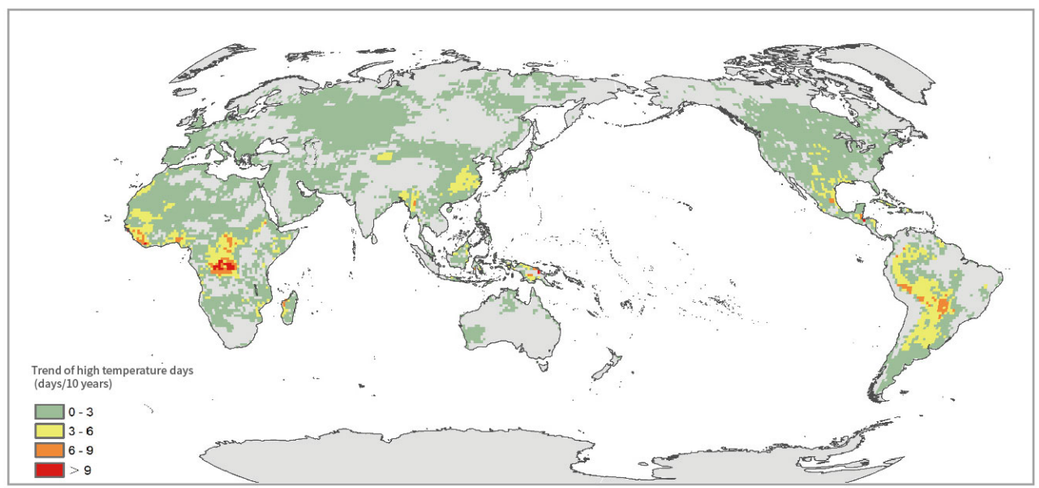


Figure 5 Increased number of high-temperature days per decade in different parts of the world

With regard to the ten-year average daily maximum temperatures in the world (Figure 6), the daily maximum temperatures in southern Europe, southern Asia (except the Qinghai-Xizang Plateau), Africa, southern North America, South America (except the western mountain area) and Oceania were all above 32°C; while those in West Asia, South Asia, northern Africa, Oceania and other regions exceeded 40°C.

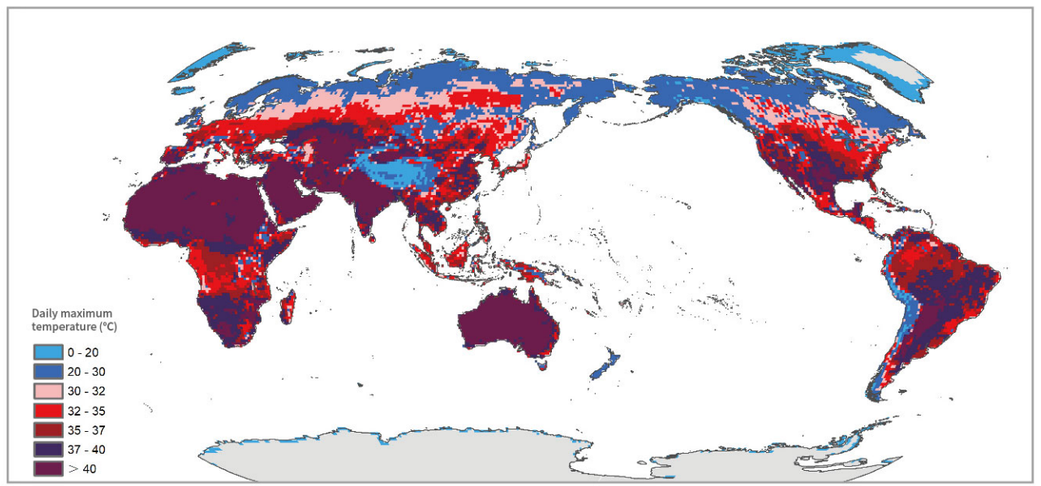


Figure 6 Maximum daily temperatures in different parts of the world

*Note: The trend data in the previous article is calculated based on the weighted average of spatial area. However, the maximum temperature on the land of each continent is unevenly distributed, and some coastal areas are relatively low, resulting in an area-weighted average of less than 40°C.

In terms of the comparison between the average daily maximum temperature from 2014 to 2018 and that from 2019 to 2023 (Figure 7), except for Eastern Antarctica, Central Asia, the Indian Peninsula, Eastern Oceania and other regions, the average daily maximum temperature from 2019 to 2023 in most parts of the world was higher than that from 2014 to 2018. It is noted that the average daily maximum temperature from 2019 to 2023 in northeastern and northwestern Asia, northern Europe and other places was more than 2°C higher than that from 2014 to 2018.

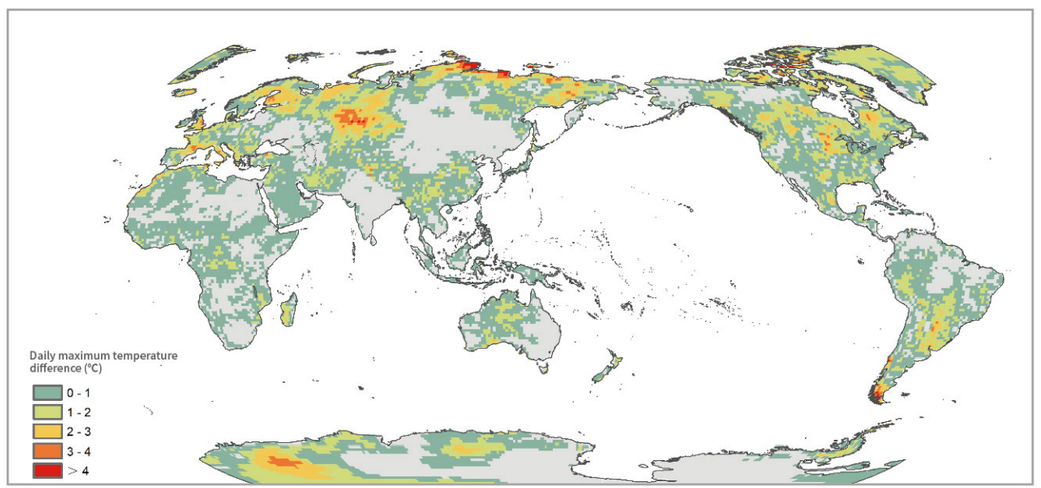


Figure 7 The difference between the average maximum temperature from 2019 to 2023 and that from 2014 to 2018

In terms of the trend of daily maximum temperature increase (Figure 8), Northeast Asia, borders between Europe and Asia, Central North America, and Northwest Antarctica warmed at a rate of 0.2-0.4°C per decade, and the daily maximum temperature increase rate in certain areas exceeded 0.6°C per decade.

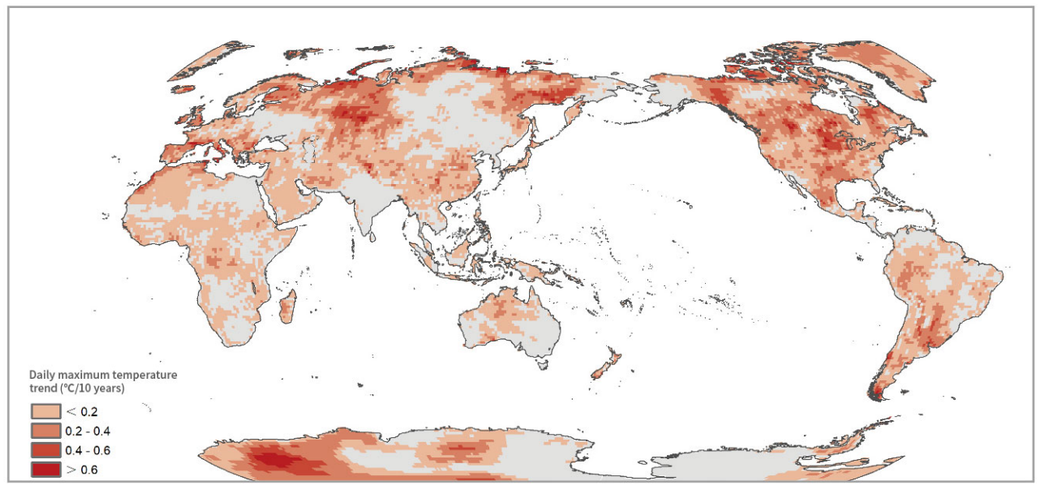


Figure 8 The rising of daily maximum temperatures in different parts of the world

As for the frequency of high temperature processes around the world (Figure 9), except for Antarctica, northern Eurasia, northern North America, the Qinghai-Xizang Plateau and western mountains of South America, all other regions of the world experienced high temperature processes. South Asia, Southeast Asia, the Turan Lowland in Asia, central and southern Africa, most of Oceania, southern North America, and the Amazon Plain in South America experienced 5-10 high temperature processes per year on average, and certain areas had more than 10.

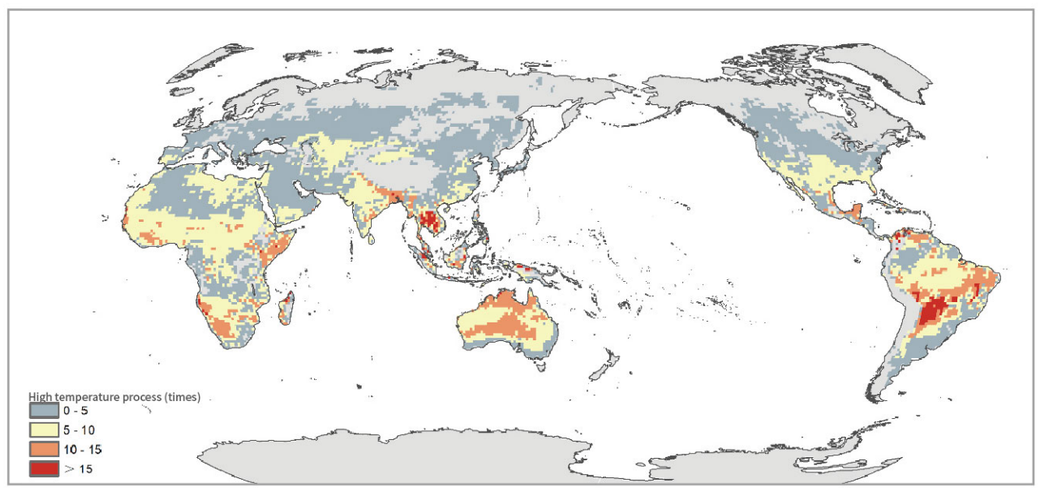


Figure 9 The frequency of high temperature processes in different parts of the world

With regard to the difference between the frequency of high temperature processes from 2014 to 2018 and that from 2019 to 2023 (Figure 10), the frequency of high temperature processes in the Congo Basin in Africa, central South America and other regions from 2019 to 2023 increased significantly compared with that from 2014 to 2018, up by about 2-4 times, or even more than 4 times in certain areas.

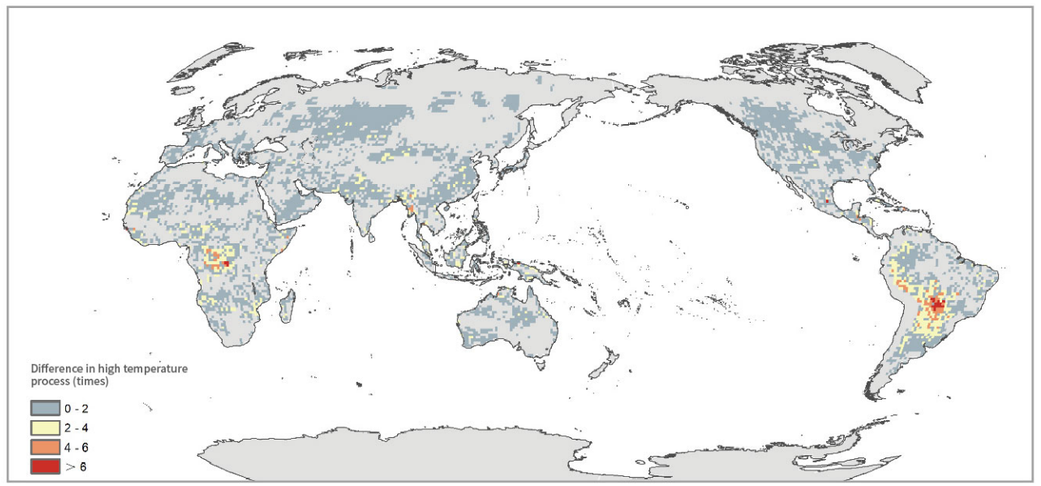


Figure 10 The difference between the frequency of high temperature processes from 2019 to 2023 and that from 2014 to 2018

As for the increasing trend of the frequency of high temperature processes (Figure 11), northwestern Africa and the Congo Basin, the surrounding areas of the Qinghai-Xizang Plateau, the Mississippi River Basin in North America and the western Amazon Plain in South America saw rapidly increasing frequency of high temperature processes, with an average of 0.2-0.6 times per decade, or even more than 0.6 times per decade in certain areas.

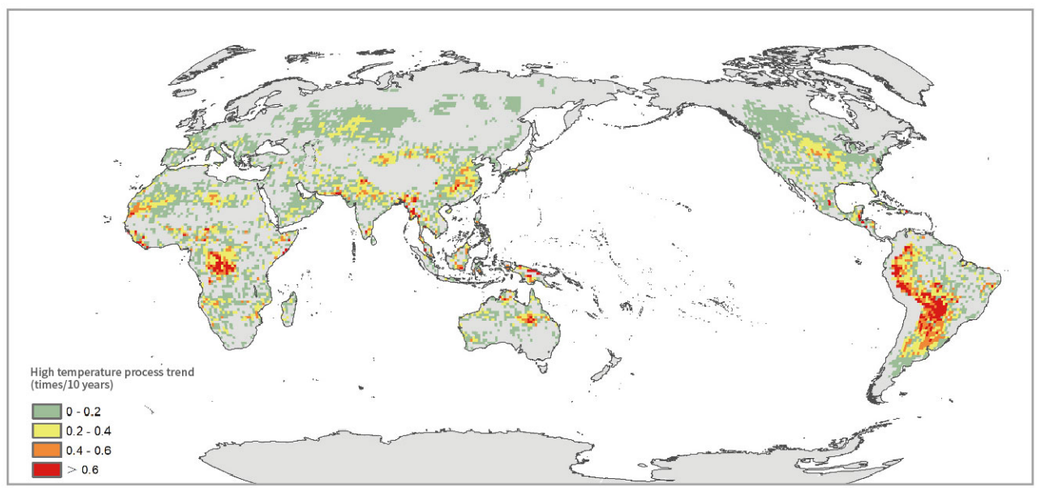


Figure 11 The increasing frequency of high temperature processes in different parts of the world

4 High temperature risks and insights

Figure 12 assessed the risk of heatwaves for the global population based on the global population distribution in 2022 by using the number of high-temperature days as a hazard indicator. The results showed that under the combined influence of the hazard of heatwaves and population exposure, people living in the Gangetic Plain of the Indian Peninsula were facing a relatively high risk of heatwaves, with over 50,000 people exposed to heatwaves per day in most areas, followed by central and western Africa, eastern and western Asia with over 20,000 people per day in certain areas. The risk of heatwaves for the population in Europe, southeastern North America and southeastern South America was relatively low, with less than 5,000 people per day in most areas. This not only reflects the characteristics of the impact of heatwaves on different regions of the world, but also highlights the urgency and necessity of the global response to heatwave disasters.

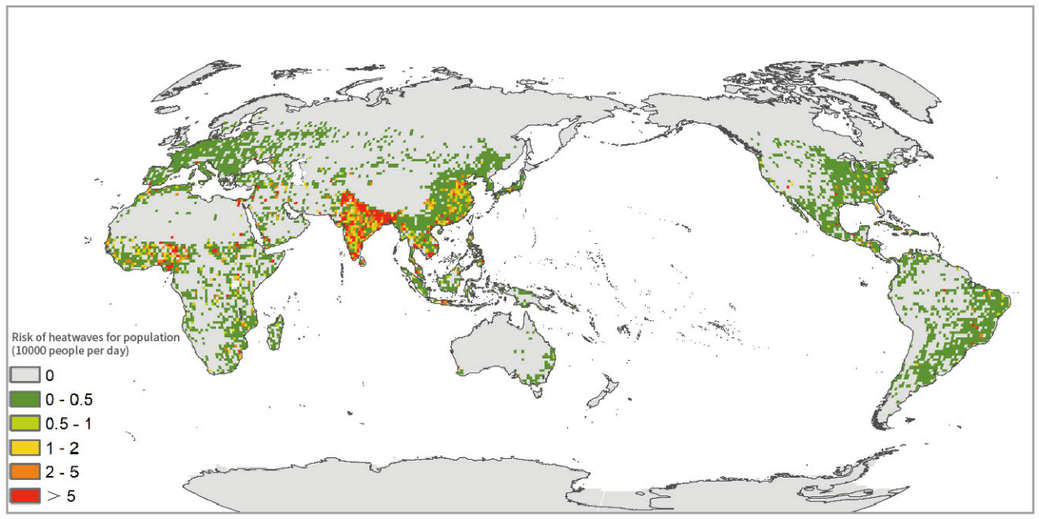


Figure 12 Global population heatwave risk

As global warming continues to intensify, the risks of heatwaves, foreseeable adverse impacts and related losses and damages caused by climate change are escalating. Climate and non-climate risks will intertwine more frequently, leading to more complex and difficult-to-manage compound and cascading risks. This report uses the heatwave standards recommended by WMO and analyzes the spatiotemporal characteristics of global heatwaves from 2014 to 2023 based on the ERA5 reanalysis dataset of ECMWF, providing scientific evidence for governments and international organizations to formulate targeted climate adaptation policies and emergency action plans to reduce the impact of heatwaves on human health and social stability.

The increasing risk of heatwaves further highlights the urgency of cross-border cooperation. Climate change and heatwaves are global challenges that require concerted efforts from all countries. Only through joint actions, including strengthening medical services and improving the early warning system in response to heatwaves, promoting urban planning and infrastructure construction to effectively respond to extreme heat events, advocating sustainable development and climate adaptation measures and strengthening disaster risk management and reduction cooperation on a global scale, can we more effectively protect the health of all mankind, maintain the global ecological environment and contribute to building a safer, healthier and more sustainable world in the future. Such global collaboration will not only help mitigate the impact of high temperatures and heatwaves, but also provide important guarantees for the stability and prosperity of the global society.

04

Special Report 3

Earthquakes in Türkiye 2023

1. Characteristics of the earthquakes in Türkiye
2. Hazard characteristics of the earthquakes
3. Impact analysis of the disasters
4. Reflections and insights

Special Report 3 Earthquakes in Türkiye 2023

1 Characteristics of the earthquakes in Türkiye

1.1 Tectonic plates

The movements of four tectonic plates (Arabian plate, Eurasian plate, Indian plate, and African plate) and one smaller tectonic block (Anatolian plate) result in seismic activities in and around Türkiye, including subduction, large-scale conversion faults, extrusion orogeny, and crustal extension. The 2023 earthquake in Türkiye occurred at the intersection of these plate boundaries, with the mainshock and aftershocks mostly concentrated in the East Anatolian Fault Zone and its associated fault systems (including the Dead Sea Fault), with the southernmost aftershocks reaching Israel in the vicinity of the Cyprus Trench (the converging plate boundary of the northward subduction of the African Plate) (Figure 1).

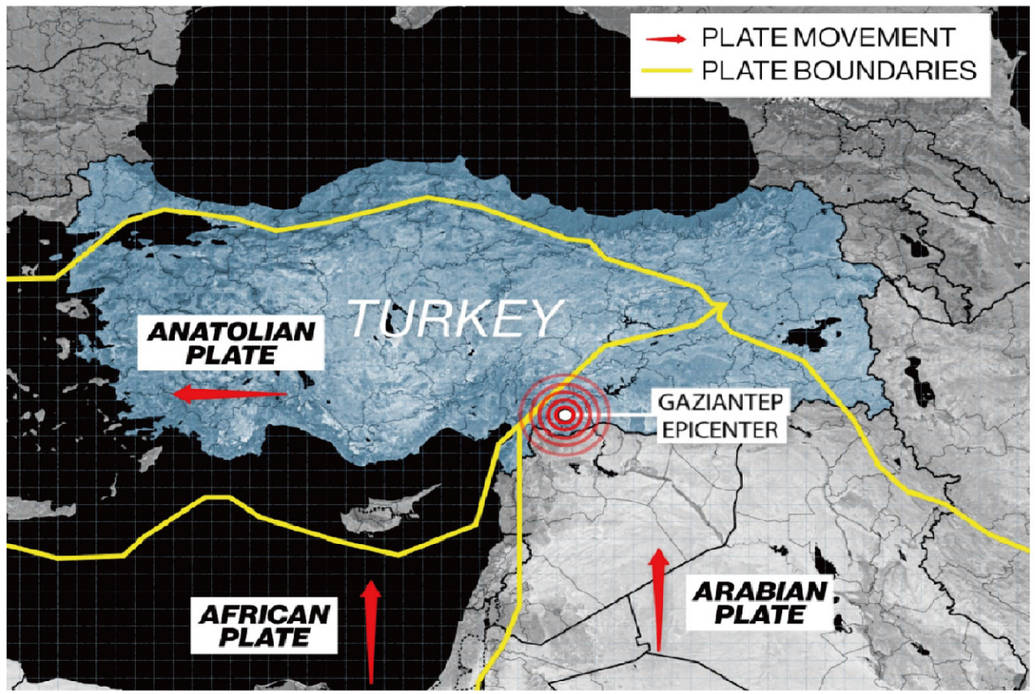


Figure 1 Schematic diagram of plate movement and plate boundaries in Türkiye and surrounding areas

1.2 Seismic structure

Along the eastern margin of the Mediterranean region around Türkiye, the complex interaction between the African, Arabian Peninsula and Eurasian plates inevitably leads to friction and collision between the plates, resulting in the Anatolian Fault System, which consists of the North Anatolian Fault Zone and the East Anatolian Fault Zone (Figure 2). The North Anatolian Fault Zone runs through northern Türkiye, resulting in 96% of Türkiye's territory being located in the seismic zone, which is recognized by the international seismological community as one of the most seismically active areas in the world. Historically, the Anatolian fault system has been the seismic fault for many major earthquakes in and around Türkiye, the worst of which occurred in May 526 and killed 250,000 people.

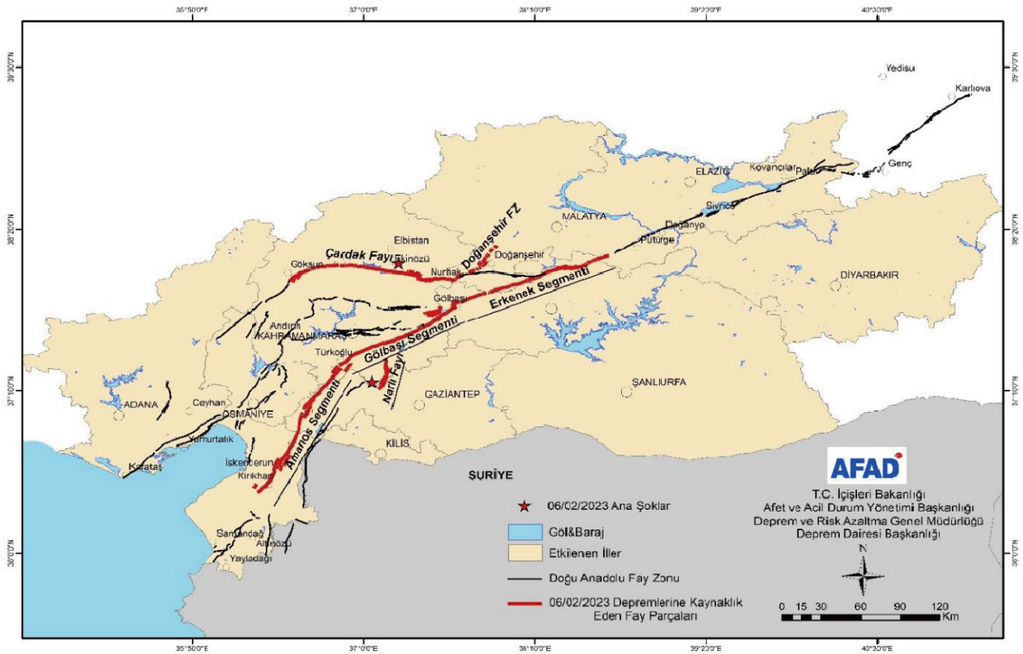


Figure 2 Distribution map of Anatolian fault system

1.3 Occurrence characteristics

A magnitude of 7.7 earthquake occurred in Southeastern region of Türkiye at 4:17 a.m. local time on February 6, 2023, followed by a 7.6 magnitude earthquake at 13:24 p.m. with the epicenters located at 37.166° N, 37.042° E, around Pazarcik (Kahramnmaras), and 38.042° N, 37.203° E , around Elbistan (Kahramanmaras), respectively, and the depth of the epicenter was 8.6 km and 7.0 km, respectively[3]. They were shallow-focus earthquakes on left-lateral strike-slip faults. The two earthquakes occurred on different branch faults of the East Anatolian fault, and the second earthquake occurred in the north-north-east direction of the first earthquake, with an interval of about 95 kilometers between the two epicenters, constituting a typical and rare twin shock (Figure 3).

In addition, the aftershocks of this earthquake were characterized by high magnitude, large numbers, and wide impact areas (Figure 4), which became a serious obstacle to disaster relief. For example, within 24 hours of the first major earthquake, hundreds of aftershocks of magnitude 4 or higher occurred in the earthquake area, stretching for more than 300 kilometers.

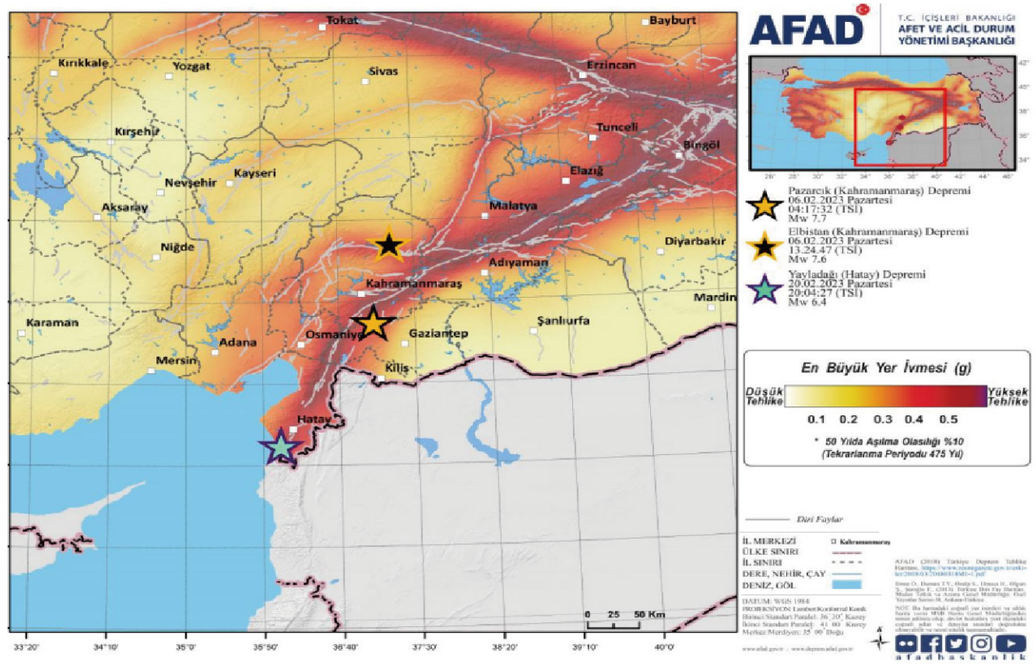


Figure 3 Distribution of the epicenters of the two earthquakes in Türkiye

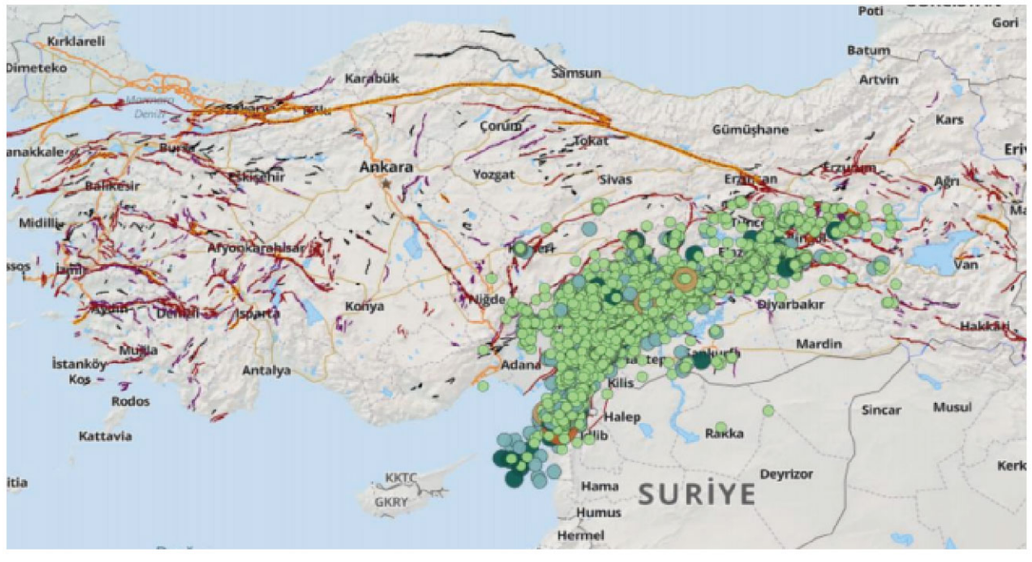


Figure 4 Distribution of aftershock epicenters in Türkiye and its surroundings

*Note: Aftershocks from February 6, 2023 to February 27, 2023 are shown in the figure.

[3] The determination of magnitude and source depth varies from country to country and from institution to institution. This Report is based on official data published by Türkiye' s Disaster and Emergency Management Authority (AFAD).

2 Hazard characteristics of the earthquakes

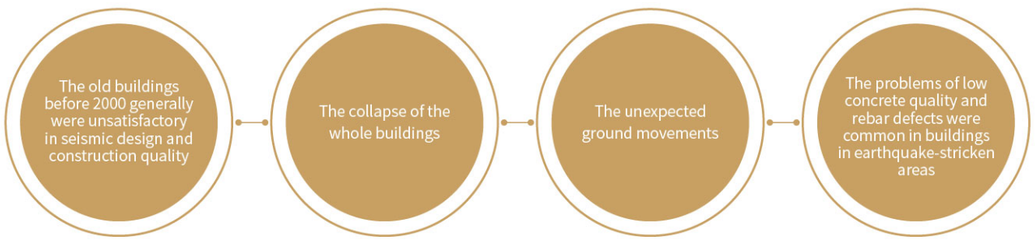
2.1 Construction quality problems

On June 5, 2023, AFAD released an official investigation report[4] on the February 6 earthquakes, and investigators found that the main reasons for the collapse of buildings were insufficient seismic fortifications, site effects, unexpected ground movements, and quality defects in building materials after conducting an on-site study of structural damage to some houses in the earthquake-stricken area.

First of all, the old buildings before 2000 generally were unsatisfactory in seismic design and construction quality, and the lack of seismic fortification measures led to the low ductility of the buildings, which caused the collapse of the whole buildings. Secondly, site effects include liquefaction and surface breaking, which once in close proximity to a building, often cause foundation damage and further lead to the collapse or severe damage of the building. In addition, the unexpected ground movements, especially the low-frequency components with a large proportion of energy, resonated with the buildings of about 10 floors during the earthquake, which exceeded the bearing capacity of the buildings. Finally, the problems of low concrete quality and rebar defects were common in buildings in earthquake-stricken areas (Fig. 5). In specific, as flat gravel extracted directly from streams or seawater was used, the aggregate particle size used in the concrete of some buildings was not suitable, resulting in widespread brittle fractures. Many building structures used ordinary rebar (the end of which failed to meet the construction requirements or was not bent at all), and only a small number of threaded rebar (stirrups), resulting in weak column and beam connections. Some rebars were corroded, and some were peeled off due to insufficient longitudinal length, which prevented them from due performance in the earthquakes.

Figure 5 Examples of defective concrete, rebar and their damage

*Note: City name a: Kahramanmaraş, b: Malatya, c: Adiyaman, d: Gaziantep.



[4] The report is titled 06 ŞUBAT 2023 PAZARCIK-ELBİSTAN KAHRAMANMARAŞ (Mw: 7.7 – Mw: 7.6) DEPREMLERİ RAPORU, report link: https://deprem.afad.gov.tr/home-page

2.2 The actual ground motion far exceeded the local fortification level

According to the Ministry of Interior Disaster and Emergency Management Presidency of the Republic of Türkiye, the Earthquake Zoning Map issued in 1996 divided Türkiye into five types of areas for seismic fortification management, namely Class I, II, III, IV, and V areas (Figure 6). The zoning map stipulates that the design basic acceleration value of the Class I, Class I, II, III, IV, and V areas shall not be less than 0.40g, 0.30g, 0.20g, 0.10g, and 0.10g, respectively. After the earthquake, the Turkish Acceleration Database and Analysis System website publicly released a total of 280 sets of strong earthquake observation records Station No. 4614 obtained the maximum peak acceleration record of the earthquake, with an epicenter distance of 34.93 kilometers and a peak east-west, north-south and vertical acceleration of 1.97g, 1.95g and 1.35g respectively, far beyond the local fortified ground motion level (0.20g-0.40g). Therefore, in addition to the unfortified housing facilities and the low construction quality, the high amplitude and complex characteristics of ground motion caused serious damage or destruction to a large number of regularly constructed housing facilities, which was also one of the important reasons for the destructive earthquake event.

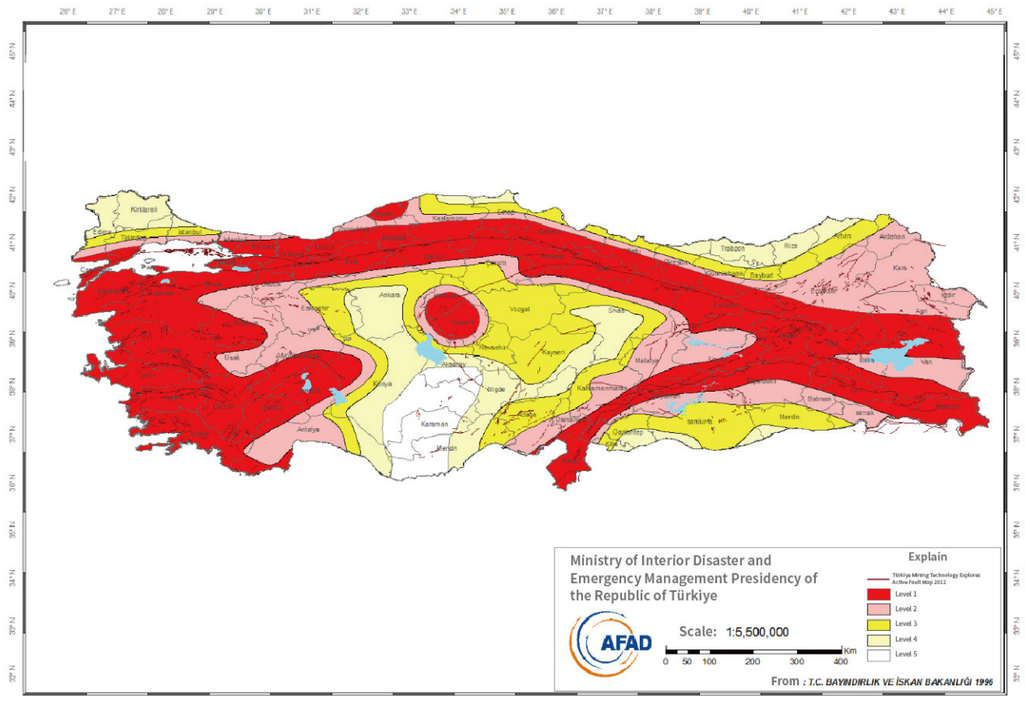


Figure 6 Seismic zoning map of Türkiye (1996)

2.3 Cascading disasters

Landslides, mudslides, tsunamis, floods, fires, explosions, toxic gas leaks, etc. triggered by earthquakes are collectively referred to as cascading disasters of earthquakes. The earthquakes in Türkiye triggered fires, explosions, and floods, worsening the aftermath. At around 5:00 p.m. local time on February 6, 2023, some goods containers at the Port of Iskenderun in Southern Türkiye collapsed due to the earthquakes, and a fire ensued. The flames spread rapidly, causing severe damage to the port (Figure 7). A gas pipeline in Hatay Province in Southeastern Türkiye exploded and caught fire after the first earthquake (Figure 8). At the same time, on February 9, 2023 local time, near Salqin in Idlib Province in Northwestern Syria, a dam was badly damaged in the earthquakes and eventually collapsed, causing a nearby village to be flooded and forcing a large number of residents to leave their homes.

Figure 7 Containers burned at the Port of Iskenderun in Türkiye

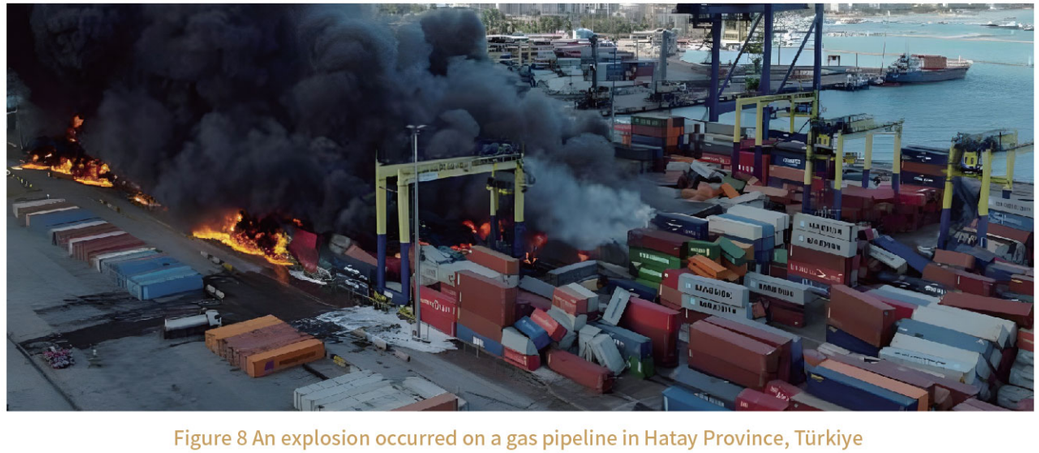


Figure 8 An explosion occurred on a gas pipeline in Hatay Province, Türkiye

3 Impact analysis of the disasters

3.1 Casualties

As of September 25, 2023, the earthquake has killed at least 54,603 people (50,103 in Türkiye and 4,500 in Syria), injured 116,928 (107,608 in Türkiye and 9,320 in Syria), and affected about 13.32 million people (9.21 million in Türkiye and 4.11 million in Syria), according to EM-DAT statistics. As can be seen in Figure 9, within 100 hours of the first earthquake, Türkiye and Syria reported more than 100,000 casualties (including more than 20,000 deaths). About 200 hours after the earthquake, the number of casualties in Türkiye and Syria increased sharply again to nearly 150,000 (including nearly 40,000 deaths). After 300 hours of the earthquake, the increase in casualties has flattened.

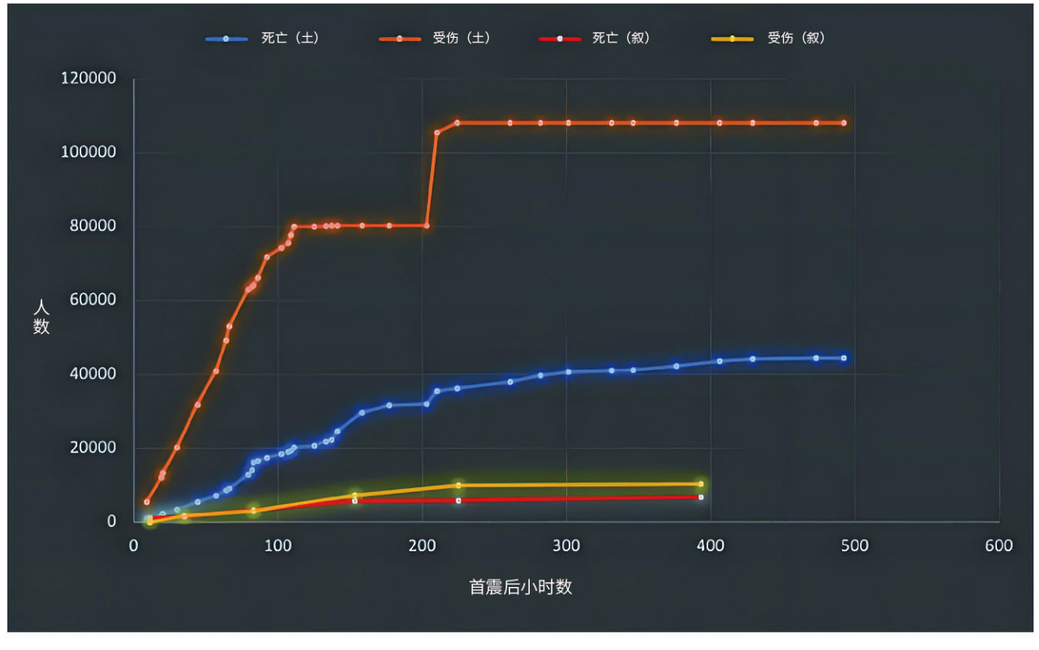


Figure 9 Changes in the number of casualties in Türkiye and Syria after the first earthquake

*Note: The data was collected as of 10:00 a.m. local time on February 27, 2023.

3.2 Economic losses

As of September 25, 2023, the earthquakes caused direct economic losses to both Türkiye and Syria amounting to USD 42.9 billion (USD 34 billion in Türkiye and USD 8.9 billion in Syria), according to EM-DAT statistics. But the Turkish Federation of Enterprises and Businesses estimates that the earthquakes might cause economic losses of more than USD 84.1 billion, or about 10% of Türkiye's GDP, USD 70.8 billion of which was building collapses, USD 10.4 billion was loss of national income, and USD 2.9 billion was loss of labor. According to the United Nations Development Programme's estimates, Türkiye's eventual losses in the strong earthquakes were estimated to be more than USD 100 billion.

34

Caused direct economic losses of USD 34 billion in Türkiye

8.9

Caused direct economic losses of USD 8.9 billion in Syria

3.3 Infrastructure

In addition to the collapse of tens of thousands of buildings in Türkiye and Syria, the earthquakes and their many aftershocks also directly damaged infrastructure such as roads, railways, and bridges, and distorted or destroyed a large amount of farmland by liquefied sediment surging from the ground. A team from the General Directorate of Construction Affairs of the Ministry of Environment, Urbanization and Climate Change of Türkiye, after conducting a damage assessment of the disaster area, found that at least 173,000 of the approximately 1.316 million buildings in Türkiye had collapsed or been severely damaged and needed to be demolished immediately. The demolition of each dwelling meant the creation of about 75 cubic meters of concrete fragments, a figure that increased to 750 cubic meters if the furniture and other equipment inside the dwellings were included.

According to AFAD, the buildings damaged by the earthquakes were in the districts of Adana, Adiyaman, Diyarbakir, Elazig, Gaziantep, Kahramanmaraş, Malatya, Hatay, Kilis, Osmaniye and Şanlıurfa. Among them, Hatay Province had the highest level of building damage and temporary shelter demand, followed by Kahramanmaraş, Adiyaman and Gaziantep Provinces (Figure 10).

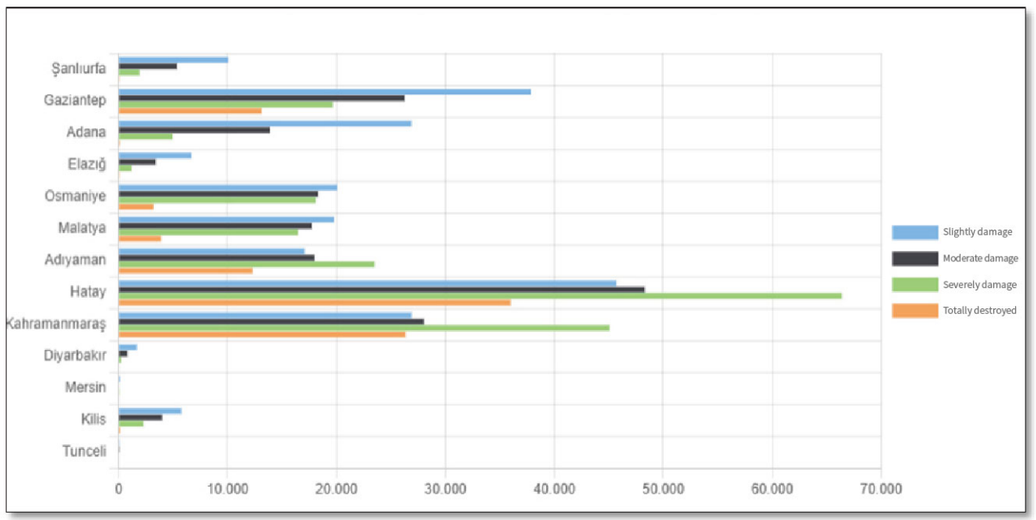


Figure 10 Number of lightly/moderate/severely damaged and destroyed buildings in the provinces of Türkiye

4 Reflections and insights

The earthquake that struck Türkiye and Syria on February 6, 2023 has become one of the world's most destructive earthquake disasters with the largest death toll and economic losses in nearly two decades for the following reasons. First of all, the earthquake occurred in the early hours of the morning, local time, when most people were asleep without early warning and preparation for the earthquake and no institutions issued warnings and guidance for evacuation in time, resulting in many people being buried. Second, most of the buildings in Türkiye and Syria used brick and concrete materials instead of frame structures, falling short of the seismic standards. The collapsed buildings in the earthquake increased the risk of injuries. Third, the earthquake occurred on the border between Türkiye and Syria with complex terrain and large population movements, coupled with the shortage of rescue personnel, insufficient heavy equipment, damaged roads, severe cold weather and frequent aftershocks, bringing huge challenges to the work of local governments and international rescue workers.

In the aftermath of the earthquake, the Türkiye government took a series of measures in response, including searching and rescuing trapped people, providing first-aid supplies and building temporary shelters. The international community also actively extended a helping hand, with nearly 100 countries and international organizations announcing assistance to Türkiye, highlighting the need for international relief cooperation in the event of a catastrophe. The international community could take a series of measures to strengthen cooperation on humanitarian assistance in earthquake disasters. First, the establishment of cross-border cooperation mechanisms is the key, including the establishment of an earthquake rescue alliance or multilateral cooperation organization (such as the International Search and Rescue Advisory Group, INSARAG) to quickly respond to and coordinate rescue operations when an earthquake disaster occurs. Second, it is necessary to simplify the international rescue cooperation process. INSARAG has the functions of standard identification and command for search and rescue teams, but it requires the process of “recipient country call-INSARAG response” to enter and coordinate, which greatly affects the efficiency of rescue. Third, sharing resources and information is also crucial. Countries can share resources such as rescue personnel, medical equipment, food, and medicines to improve rescue efficiency and coverage of rescue. Forth, training and technical support are essential, and the international community can work together to provide training and technical support to help rescuers in various countries improve their emergency response capabilities and professional skills in response to earthquake disasters. Through these comprehensive measures, the international community will effectively strengthen cooperation on humanitarian actions in earthquake disasters, improve the level of support and assistance to the people in the disaster areas and reduce the casualties and property losses caused by earthquake disasters.

Annex Ⅰ Top 50 Natural Disasters in Terms of Global Deaths and Direct Economic Losses from 1991 to 2023

Top 50 natural disasters worldwide by death toll, 1991-2023

No.	Time	Countries or regions affected	Type of disaster	Deaths (persons)	Direct economic losses (USD 0.1 billion, current year prices)
1	2010/1/12	Haiti	Earthquake	222,570	80
2	2004/12/26	Indonesia	Earthquake	165,708	44.516
3	1991/4/29-5/10	Bangladesh	Storm	138,866	17.8
4	2008/5/2-3	Myanmar	Storm	138,366	40
5	2008/5/12	China	Earthquake	87,476	850
6	2005/10/8	Pakistan	Earthquake	73,338	52
7	2023/2/6	Syria, Türkiye	Earthquake	56,683	429
8	2010/6/-2010/8/	Russia	Extreme high temperature	55,736	4
9	2004/12/26	Sri Lanka	Earthquake	35,399	13.165
10	1999/12/15-12/20	Venezuela	Flood	30,000	31.6
11	2003/12/26	Iran	Earthquake	26,796	5
12	2003/7/16-8/15	Italy	Extreme high temperature	20,089	44
13	2001/1/26	India	Earthquake	20,005	26.23
14	2010/2/-2011/11/	Somalia	Drought	20,000	0
15	2011/3/11	Japan	Earthquake	19,846	2100
16	2003/8/1-8/20	France	Extreme high temperature	19,490	44
17	1999/8/17	Türkiye	Earthquake	17,127	200
18	2004/12/26	India	Earthquake	16,389	10.228
19	2003/8/1-8/11	Spain	Extreme high temperature	15,090	8.8
20	1998/10/25-11/8	Honduras	Storm	14,600	37.936
21	2023/9/10-9/11	Libya	Storm	12,352	62
22	1999/10/28-10/30	India	Storm	9,843	25
23	1993/9/29	India	Earthquake	9,748	2.8
24	2003/8/-2003/8/	Germany	Extreme high temperature	9,355	16.5
25	2015/4/25	Nepal	Earthquake	8,831	51.74
26	2004/12/26	Thailand	Earthquake	8,345	10
27	2013/11/8	The Philippines	Storm	7,354	100
28	2013/6/12-6/27	India	Flood	6,054	11
29	1991/11/5-11/8	The Philippines	Storm	5,956	1
30	2006/5/26	Indonesia	Earthquake	5,778	31
31	1995/1/17	Japan	Earthquake	5,297	1000
32	1998/5/30	Afghanistan	Earthquake	4,700	0.1
33	2018/9/28	Indonesia	Earthquake	4,340	14.5
34	2007/11/15-11/19	Bangladesh	Storm	4,234	23
35	1997/11/2-11/4	Vietnam	Storm	3,682	4.7
36	1998/7/1-8/30	China	Flood	3,656	300
37	1998/10/25-11/8	Nicaragua	Storm	3,332	9.877
38	2015/6/29-8/9	France	Extreme high temperature	3,275	0
39	2023/5/2-5/5	Democratic Republic of the Congo	Flood	2,970	0.1
40	2010/4/14	China	Earthquake	2,968	5
41	2023/9/8	Morocco	Earthquake	2,946	70
42	1998/6/9-6/11	India	Storm	2,871	4.69
43	1996/6/30-7/26	China	Flood	2,775	126
44	2004/9/17-9/18	Haiti	Storm	2,754	0.5
45	2003/8/-2003/8/	Portugal	Extreme high temperature	2,696	0
46	2004/5/23-6/1	Haiti	Flood	2,665	0
47	2021/8/14	Haiti	Earthquake	2,575	16.2
48	2020/6-2020/8	The United Kingdom	Extreme high temperature	2,556	0
49	1998/5/26	India	Extreme high temperature	2,541	0
50	1992/12/12	Indonesia	Earthquake	2,500	1

Top 50 natural disasters worldwide by direct economic losses, 1991-2023

No.	Time	Countries or regions affected	Type of disaster	Direct economic losses (USD 0.1 billion, current year prices	Deaths (persons)
1	2011/3/11	Japan	Earthquake	2100	19,846
2	2005/8/29-9/19	The United States	Storm	1250	1,833
3	1995/1/17	Japan	Earthquake	1000	5,297
4	2017/8/25-8/29	The United States	Storm	950	88
5	2008/5/12	China	Earthquake	850	87,476
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	2023/2/6	Syria, Türkiye	Earthquake	429	56,683
11	2021/7/12-7/15	Germany	Flood	417	242
12	2011/8/5-2012/1/4	Thailand	Flood	400	813
13	1998/7/1-8/30	China	Flood	300	3,656
14	2010/2/27	Chile	Earthquake	300	562
15	2021/2/10-2/20	The United States	Storm	300	235
16	2008/9/12-9/16	The United States	Storm	300	82
17	1994/1/17	The United States	Earthquake	300	60
18	2004/10/23	Japan	Earthquake	280	40
19	1992/8/24	The United States	Storm	265	44
20	2023/7/21-8/2	China, the Philippines	Storm	252.94	87
21	2019/10/10-10/17	The United States	Wildfire	250	3
22	2016/6/28-7/13	China	Flood	220	289
23	2008/1/10-2/5	China	Extreme low temperature	211	129
24	1999/8/17	Türkiye	Earthquake	200	17,127
25	2016/4/16	Japan	Earthquake	200	49
26	2012/6/-2012/12/	The United States	Drought	200	0
27	2010/5/29-8/31	China	Flood	180	1,691
28	2004/9/15-9/16	The United States	Storm	180	52
29	2019/10/12-10/17	Japan	Storm	170	99
30	2020/5/21-7/30	China	Flood	170	280
31	2021/6/1-/8/30	China	Flood	165	352
32	2018/11/8-11/16	The United States	Wildfire	165	88
33	2014/9/	India	Flood	160	298
34	2018/10/10-10/11	The United States	Storm	160	45
35	2005/9/23-10/1	The United States	Storm	160	10
36	2004/8/13	The United States	Storm	160	10
37	2012/5/20	Italy	Earthquake	158	7
38	2011/2/22	New Zealand	Earthquake	150	181
39	1995/8/1-9/8	South Korea	Flood	150	68
40	2023/4/1-9/30	The United States	Drought	145	247
41	2005/10/24	The United States	Storm	143	4
42	1999/9/21	China	Earthquake	141	2,264
43	2011/5/20-5/25	The United States	Storm	140	176
44	2018/9/12-9/18	The United States	Storm	140	53
45	1994/1/-1994/12/	China	Drought	138	0
46	2020/5/20	India	Storm	135	90
47	2020/8/27-8/28	The United States	Storm	130	33
48	2017/10/8-10/20	The United States	Wildfire	130	30
49	2020/8/16-10/1	The United States	Wildfire	130	31
50	2013/5/28-6/18	Germany	Flood	129	4

Annex Ⅱ Calculation method, data source and conversion method for comprehensive disaster index

1 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 multi-regional historical disaster data, 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 China's overall disaster situation at the national and provincial levels. The national-level disaster index is used to evaluate the overall disaster situation of China by year, while the provincial-level disaster index is used to evaluate the overall disaster situation of each province by year. The calculation methods are briefly described below.

(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. The population indicators include the population affected by disasters, the death and missing toll, the population who have been urgently resettled, and the population in need of assistance due to drought and drinking water difficulties. The agricultural dimension indicators include the area of crops affected and the area of crops that have been lost. The housing dimension indicators include the number of collapsed houses and the number of damaged houses. The economic dimension indicator includes direct economic losses. Each disaster indicator in the three dimensions of population, agriculture and housing will be first normalized. The economic dimension indicator will be converted using the GDP index before normalization. The conversion method is detailed in Part II of the Annex. The normalization formula is (take the affected population as an example)

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

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

2. Calculation of the dimension index

For each year in the historical series, the indicators of each dimension of China's overall disaster situation in that year are calculated separately, which is the geometric average of the normalized disaster indicators within the dimensions. 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 (denoted as I) for that year is the geometric mean of the normalized indicators of its four dimensions. The formula is

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

I_P^*, I_C^*, I_H^*, and I_E^* are the normalized values of I_P, I_C, I_H, and I_E respectively, and W_P, W_C, W_H, and W_E are the weight of the corresponding dimension indicator (Table 2).

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

Dimension indicator	Symbol	Normalized symbol	Disaster indicator	Symbol	Normalized symbol
Dimension index of population	I_P	I_P^*	Affected population	P_a	P_a^*
			Death and missing toll	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 assignments for the calculation of national-level comprehensive disaster index

Dimension index	Weight symbol	Weight assignment
Dimension index of population	W_P	0.30
Dimension index of agriculture	W_C	0.15
Dimension index of housing	W_H	0.30
Dimension index of economy	W_E	0.25
Affected population	W_{pa}	0.20
Death and missing toll	W_{pd}	0.40
Evacuated population	W_{pt}	0.20
Number of 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. 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. The differences between the steps are briefly described below.

1. Pretreatment of disaster indicators

Some provinces suffered no disaster in certain years with disaster indicator values at zero. In order to ensure that zero is not used in the geometric mean in the index calculation, the following formula is adopted for the normalization of the provincial disaster indicators (taking 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 formula for calculating the provincial agriculture, housing and economic dimension indicators is the same as that for the national level, and the calculation of the population dimension indicators does not include the population in need of assistance due to drought and drinking water difficulties. Specifically for

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

3. Calculation of the comprehensive disaster index

The formula for calculating 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 population dimension indicators, the weight values of the other dimension indicators and disaster indicators are also the same as those for the national-level disaster index. Attachment 3 shows the calculation of the weight assignment of the population dimension.

Attachment 3 Calculation of the weight assignment of the population dimension for the provincial-level comprehensive disaster index

Dimension indicator	Weight symbol	Weight assignment
Affected population	W_{pa}	0.25
Death and missing toll	W_{pd}	0.50
Evacuated population	W_{pt}	0.25

2 Data sources and conversion methods

1.Data on China's total population, gross domestic product (GDP) and provincial permanent population and gross regional product (GRP) at the end of the year from 2003 to 2022 are from the annual data of the National Bureau of Statistics.

2.Data on China's total population and GDP at the end of 2023 are sourced from the Statistical Communiqué of the People's Republic of China on the 2023 National Economic and Social Development released by the National Bureau of Statistics.

3.The permanent resident population of each province (autonomous region and municipality) at the end of 2023 is estimated using the natural growth rate of Chinese population in 2023 published by the National Bureau of Statistics:

Permanent resident population at the end of 2023 = permanent resident population at the end of 2022×(1-1.48‰)

The GRP of each province (autonomous region and municipality) in 2023 is estimated using the GDP growth rate in 2023 published by the National Bureau of Statistics:

GRP in 2023 = GDP in 2022 × (1+5.2%)

4.Conversion methods for GDP and direct economic losses.

In the Report, the GDP from 2003 to 2023 and the direct economic losses caused by disasters in China are converted according to the GDP index published by the National Bureau of Statistics, with 2003 as the base period, and the calculation formula is:

Converted value of GDP for the year = GDP for 2003 × cumulative value of the GDP index for that year relative to 2003

The rate of change in GDP in that year compared to 2003 = GDP in that year ÷ converted value of GDP in that year

Converted value of direct economic losses for the year = direct economic losses for the year ÷ rate of change in GDP for that year compared to 2003

In the formula, “cumulative value of the GDP index for that year relative to 2003” is the product of the GDP index (1 denotes the previous year) from 2004 to the current year, and the year 2003 is expressed as 1. In the case of 2010, the cumulative value is the product of the GDP index from 2004 to 2010 (1 denotes the previous year).

From 2003 to 2023, the GRP of each province and the direct economic losses of each disaster type in each province are converted using the above method, and the GDP index is replaced by the GRP index of the province.

Acknowledgments

Secretariat of UNDRR Asia-Pacific Scientific and Technical Advisory Group
Chinese Culture Research and Innovation Team for Global Initiatives, Beijing Normal University
National Key Research and Development Program: "Loss Evaluation and Integrated Risk Assessment of Multi-hazard of the Qinghai-Tibetan Plateau" (2019QZKK0906)
China Earthquake Networks Center, China Earthquake Administration
China Institute of Water Resources and Hydropower Research
Future Earth Core Science Project – Integrated Risk Governance
International Center for Collaborative Research on Disaster Risk Reduction, Beijing Normal University
The Platform of International Collaboration on Disaster Risk Reduction, Beijing Normal University

Supporting Institutions

National Climate Center, China Meteorological Administration
China Association for Disaster Prevention

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Citation of this publication: ADREM, SNSE, NDRC, IFRC and IRDR (2024). 2023 Global Natural Disaster Assessment Report. Beijing.

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