Chapter

Perspective Chapter: A Global View of Natural Hazards Related Disasters

Mohammad Mokhtari, Parvaneh Faridi, Mehdi Masoodi and Seyed Mehran Ahmadi

Abstract

Natural hazards have become an increasingly prevalent threat to the world, with the frequency of recorded disasters rising in the recent years. Analyzing global data on natural hazards, identifying the most common and deadly events, and prioritizing decision-making on safe constructions, settlements, and factories are crucial to respond effectively to this trend. Using the EM-DAT database, this study examined primary natural hazards worldwide from 1900 to 2022, including earthquakes, volcanic eruptions, landslides, floods, droughts, wildfires, storms, and extreme temperatures. Statistical data show that storms have the highest frequency of occurrence (38%), droughts are the deadliest (53%), floods affect the most people (50%), and storms cause the most economic losses (41%). Asia has experienced the highest frequency, most deaths, and most total affected people due to natural hazards, followed by North America and Africa, respectively. North America has also seen the highest economic losses, followed by Asia and Europe. The study emphasizes the importance of databases like EM-DAT in advancing our knowledge of natural hazards worldwide, and supporting informed decision-making in risk assessment, disaster management, and mitigation efforts.

Keywords: affected people, death, direct economic losses, frequency, global view, natural hazards

1. Introduction

According to the emergency event database (EM-DAT) classification, there are two main types of disasters [1]: natural and human-made or technological. Natural hazards are defined as natural phenomena that have the potential to have a negative impact on humans, societies, and the environment. They are different from other types of hazards such as man-made hazards [2, 3]. Natural hazards can also lead to secondary events, creating additional hazards. For example, a volcanic eruption can trigger other hazards such as ash and lava flow. Although related, natural hazards and natural disasters are not identical. A natural hazard is a potential threat of an event that has the potential to cause a negative impact, while a natural disaster is the actual occurrence of that event, causing significant harm to a community. Natural hazards

and disasters are caused by natural processes throughout the earth's history. However, the risk (the notion of risk is defined as the product of a hazard by a vulnerability) associated with environmental hazards is determined by physical conditions and events and human actions, conditions, decisions, and culture.

Human activities can directly contribute to physical events such as small- and medium-scale flooding, landslides, land subsidence, and drought in rural and urban areas due to environmental degradation, human intervention in ecosystems, and global climate change. These human-induced hazards occur at the intersection of natural and human processes and result in environmental degradation. Climate change introduces a new type of hazard modification, and it is essential to study these human-induced events and how they have affected the frequency of disasters in the past. This knowledge can be used to reduce risk in the future. Additionally, it is important to consider low probability but high-consequence hazards such as impact by near-Earth objects in risk analysis [4].

Natural hazards can be broadly categorized into six groups [1]: geohazards (such as earthquakes, tsunamis, and volcanic eruptions), meteorological hazards (such as storms and extreme temperatures), hydrological hazards (such as flooding and landslides), climatological hazards (such as drought and wildfires), biological hazards (such as epidemics and insect infestations), and extraterrestrial hazards (such as airbursts and space weather). The impacts of these hazards can be classified into three categories: primary, secondary, and tertiary. Primary impacts are the immediate effects of the hazard such as water damage from flooding or building collapse during an earthquake. Secondary impacts are consequences caused by the primary impact such as fires following an earthquake or disrupted electricity and water supply. Tertiary impacts are long-term outcomes resulting from the primary impact such as habitat loss due to flooding, changes in riverbed permeability, and crop failure due to volcanic eruptions.

Technological and human-made disasters can lead to the sudden and uncontrollable release of hazardous and explosive materials [1, 5] such as coal mine explosions, building fires, oil truck accidents in tunnels, train accidents, road accidents, bus collisions, fuel tank explosions, building collapses, shipwrecks involving migrants, plane crashes, bridge collapses, stampedes during concerts, and bomb accidents.

Technological disasters account for a significant proportion of disasters worldwide and demand close attention. However, this study exclusively focuses on natural hazards, analyzing the most significant events in the top ten countries worldwide over the past 123 years (1900–2022). To provide a better understanding of the location and types of hazards worldwide, this study proposes using databases such as EM-DAT as a source of information. The primary data from the EM-DAT database is used to analyze the most frequent, deadly, and impactful natural hazards, aiding earthquake occurrence, identifying high-risk areas, and supporting decisions on safe constructions, settlements, and factories. This paper provides an exemplary model of such a research type.

In this chapter, we will begin with a brief introduction followed by an explanation of the data and methodology used. Next, we will present the most common natural hazards in the world. Finally, we will provide a discussion of the findings and draw conclusions based on the analysis.

2. Data and method

The study aims to present an overview of the most frequent natural hazards that have occurred worldwide from 1900 to 2022. The information presented here was

compiled from the EM-DAT emergency disaster database (public.emdat.be). The eight most common events are earthquakes, volcanic eruptions, landslides, floods, droughts, wildfires, storms, and extreme temperatures. Several other hazards have been omitted because they are too localized, and adequate data are unavailable. Additionally, it should be noted that tsunamis, a sub-group of earthquake events, can cause significant destruction to human life and economic losses in affected areas. A list of significant natural hazards in the following as comprehensively as possible is an attempt to present the frequency, deaths, total affected people, and economic losses of natural hazards events in the world.

3. The most common natural hazards in the world

In the twenty-first century, reporting natural hazards and their types has become more advanced and comprehensive on a global scale (**Figure 1**) [5, 6]. **Figure 2** and **Table** 1 provide statistical analysis of natural hazards. The data from the top ten countries indicate that 6358 significant natural hazards (excluding biological and extraterrestrial disasters) occurred between 1900 and 2022.

Of all hazards, 2410 were caused by storms, representing the highest frequency at 38% of the total. 1840 were caused by floods, accounting for 29%. 894 were caused by earthquakes, accounting for 14%. 410 were caused by landslides, accounting for 7%. 270 were caused by wildfires, accounting for 4%. 255 were caused by extreme temperatures, accounting for 4%. 192 were caused by volcanic activities, accounting for 3%. And 87 were caused by drought, accounting for 1% (**Table** 1, **Figure 2a**).

4. Continent's natural hazards: 1900–2022

An estimated 45,000 people die yearly due to natural disasters, representing about 0.1% of global deaths. The number and proportion of fatalities caused

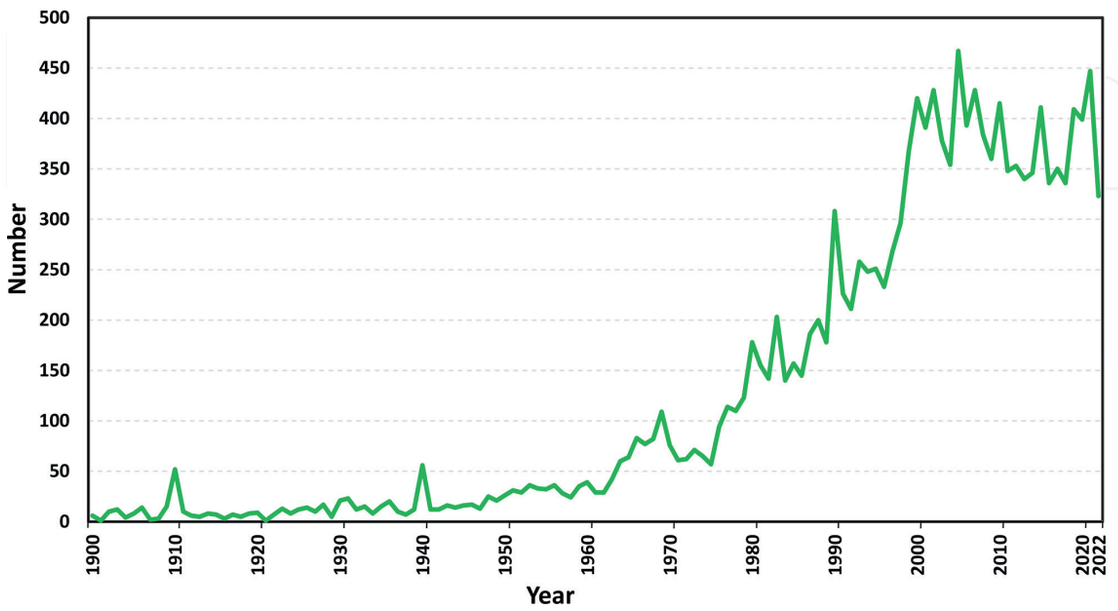

Figure 1.
The diagram shows the increased and completed of recorded natural hazards during 1900–2022.

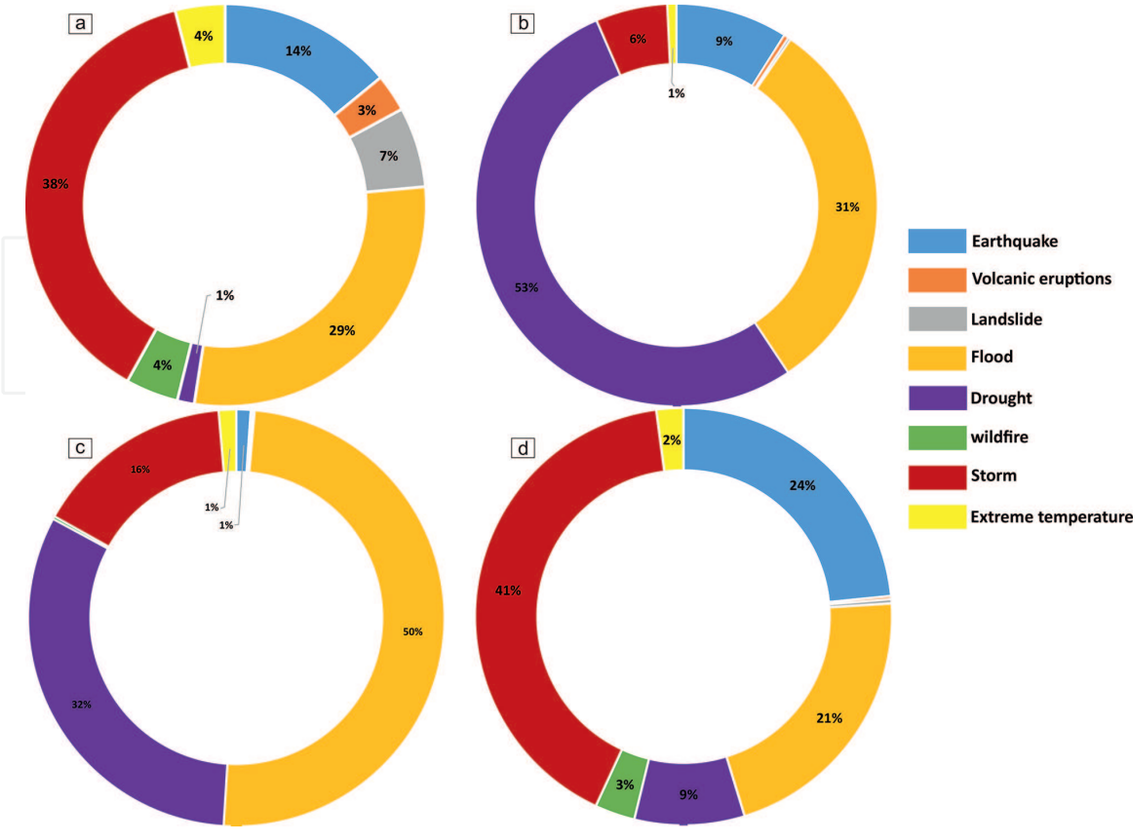

Figure 2.
(a) Frequency, (b) deaths, (c) total affected people, (d) direct economic losses (US dollars) per natural hazard types, based on the top ten countries in the world (1900–2022).

Disaster group	Disaster sub-group	Main disaster type	Frequency	Deaths	Total affected people	Economic losses (in million USdollars)
Natural	Geophysical	Earthquake	894	1,995,580	81,809,874	1,221,061
		Volcanic eruptions	192	85,319	9,230,986	12,411
	Hydrological	Landslide	410	48,532	13,505,420	17,476
		Flood	1840	6,884,491	3,676,715,666	1,109,311
	Climatological	Drought	87	11,715,980	2,365,801,967	444,784
		wildfire	270	3684	17,217,656	162,322
	Meteorological	Storm	2410	1,278,982	1,152,095,652	2,137,312
		Extreme temperature	255	165,880	101,216,729	109,314
		Total	6358	22,178,448	7,417,593,950	5,213,995

Table 1.
Statistical results on natural hazards, based on the top ten countries in the world (1900–2022).

by natural disasters have fluctuated in recent decades. While the number of deaths often falls below 10,000, the impact of major events, such as the famine and drought in Ethiopia in 1983–1985, the Indian Ocean 2004 earthquake and

tsunami, the 2008 Cyclone Nargis, and the 2010 earthquake in Haiti, can be devastating, with over 200,000 deaths worldwide. While natural hazards such as earthquakes and tsunamis, which have low frequencies but high impacts, cannot be avoided, such human losses can be reduced through predictions, more resilient infrastructure, emergency preparedness, and response systems. Historical evidence shows that the world has significantly reduced disaster-related deaths due to these efforts [6].

Table 2 and **Figure 3** present the statistical results of natural hazards in various continents from 1900 to 2022 (based on data from the top ten countries). Of the 5734 natural events included in the statistics, Asia had the highest number of events with

Continent	Frequency	Deaths	Total affected people	Economic losses (in million USdollars)
Africa	0	820,337	113,350,602	0
Asia	4053	29,053,499	6,872,568,275	1,863,510
Europe	0	0	0	364,754
North America	1420	25,632	115,722,303	2,116,425
South America	261	0	11,736,425	86,415
Oceania	0	0	0	116,873
Total	5734	29,899,468	7,113,377,605	4,547,978

Table 2.
Statistical results on natural hazards in the continents (1900–2022).

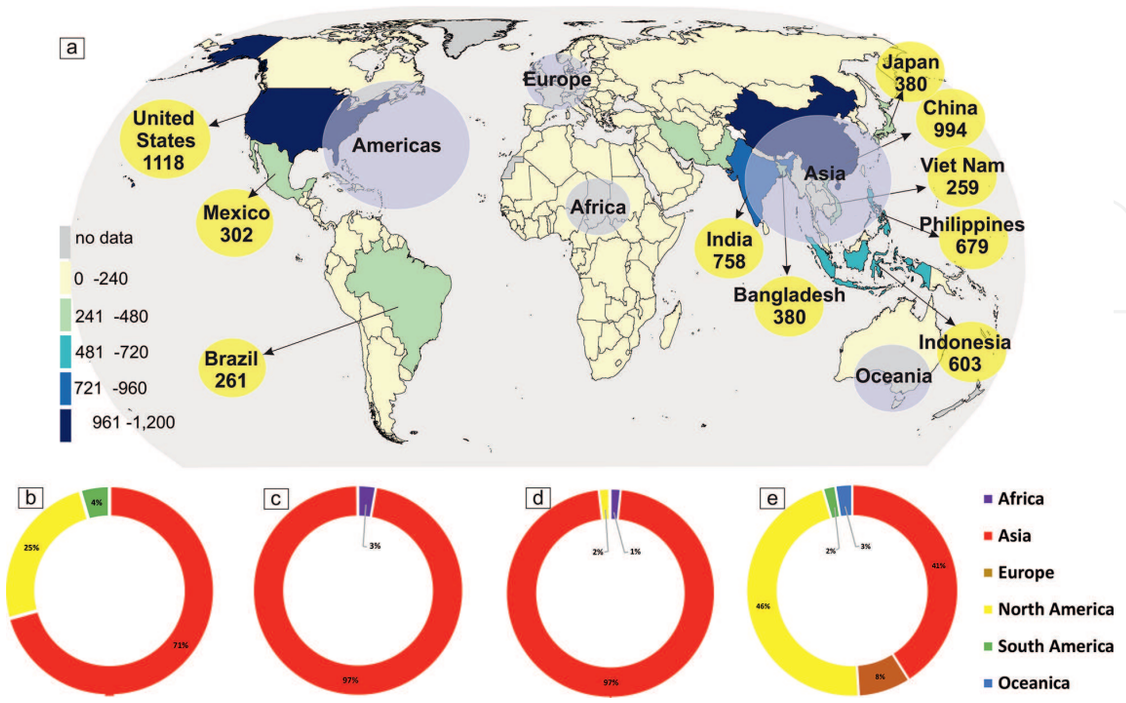

Figure 3.
(a) The number of naturel hazards in the continents and countries shown on the map, (b) frequency, (c) deaths, (d) total affected people, (e) direct economic losses (US dollars) per continents (1900–2022).

4053, accounting for 71%, followed by North America and South America with 1420 (25%) and 261 (4%), respectively. Regarding deaths attributed to natural hazards, Asia had the highest number with 29,053,499, accounting for 97%, followed by Africa with 820,337 (3%) for the top ten countries in the world. In terms of affected people, Asia had the highest number with 6,872,568,275 (97%), followed by North America with 115,722,303 (2%) and Africa with 113,350,602 (1%). North America incurred the most economic losses due to natural hazards, reaching 2,116,425,136,000 US dollars, accounting for 46% of the total global economic losses. Asia came in second with 1,863,510,715,000 US dollars, accounting for 41%, followed by Europe with 364,754,712,000 US dollars, accounting for 8%, Oceania with 116,873,181,000 US dollars, accounting for 3%, and South America with 86,415,200,000 US dollars, accounting for 2%.

The frequency of the most common natural hazards around the world is explained as follows:

4.1 Earthquakes

Earthquakes have been a persistent global threat to human life, with occurrences reported daily by the United States Geological Survey (USGS), among other national and international seismological networks. While most earthquakes are not powerful enough to cause significant damage, major earthquakes with a magnitude of 7.5 or higher can result in significant loss of life and economic destruction. Historically, other natural disasters, such as floods, droughts, and epidemics, have resulted in higher death tolls. However, today, earthquakes and their resulting tsunamis often result in a high annual death toll. The deadliest earthquake in recorded history occurred in 1556 in Shaanxi, China, resulting in the deaths of 830,000 people. Recent devastating earthquakes such as the 2004 Sumatra earthquake and tsunami and the 2010 Haiti earthquake, resulted in 93% and 69% of deaths, respectively, with hundreds of thousands of deaths in total.

From 1900 to 2022, a total of 894 (14%) earthquakes occurred globally, resulting in 1,995,580 deaths (9% of the total) and affecting 81,809,874 people (1% of the total). The direct economic losses amounted to 1,221,061,032,000 US dollars (24% of the total). Asia had the highest number of earthquake events (74%), followed by Europe (10%) and North America (10%). China, Indonesia, and Iran were the countries with the most frequent earthquake events during this period. (see **Table** 1 and **Figure 2** for more details).

4.2 Volcanic eruptions

Many volcanic eruptions are active but have little to no activity. **Figure 3** shows the significant volcanic eruptions in each country. A significant eruption is classified by a volcanic explosivity index (VEI) of six or larger, a tsunami or major earthquake, and over dollars1 million in damages.

From 1900 to 2022, a total of 3% of all volcanic events, or 192 eruptions, occurred globally. These eruptions resulted in 85,319 deaths, affected 9,230,986 people, and caused direct economic losses of 12,411,593,000 US dollars (as shown in **Table** 1 and **Figure 2**). Asia, South America, and North America have the most volcanic eruption events in the world from 1900 to 2022. Notable eruptions from the past century include the 1902 Mount Pelée eruption in Martinique and the 1985 Nevado del Ruiz eruption in Colombia, which resulted in a high number of deaths.

4.3 Landslides

Landslides are a common geological phenomenon that can occur worldwide. They happen when a large amount of soil, rocks, and debris move down a slope as a result of natural events or human activities. Heavy rains, earthquakes, volcanoes, and droughts can all cause landslides. Climate change and warming have been linked to an increase in landslides, particularly in mountainous regions with snowy and icy conditions. Landslides can also have severe impacts on healthcare systems and essential services such as water supply and communication infrastructure.

The global distribution of landslide mortality risk highlights that densely populated mountainous areas such as the Andes in South America and the Himalayas in Asia are at the highest risk. From 1900 to 2022, a total of 7% of all landslide events, or 410 occurrences, took place globally. These landslides resulted in 48,532 deaths, affected 13,505,420 people, and caused direct economic losses of 17,476,352,000 US dollars (as shown in **Table** 1 and **Figure 2**). Asia and South America had the highest number of landslide events in the world during this time period.

4.4 Tsunami

A tsunami is a type of wave that can strike any coast and can be generated in oceans, inland seas, and any large body of water. They are most common in Asia, the Pacific islands, and the United States West Coast, but experts say that seismic activity under the Atlantic Ocean could also trigger tsunamis on the East Coast. The last documented tsunami on the East Coast was in Canada in 1929. Tsunamis are most frequent in the Pacific Ocean's "Ring of Fire" (98%), the Atlantic Ocean and the Caribbean Sea (9%), the Mediterranean Sea (6%), the Indian Ocean (1%), and other seas (1%). Throughout history, tsunamis have occurred from approximately 1.4 million years ago (in Hawaii) to the present day (in Mexico on September 19, 2022). They can be caused by earthquakes, landslides, and volcanic activity. Tsunamis have caused damage and deaths in coastal areas worldwide. Some of the deadliest tsunamis in the world from 1900 to 2022 are the 2004 Indian Ocean earthquake and tsunami and the 2011 Tōhoku Japan Tsunami.

From 1900 to 2022, a total of 39 major tsunami events occurred worldwide. These tsunamis resulted in 266,629 deaths, affected 10,709,690 people, and caused direct economic losses of 334,985,586,000 US dollars (as shown in **Table** 1 and **Figure 2**). The countries with the highest number of tsunami events in the world during this time period were Indonesia and Japan in the Asia continent.

4.5 Extreme temperature

Extreme weather or climate events include unusual or severe weather patterns that deviate from historical norms. These events can include heat waves, cold waves, and tropical cyclones, resulting in significant economic costs, loss of life, and ecosystem changes [7]. Extreme events are often based on a weather pattern recorded at a location and are defined as being in the most unusual 10%. [8]. The most important extreme weather types include heat waves, cold waves, and tropical cyclones. The effects of extreme weather events are reflected in increasing economic costs, loss of life, drought, flooding, landslides, and ecosystem changes.

From 1900 to 2022, 255 extreme temperature events occurred globally, causing 165,880 deaths, impacting 101,216,729 people, and resulting in direct economic losses of 109,314,953,000 US dollars. The continents with the highest frequency of these events include Asia, Europe, and North America, with India, the United States, and France having the highest frequency of events.

4.6 Wildfire

A wildfire, forest fire, bush fire, wildfire, or rural fire is an unplanned, uncontrolled, and unpredictable fire in an area of combustible vegetation [9, 10]. A wildfire can be more accurately identified as a bush fire (in Australia), desert fire, grass fire, hummock fire, peat fire, prairie fire, vegetation fire, or steppe fire, depending on the type of vegetation present [11]. Some natural forest ecosystems depend on wildfire [12]. Wildfires are the most common natural hazards in Siberia, California, and Australia [13–15]. Areas with a Mediterranean climate or in the taiga biome are particularly susceptible. On a global scale, human practices have exacerbated the effects of wildfires, with the area of land burned by wildfires doubling compared to natural levels. Wildfires have steadily decreased since records began in the early twentieth century. Humans have impacted wildfires through climate change, landslide change, and wildfire suppression [16].

A total of 270 (4%) wildfire events occurred from 1900 to 2022. However, the natural hazard caused 3684 deaths, accounting for <0.5% of the total; 17,217,656 people were affected, accounting for 1%; and direct economic losses were 162,322,664,000 US dollars, accounting for 3% (**Table** 1, **Figure 2**). Northern America (45%), Europe (23%), Oceania (14%), Asia (13%), and Southern America (5%) continents had the highest to the lowest number of wildfire events, respectively, in the world. The United States of America, Australia, and Spain, respectively, in the continents have had more frequency of events from 1900 to 2022.

4.7 Drought

Drought is a complex phenomenon characterized by a deficiency of water relative to average availability at a specific location and time of year. According to the IPCC's Sixth Assessment Report, drought is defined as drier than normal conditions [17]. The National Integrated Drought Information System (NIDIS) defines it as a prolonged lack of precipitation resulting in a water deficit. The NOAA (National Oceanic and Atmospheric Administration) defines it as a moisture deficiency that negatively impacts humans, animals, or vegetation over a large area [18]. However, due to its complex nature, drought is difficult to monitor and define [19]. In fact, by the early 1980s, over 150 different definitions of drought had been published, [20] reflecting different perspectives based on regions, needs, and disciplinary approaches.

A total of 87 (1%) drought events occurred from 1900 to 2022. However, the natural hazard caused 11,715,980 deaths, accounting for 53% of the total; 2,365,801,967 people were affected, accounting for 32%; and direct economic losses were 444,784,962,000 US dollars, accounting for 9% (**Table** 1). Africa (51%), Asia (29%), Northern America (20%), and Southern America (20%) continents had the highest to the lowest number of wildfire events, respectively, in the world from 1900 to 2022. Ethiopia, China, the United States of America, and Brazil countries, respectively, in the continents have had more frequency of the events.

4.8 Flood

A flood is an overflow of water or, less commonly, other liquids that typically inundate dry land [21]. The term can also refer to the inflow of tides. Floods are an important area of study in fields such as hydrology, agriculture, civil engineering, and public health. Human-caused changes to the environment, such as land use changes, changes to waterway courses or flood control measures, and larger environmental issues, can increase the intensity and frequency of floods. Additionally, climate change, increased rainfall, and extreme weather events can exacerbate flooding causes, resulting in more severe floods and an increased risk of flooding [22, 23].

There were 1840 major flood disasters during 1900–2022, accounting for 29% of the total number of significant natural hazards. 6,884,491 deaths were caused by flood disasters, accounting for 31% of the total deaths; 3,676,715,666 people were affected, accounting for 50%; and direct economic losses were 1,109,311,917,000 US dollars. India and other Asian countries have suffered severe floods (**Table** 1). The 1931 Yangtze-Huai River floods 1931 in China took place in China from June to August 1931 and were the deadliest floods, and this figure accounted for less than a quarter of all deaths in the first 100 days of the flood. The official report found 140,000 drowned and claimed 2 million people drowned or died of starvation during the flood [24].

4.9 Storm

A storm is any disturbance in the natural environment or atmosphere marked by strong winds, hail, thunder, tornadoes, lightning, heavy precipitation, ice storms, strong winds, and dust storms, among others. Storms are caused by the formation of a center of low pressure surrounded by high pressure. These events can have significant impacts on human life, agriculture, and navigation. One notable example is the 1970 Bhola cyclone, also known as the Great Cyclone of 1970, which struck Bangladesh (then East Pakistan) and resulted in an estimated death toll of between 150,000 and 550,000 people [25].

There were 2410 major storm disasters, accounting for 38% of the total number of major hazards; storm disasters caused 1,278,982 deaths (6%), 1,152,095,652 people were affected the direct (16%), and direct economic losses were 2,137,312,395,000 US dollars during 1900–2022.

5. Discussion

By considering the limitations of the data, such as potential underreporting or variations in reporting methods across different regions and time periods the following are important to be noted. The presented data shows a total of 22,178,448 deaths globally due to natural hazards between 1900 and 2022 (**Table** 1), with drought being the leading cause of death accounting for 53% (11,715,980 number of deaths), followed by floods at 31% (6,884,491 number of deaths), earthquakes at 9% (1,995,580 number of deaths), storms at 6% (1,278,982 number of deaths), extreme temperatures at 0.75% (165,880 number of deaths), volcanic activity at 0.38% (85,319 number of deaths), landslides at 0.22% (48,532 number of deaths), and wildfires at 0.02% (3648 number of deaths). The sources for the data presented in **Table** 1 can be found in the references section.

A total of 7,417,593,950 people were affected by natural hazards globally between 1900 and 2022, with flooding being the leading cause of impact, accounting for 50% (3,676,715,666 affected), followed by drought at 32% (2,365,801,967 affected), storm at 16% (1,152,095,652 affected), the extreme temperature at 1% (101,216,729 affected), earthquake at 1% (81,809,874 affected), a landslide at 0.18% (13,505,420 affected), and volcanic eruptions at 0.12% (9,230,986 affected). The units used for each measurement are provided in parentheses.

A total of 5,213,995,868,000 US dollars in direct economic losses were caused by natural disasters globally between 1900 and 2022, with earthquakes being the leading cause of economic loss accounting for 41% (2,137,312,395,000 US dollars), followed by storms at 24% (1,221,061,032,000 US dollars), floods at 21% (1,109,311,917,000 US dollars), a drought at 9% (444,784,962,000 US dollars), wildfire at 3% (162,322,664,000 US dollars), the extreme temperature at 2% (109,314,953,000 US dollars), a landslide at 0.34% (17,476,352,000 US dollars), and volcanic activities at 0.24% (12,411,593,000 US dollars). The limitations of the data, such as potential underreporting or variations in reporting methods across different regions and time periods, should be considered when interpreting the results.

The study also found that climatological hazards were responsible for the most deaths caused by natural hazards (53%), followed by hydrological hazards (31%), geophysical hazards (9%), and meteorological hazards (7%). This indicates that despite having a lower frequency of occurrence, climatological hazards are the deadliest type of hazard. In terms of the number of people affected by natural hazards, hydrological hazards had the greatest impact, affecting 50% of the total (3,690,221,086 people), followed by meteorological hazards (17%), climatological hazards (32%), and geophysical hazards (1%).

It is important to note that the frequency and severity of natural hazards have changed over time, and the potential impacts of climate change on natural hazards should also be considered when interpreting these results.

6. Conclusions

This study utilized the EM-DAT database to investigate the primary natural hazards worldwide from 1900 to 2022. The results show that earthquakes, volcanic eruptions, landslides, floods, droughts, wildfires, storms, and extreme temperatures have been the primary natural hazards globally during the last 123 years. Regarding continents, Asia has experienced the highest frequency of natural hazards, with the most significant number of deaths and total affected people. North America follows in terms of natural hazard frequency, with Africa experiencing the highest number of fatalities and North America experiencing the most total affected people. North America has also suffered the highest economic losses due to natural hazards, followed by Asia and Europe. The highest frequency of natural hazards with the most significant economic losses is caused by meteorological events. Climatological events are the deadliest, while hydrological events affect the most people. The study's findings highlight databases such as EM-DAT are critical in enhancing our understanding of natural hazards worldwide. By providing comprehensive data on these events' type, location, and frequency, such databases can support informed decision-making in risk assessment, disaster management, and mitigation efforts. The results underscore the importance of continued monitoring of natural hazards and preparedness measures to mitigate

their impact. Overall, the findings of this study contribute to advancing our knowledge of natural hazards and improving our ability to address the associated challenges.

Table 3 and **Figure 4** present the results of this study, which analyzed the top ten countries affected by natural hazards between 1900 and 2022. The data show that a total of 6358 natural hazard events occurred globally during this period. The majority of these events were caused by meteorological hazards (42%), followed by hydrological hazards (35%), climatological hazards (6%), and geophysical hazards (17%).

The economic impact of natural hazards was also significant, with a total of 5,213,995,868,000 US dollars in direct economic losses. Meteorological hazards accounted for the largest share of economic losses (43%), followed by geophysical hazards (23%), hydrological hazards (21%), and climatological hazards (12%). This suggests that while meteorological hazards may not cause the most deaths or affect the most people, they have the most significant economic impact.

Overall, these findings demonstrate the importance of understanding the distribution and impact of different types of natural hazards. By identifying which hazards are most frequent, deadly, and costly, policymakers and disaster management teams can better prepare and allocate resources to mitigate their effects.

Disaster group	Disaster sub- group	Frequency	Deaths	Total affected people	Economic losses (in million USdollars)
Natural	Geophysical	1086	2,080,899	91,040,860	1,233,472
	Hydrological	2250	6,933,023	3,690,221,086	1,126,788
	Climatological	357	11,719,664	2,383,019,623	607,107
	Meteorological	2665	1,444,862	1,253,312,381	2,246,627
	Total	6358	22,178,448	7,417,593,950	5,213,995

Table 3.
Statistical results on sub-group of natural hazards in the continents (1900–2022).

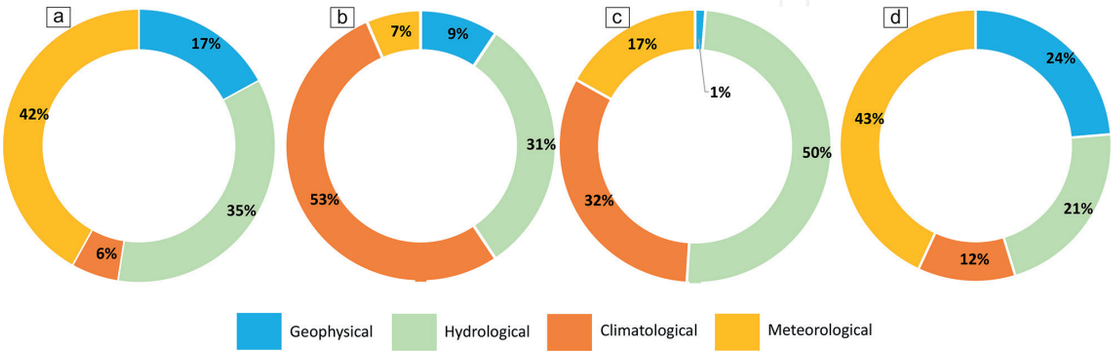

Figure 4.
(a) Frequency, (b) deaths, (c) total affected people, and (d) direct economic losses (US dollars) of the four main sub-group of natural hazards (1900–2022).

Conflict of interest

The author has no conflict of interest to declare. All co-authors have seen and agree with the manuscript's contents, and there is no financial interest to report.

Author details

Mohammad Mokhtari*, Parvaneh Faridi, Mehdi Masoodi and Seyed Mehran Ahmadi
Tsunami and Earthquake Research Centre (TERC), University of Hormozgan, Bandar-Abbas, Iran

*Address all correspondence to: m_7_mokhtari@yahoo.com

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