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Article

Geospatial and Temporal Patterns of Natural and Man-Made (Technological) Disasters (1900-2024): Insights from Different Perspectives

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Abstract: This pioneering study explores the geospatial and temporal patterns of natural and human-induced disasters from 1900 to 2024, providing essential insights into their global distribution and impacts. Utilizing the comprehensive international EM-DAT database, our analysis reveals significant trends and disparities in disaster occurrences and their widespread consequences. Results showed a dramatic escalation in both natural and man-made (technological) disasters over the decades, with notable surges in the 1991-2000 and 2001-2010 periods. A total of 25,836 disasters were recorded worldwide, of which 69.41% were natural disasters (16,567) and 30.59% were man-made (technological) disasters (9,269). The most significant increase in natural disasters occurred from 1961-1970, while man-made (technological) disasters surged substantially from 1981-1990. Seasonal trends reveal that floods peak in January and July, while storms are most frequent in June and October. Droughts and floods being the most devastating in terms of human lives, while storms and earthquakes cause the highest economic losses. The most substantial economic losses were reported during the 2001-2010 period, driven by catastrophic natural disasters in Asia and North America. Our research highlights Asia as the most disaster-prone continent, accounting for 41.75% of global events, with natural disasters making up 61.89% of these events. Oceania, despite experiencing fewer total disasters, shows a remarkable 91.51% of these as natural disasters. Africa is notable for its high incidence of man-made (technological) disasters, which constitute 43.79% of the continent's disaster events. Europe, representing 11.96% of total disasters, exhibits a balanced distribution but tends towards natural disasters at 64.54%. Examining specific countries, China, India, and the United States emerged as the most frequently affected by both natural and man-made (technological) disasters. The impact of these disasters has been immense, with economic losses reaching their highest during the decade of 2010-2020, largely due to natural disasters. The human toll has been equally significant, with Asia recording the most fatalities and Africa the most injuries. Particularly, the decade from 2001 to 2010 experienced the greatest economic losses, primarily driven by natural disasters in Asia and North America. These insights highlight the urgent need for tailored disaster risk management strategies that address the distinct challenges and impacts in various regions. By understanding historical disaster patterns, policymakers and stakeholders can better anticipate and manage future risks, ultimately safeguarding lives and economies.

Keywords: hazards; emergencies; natural disasters; man-made (technological) disasters; disaster risk management; economic impact; human impact; em-dat database; geospatial analysis; temporal analysis

1. Introduction

In our increasingly interconnected world, grasping disasters' geospatial and temporal patterns has become vital for effective disaster management and resilience planning [1,2]. Disasters, whether natural or human-induced, can have profound impacts on communities, economies, and the environment [3–6]. The risk of a disaster occurring is always a combination of vulnerability and exposure due to inadequate preparation or coping capacity [7]. This underscores the necessity of delving into the complex dynamics that influence their occurrence and distribution.

Environmental events like earthquakes, floods, hurricanes, and wildfires are driven by natural and climatic forces [8–21]. The patterns of these disasters, including their frequency, intensity, and locations, have evolved over time due to shifts in climate, land usage, and population growth [22–27]. Analyzing past data helps us uncover trends and identify high-risk areas, improving our ability to forecast and respond to future events [28]. In contrast, technological disasters arise from human activities such as industrial mishaps, nuclear accidents, and oil spills. These incidents often occur due to equipment failures, human and organizational mistakes [29] or weak regulatory measures. Failures can occur during the design, construction, operation or maintenance phases [30]. By examining when and where these disasters happen, we can gain insights into industrial operations and regulatory practices, leading to better safety protocols and emergency response strategies [31].

Recent research has shed light on significant advancements and methodologies for understanding the geospatial and temporal patterns of natural disasters. Han et al. [32], for instance, use textual records to uncover spatial-temporal patterns of natural disasters in China. Their findings highlight critical intervals and interactions between events, offering valuable guidance for disaster prevention efforts [32]. Ghosh [33] explores the integration of various geospatial technologies and data sources in disaster management. Also, he emphasizes how AI and big data can enhance emergency responses and decision-making processes. On the other hand, Wang [34] delves into the historical patterns of marine disasters in China, providing a multiscalar analysis of their temporal changes and spatial evolution. This research helps in understanding long-term trends and impacts (Wang, 2020). Additionally, Wei et al. [35] conduct a comprehensive study on the spatial-temporal evolution and prediction of flood disasters in China over the past 500 years, highlighting critical trends and future risks. Together, these studies deepen our understanding of disaster patterns and offer valuable insights for effective disaster management and mitigation strategies.

The wealth of existing research on this subject provides crucial insights into the factors shaping these disaster patterns [5,34–43]. Geospatial analyses have revealed that some areas are particularly at risk for specific types of disasters. Factors such as the terrain, local climate, and how densely populated an area are significantly influence where these disasters occur [17]. Moreover, by studying temporal patterns, researchers can identify seasonal or cyclical trends and assess how climate change might be altering the frequency and severity of these events [44,45]. Besides that, some study highlights the significant toll natural disasters can take on mental health, stressing the importance of comprehensive post-disaster intervention strategies to tackle the behavioral and psychological symptoms that follow such events [46].

Regarding that, the aim of this study is to provide a scientific description and comprehensive understanding of the patterns and impacts of natural and man-made (technological) disasters over more than a century. By analyzing the geospatial and temporal distribution of these events, the study aims to offer valuable insights that can inform future disaster risk management strategies, enhance preparedness, and ultimately contribute to the reduction of disaster-related losses. This research highlights the urgent need for tailored disaster risk management strategies that address the distinct

challenges and impacts in various regions, thereby promoting resilience and sustainable development.

1.1. Literature Review Geospatial and Temporal Patterns of Disasters

Understanding and managing the effects of natural and man-made (technological) disasters have been significantly improved through geospatial analysis [47–49]. Analyzing historical data through geospatial techniques unveils patterns in the frequency and distribution of natural disasters worldwide [50]. This type of analysis is essential for grasping the temporal and spatial behaviors of these events, which in turn is critical for making accurate future predictions and improving disaster preparedness efforts [51–55]. Utilizing tools like remote sensing and GIS, researchers can now map out affected areas, predict potential damage, and evaluate the aftermath of these events [56]. This technological approach greatly supports efforts in disaster preparedness, effective response, and efficient recovery [4,23]. Geospatial technologies, including GIS and remote sensing, have proven to be highly effective tools for mapping and predicting natural disasters such as earthquakes, landslides, floods, and cyclones [49,56–59]. By utilizing these advanced technologies, researchers can accurately identify areas that are at high risk for such events [5,60–62].

Moreover, these tools play a vital role in developing early warning systems that can help mitigate the impact of disasters by providing timely alerts and enabling better preparedness [37,38,42,63–68]. Remote sensing and geospatial analyses play a crucial role in evaluating damage and monitoring recovery efforts following disasters [43,69]. For example, the use of medium-resolution imagery alongside indices like NDVI and UI has been particularly effective in assessing recovery rates after tornadoes, where severely damaged areas tend to recover more slowly [69]. Satellite-based geospatial techniques offer a dependable alternative to traditional ground-based surveys, which are often hindered by hazardous conditions and logistical difficulties [50]. These technologies enable a comprehensive assessment of disaster impacts and facilitate more efficient recovery planning [56].

Understanding the patterns, predicting future occurrences, and mitigating the impacts of natural and man-made (technological) disasters hinge significantly on temporal analysis [70–72]. Andersen et al. [73] provide comprehensive guidance on conducting time-to-event analysis in observational studies, with a particular focus on hazard models and the Cox proportional hazards regression model. Their paper includes practical examples and computational implementation using R. In another study, Tian et al. [41] introduce a framework for evaluating community resilience to multiple hazards in the Anning River basin, underscoring the significance of socio-economic factors in enhancing adaptive risk management. Melkov et al. [74] analyze geophysical data in North Ossetia, Russia, and develop a complex hazard map aimed at improving risk assessments in the region. Also, Chen et al. [75] examine the temporal assessment of disaster risk, using case studies from China to demonstrate how risk varies over time and proposing long-term mitigation strategies.

Over the past century, studies have shown a general uptick in both the frequency and intensity of natural disasters, with pronounced peaks in recent decades [39,76,77]. Chen et al. [78] explored the occurrence of rainstorms and floods in the Tarim Basin from 1980 to 2019. Their findings show a notable rise in these events, especially between April and September. The western and northern regions of the basin are particularly vulnerable, with severe incidents significantly impacting the damage index. Similarly, Buszta et al. [47] conducted a geospatial analysis of 9962 natural disasters from 1960 to 2018, examining their frequency and impact across different continents. This study also provides a predictive outlook on future trends, highlighting the influence of climatic factors on disaster patterns. Besides that, Summers et al. [40] investigated changes in the frequency, intensity, and spatial distribution of hazards like hurricanes, tropical storms, and droughts. Their research connects these variations to climate change, using empirical data to bolster previous theories. Furthermore, Herrera and Aristizábal [79] examined the relationship between precipitation patterns and landslides in the Aburrá Valley. Their study revealed that rainfall-induced landslides are affected by macroclimatic phenomena such as ENSO, with specific hotspots identified in the valley's eastern hills.

There's strong evidence pointing to a sharp rise in economic damages from extreme natural events, especially in temperate regions, driven by their increasing severity [76]. Patterns of droughts and floods reveal alternating positive and negative correlations over time, with a notable lag effect where floods tend to follow droughts by about 4-5 years [80]. The number of people affected by natural disasters has surged, leading to more fatalities, injuries, and property damage [48,80]. People's information-seeking behavior during disasters shifts across different phases, underscoring the need for varied communication strategies before, during, and after such events [36]. To analyze the temporal and spatial distribution of disasters, researchers are increasingly turning to advanced methods like time series analysis, spatial statistics, and big data techniques [81,82].

2. Methods

The subject of this research encompasses an extensive analysis of both natural and man-made (technological) disasters from 1900 to 2024. The primary objective is to identify geospatial and temporal patterns of these disasters, examining their frequency, distribution, and impact across various geographic regions and periods. Utilizing the EM-DAT database, the study aims to uncover significant trends and disparities in disaster occurrences and their widespread consequences on a global scale.

In a narrower sense, this research delves into the historical data of natural and man-made disasters, categorizing them by type, region, and period. It explores specific trends such as the escalation of natural disasters from 1960-1970 and man-made (technological) disasters from 1981-1990. Furthermore, it identifies seasonal trends, assesses the economic and human impacts of these disasters, and examines the specific vulnerabilities of different continents and countries.

2.1. Hypothetical Framework

This study is based on the general hypothesis that the geospatial and temporal patterns of natural and man-made (technological) disasters exhibit significant variations in frequency, distribution, and impact across different geographic regions and periods, reflecting changes in natural conditions and socio-economic factors. The specific hypotheses include:

H1. *Natural disasters occur more frequently and have a greater impact on human and economic resources compared to technological disasters.*

H2. *The frequency and distribution of disasters differ between continents, with certain regions experiencing higher frequencies of specific types of disasters.*

H3. *There are significant temporal changes in the frequency of natural and technological disasters, with particular periods showing notable increases or decreases in the number of events.*

H4. *Certain natural disasters show seasonal variations in frequency, reflecting climatic and weather patterns.*

H5. *Different types of disasters have varying impacts on economic losses and human resources, with some disasters causing more severe consequences than others.*

2.2. Data Collection and Preparation

Data for this study were sourced from the international EM-DAT (Emergency Events Database). EM-DAT is a comprehensive global database that tracks and records all types of natural and human-induced (technological) disasters. It is maintained and regularly updated by the Centre for Research on the Epidemiology of Disasters (CRED) at the University of Louvain, Belgium.

The database contains information on disasters that have occurred worldwide since 1900 and meet at least one of the following criteria: 10 fatalities, 100 people affected, declaration of a state of emergency and an international request for assistance. Each entry in EM-DAT includes detailed information about the disaster type, the number of affected individuals, economic losses,

geographical distribution, and other relevant parameters. For this study, a total of 25,836 disasters from 1900 to 2024 were analyzed. After downloading the data, it was cleaned and prepared for analysis using the Statistical Package for the Social Sciences (SPSS) software.

The data preparation process included several key steps: a) identifying and removing duplicates and missing values to ensure data accuracy and consistency; b) converting all data into a uniform format to facilitate easier analysis and interpretation; classifying disasters by type, intensity, geographical area, and period.

2.2. Analyses

Statistical analyses were performed using a two-tailed approach with a significance level set at $p < 0.05$, utilizing IBM SPSS Statistics (Version 26, New York, NY, USA). The data were analyzed using descriptive statistics to identify the geospatial and temporal patterns of natural and technological disasters. The statistical analysis included the following steps:

- Analysis of the geographical distribution of disasters by continents for the period from 1900 to 2024. This included calculating the total number and percentage of different types of disasters on each continent. The geographical distribution was analyzed to identify regions with the highest frequency of disasters and to determine the specific characteristics of disasters in those regions.
- Detailed analysis of the frequency of disasters by countries, including the identification of countries most affected by different types of disasters. The analysis included quantifying the number of events by country and assessing their impact on human and economic resources.
- Analysis of temporal trends in the frequency of natural and technological disasters in 10- and 5-year intervals. This analysis enabled the identification of changes in the frequency and types of disasters over time, as well as the identification of periods with the highest disaster frequency.

The results were presented in tables and charts illustrating the spatial and temporal patterns of disasters. The graphical representations included: a) visualization of the geographical patterns of natural and technological disasters by continents and countries; b) display of changes in the frequency of different types of disasters over time, with a particular focus on decadal and five-year intervals. The results of the analysis were validated using multiple data sources to ensure the accuracy and reliability of the findings. This included comparison with similar studies and literature. Additionally, cross-validation methods were used to verify the consistency and reliability of the results obtained.

3. Results

The results of this study encompass a comprehensive overview of the geospatial and temporal patterns of natural and technological disasters, revealing key trends in their frequency, distribution, and impact across different geographic regions and periods. These findings provide valuable insights into the variations and dynamics of disaster events, contributing to a better understanding of their historical patterns and informing future disaster risk management strategies.

Based on the methodological framework and study design above, the results were divided into two main sections, each with two subsections: a) geographical distribution of natural and man-made (technological) disasters (in-depth analysis of disaster distribution by continent and country with comprehensive supporting data); b) temporal distribution of natural and man-made (technological) disasters (yearly and monthly trends in occurrences and consequences of natural and man-made (technological) disasters).

3.1. Geographical Distribution of Natural and Man-Made (Technological) Disasters

3.1.1. In-Depth Analysis of Disaster Distribution by Continent with Comprehensive Supporting Data

The geospatial distribution of both natural and man-made (technological) disasters across continents from 1900 to 2024 reveals significant trends and patterns in the frequency and spread of

various disaster types (Table 1 and Figure 1). A total of 25,836 disasters were recorded worldwide, of which 69.41% were natural disasters (16,567) and 30.59% were man-made (technological) disasters (9,269). By examining this data, we can discern key trends and patterns in the frequency and spread of various disaster types. Asia experienced the highest number of disasters, with 10,786 events, representing 41.75% of all recorded events. Following Asia, Africa encountered 5,540 disasters (21.44%), and North America had 3,575 events (13.84%). Oceania reported the fewest disasters, with 730 events, accounting for just 2.83%.

Natural disasters predominantly occurred in Oceania, where they comprised 91.51% of all recorded disasters. In North America, natural disasters constituted 75.75% of the total, while Asia and Europe had slightly lower percentages, at 61.89% and 64.54% respectively. Africa had the smallest proportion of natural disasters at 56.21%.

In contrast, man-made (technological) disasters were most prevalent in Africa, accounting for 43.79% of all disasters on the continent. Asia followed with 38.11%, while Europe and South America reported 35.46% and 33.44% respectively. Oceania had the lowest percentage of man-made (technological) disasters, at just 8.49%. From the comprehensive data, it's evident that natural disasters dominate most continents, particularly in Oceania and North America. Despite Asia having the highest total number of disasters, it also has a significant proportion of man-made (technological) disasters (38.11%), highlighting the presence of technological accidents in the region. Africa's notable percentage of man-made (technological) disasters (43.79%) may reflect various socio-economic factors and levels of infrastructure development (Table 1 and Figure 1).

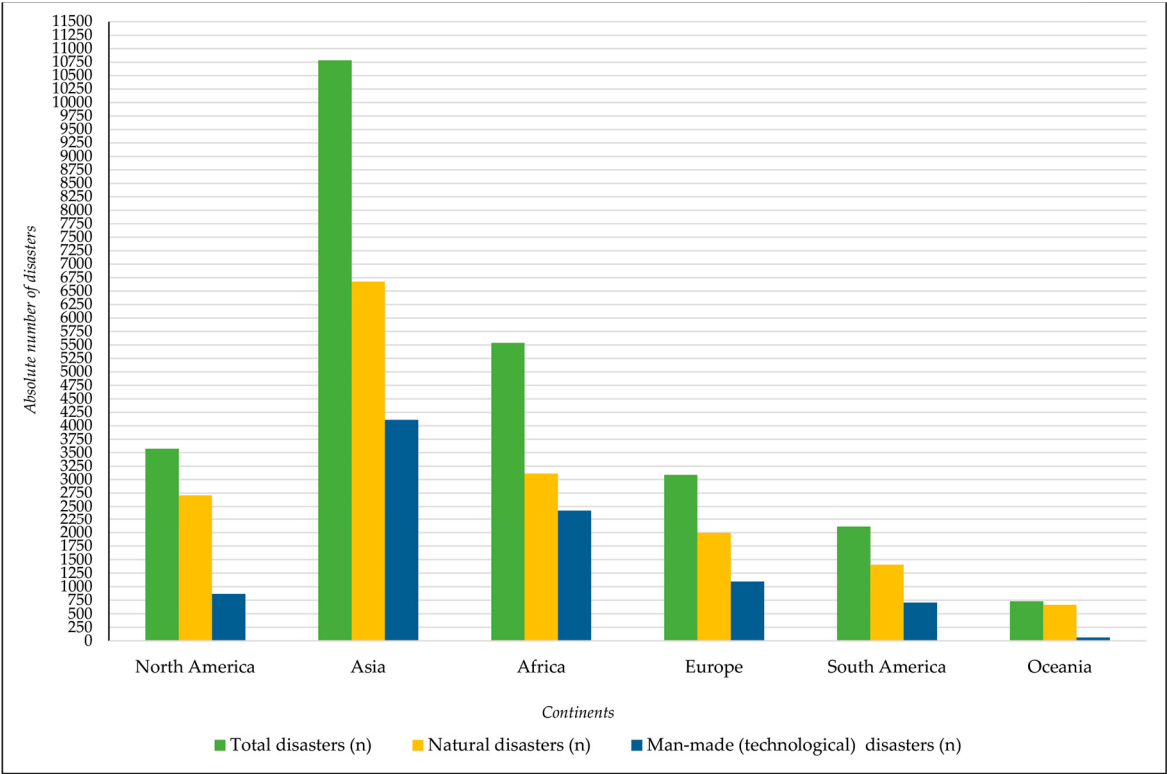


Figure 1. Geospatial distribution of natural and man-made (technological) disasters by continent (1900-2024).

Table 1. Geospatial distribution of natural and man-made (technological) disasters by continent (1900-2024).

Continent	Total disasters		Natural disasters		Man-made (tech.) disasters	
	n	%	n	%	n	%
North America	3,575	13.84	2,708	75.75	867	24.25
Asia	10,786	41.75	6,675	61.89	4,111	38.11
Africa	5,540	21.44	3,114	56.21	2,426	43.79
Europe	3,091	11.96	1,995	64.54	1,096	35.46
South America	2,114	8.18	1,407	66.56	707	33.44
Oceania	730	2.83	668	91.51	62	8.49
Total	25,836	100	16,567	69.41	9,269	30.59

An analysis of the geospatial distribution of both natural and man-made (technological) disasters across continents from 1900 to 2024 reveals significant insights into regional vulnerabilities and disaster management challenges.

Natural disasters vary widely across continents, each facing unique challenges and frequencies. Here is a detailed look at the occurrences of different natural disasters (Table 2 and Figure 2):

- a) Earthquakes: Asia recorded the highest number of earthquake events with 951 events (3.68% of the total), followed by Europe with 163 events (0.63%) and North America with 167 events (0.65%). Oceania experienced the fewest earthquakes, with 57 events (0.22%);
- b) Volcanic activity: volcanic activity was most prevalent in Asia with 112 events (0.43%), while North America and South America each reported 45 events (0.17%). Europe had the least volcanic activity, with 11 events (0.04%);
- c) Floods: most frequent were in Asia, accounting for 2,429 events (9.40%), with significant occurrences in Africa (1,240 events, 4.80%) and North America (688 events, 2.66%). Oceania had the fewest flood events, with 160 events (0.62%);
- d) Water-related disasters¹: these disasters were predominantly seen in Asia with 703 events (2.72%), followed by Africa with 561 events (2.17%) and North America with 99 events (0.38%). Oceania experienced the least, with 14 events (0.05%);
- e) Mass movement (wet): Asia experienced the most mass movement (wet) events, with 440 events (1.70%), followed by South America with 155 events (0.60%) and Africa with 68 events (0.26%). Oceania had the fewest, with 18 events (0.07%);
- f) Drought: Africa reported the highest number of droughts with 361 events (1.40%), while Asia had 179 events (0.69%) and North America had 102 events (0.39%). Oceania recorded the least, with 34 events (0.13%);
- g) Extreme temperature: Europe led in extreme temperature events with 297 events (1.15%), followed by Asia with 200 events (0.77%) and North America with 70 events (0.27%). Oceania had the fewest events, with 8 events (0.03%);
- h) Storms: North America experienced the most storms with 1,338 events (5.18%), followed by Asia with 1,899 events (7.35%) and Europe with 576 events (2.23%). South America reported the least, with 105 events (0.41%);
- i) Epidemics: most common were in Africa with 899 events (3.48%), followed by Asia with 361 events (1.40%) and North America with 100 events (0.39%). Oceania recorded the fewest, with 24 events (0.09%);
- j) Wildfires: North America led in wildfire events with 145 events (0.56%), followed by Europe with 123 events (0.48%) and South America with 49 events (0.19%). Asia had the fewest wildfires, with 69 events (0.27%).

¹ The category includes a wide range of water-related disasters, not just floods. It also covers incidents like glacial lake outburst floods and coastal erosion. The common thread is that water plays a crucial role in causing these events.

Table 2. Distribution of individual natural and man-made (technological) disasters by continent (1900-2024).

Disaster type	North America		Asia		Africa		Europe		South America		Oceania		Total	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Earthquake	167	0.65	951	3.68	75	0.29	163	0.63	154	0.60	57	0.22	1567	6.07
Volcanic activity	45	0.17	112	0.43	19	0.07	11	0.04	45	0.17	32	0.12	264	1.00
Flood	688	2.66	2429	9.40	1240	4.80	650	2.52	685	2.65	160	0.62	5852	22.65
Water-related	99	0.38	703	2.72	561	2.17	163	0.63	63	0.24	14	0.05	1603	6.19
Mass movement (wet)	45	0.17	440	1.70	68	0.26	77	0.30	155	0.60	18	0.07	803	3.10
Drought	102	0.39	179	0.69	361	1.40	49	0.19	74	0.29	34	0.13	799	3.09
Extreme temperature	70	0.27	200	0.77	20	0.08	297	1.15	48	0.19	8	0.03	643	2.49
Glacial lake outburst flood	0	0.00	3	0.01	0	0.00	1	0.00	0	0.00	0	0.00	4	0.01
Storm	1338	5.18	1899	7.35	311	1.20	576	2.23	105	0.41	290	1.12	4519	17.49
Epidemic	100	0.39	361	1.40	899	3.48	44	0.17	84	0.33	24	0.09	1512	5.86
Wildfire	145	0.56	69	0.27	38	0.15	123	0.48	49	0.19	41	0.16	465	1.81
Air	187	0.72	312	1.21	169	0.65	233	0.90	124	0.48	21	0.08	1046	4.04
Animal incident	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Chemical spill	47	0.18	20	0.08	4	0.02	29	0.11	3	0.01	1	0.00	104	0.40
Collapse (Industrial)	3	0.01	88	0.34	70	0.27	7	0.03	15	0.06	0	0.00	183	0.71
Collapse (Miscellaneous)	29	0.11	156	0.60	61	0.24	30	0.12	25	0.10	2	0.01	303	1.18
Explosion (Industrial)	57	0.22	509	1.97	59	0.23	108	0.42	32	0.12	4	0.02	769	2.98
Explosion (Miscellaneous)	17	0.07	118	0.46	40	0.15	35	0.14	10	0.04	0	0.00	220	0.86
Fire (Industrial)	22	0.09	137	0.53	15	0.06	35	0.14	7	0.03	0	0.00	216	0.85
Fire (Miscellaneous)	111	0.43	395	1.53	117	0.45	117	0.45	42	0.16	7	0.03	789	3.05
Fog	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Gas leak	13	0.05	38	0.15	0	0.00	10	0.04	0	0.00	1	0.00	62	0.24
Industrial accident	7	0.03	89	0.34	16	0.06	5	0.02	8	0.03	1	0.00	126	0.48
Infestation	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Mass movement (dry)	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Miscellaneous accident	23	0.09	129	0.50	68	0.26	31	0.12	19	0.07	1	0.00	813	2.10
Oil spill	3	0.01	2	0.01	0	0.00	2	0.01	1	0.00	0	0.00	24	0.03
Poisoning	6	0.02	50	0.19	6	0.02	10	0.04	4	0.02	0	0.00	228	0.29
Radiation	1	0.00	4	0.02	0	0.00	0	0.00	1	0.00	0	0.00	18	0.01
Rail	74	0.29	288	1.11	111	0.43	122	0.47	15	0.06	5	0.02	1845	2.38
Road	168	0.65	1073	4.15	1129	4.37	159	0.62	338	1.31	5	0.02	8616	11.21

Man-made (technological) disasters, resulting from human activities, also show distinct patterns across continents (Table 2 and Figure 2):

- a) Air disasters: Asia reported the highest number of air disaster events with 312 events (1.21%), followed by Europe with 233 events (0.90%) and North America with 187 events (0.72%). Oceania had the fewest, with 21 events (0.08%);
- b) Chemical spills: North America recorded the most chemical spill events with 47 events (0.18%), while Asia reported 20 events (0.08%). Oceania had the least, with 1 incident (0.00%);
- c) Industrial and miscellaneous collapses: Asia led in industrial collapses with 88 events (0.34%) and miscellaneous collapses with 156 events (0.60%). Africa followed with 70 industrial collapses (0.27%) and 61 miscellaneous collapses (0.24%);
- d) Explosions: industrial explosions were most frequent in Asia with 509 events (1.97%), while miscellaneous explosions were also highest in Asia with 118 events (0.46%). Oceania had the fewest events in both categories, with 4 industrial explosions and 0 miscellaneous explosions;
- e) Fires (industrial and miscellaneous): North America recorded the most industrial fire events with 22 events (0.09%) and miscellaneous fire events with 111 events (0.43%). Oceania had the fewest events in both categories, with 0 industrial fires and 7 miscellaneous fires;
- f) Gas leaks and oil spills: gas leaks were most common in Asia with 38 events (0.15%), while oil spills were rare globally, with North America and Asia each reporting only a few events (3 and 2, respectively);

- g) Poisoning and radiation events: Poisoning events were highest in Asia with 50 events (0.19%), and radiation events were minimal worldwide, with North America and Asia each reporting only a few events (1 and 4, respectively);
- h) Rail and road disasters: road disasters were highly prevalent in Asia with 1,073 events (4.15%) and in Africa with 1,129 events (4.37%). Rail disasters were more common in Asia with 288 events (1.11%) and in Europe with 122 events (0.47%).

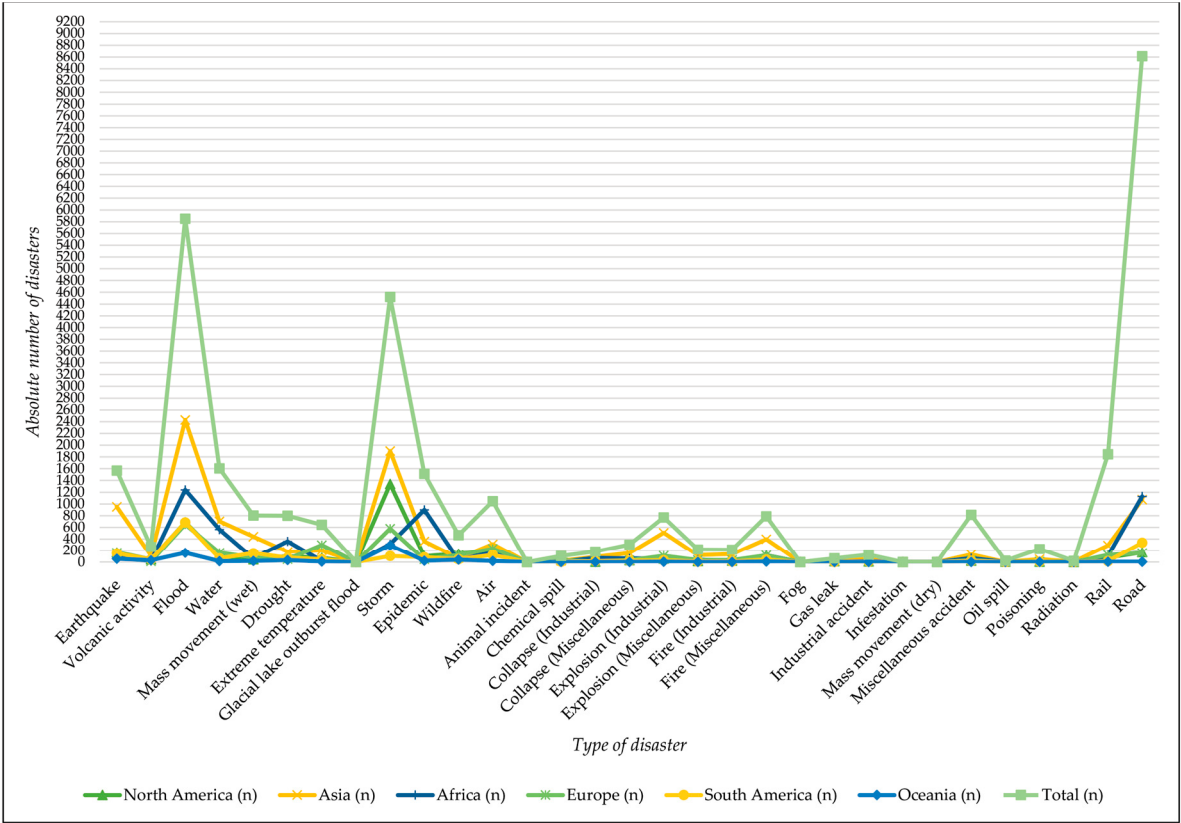


Figure 2. Distribution of individual natural and man-made (technological) disasters by continent (1900-2024).

These detailed distributions reveal specific regional vulnerabilities and can inform targeted disaster risk reduction strategies. For instance, Asia's high frequency of both natural and man-made (technological) disasters highlights the need for comprehensive disaster management plans. Similarly, Africa's significant number of man-made (technological) disasters indicates a need for improved technological safety and infrastructure development (Table 2 and Figure 2).

3.1.2. In-Depth Analysis of Disaster Distribution by Country with Comprehensive Supporting Data

A comprehensive overview of the distribution of total, natural, and man-made (technological) disasters by country from 1900 to 2024 highlights the most disaster-prone nations and the types of disasters they frequently encounter. Total disasters encompass all recorded events, both natural and man-made, that have occurred within a given country. This measure provides insight into the overall disaster burden each country faces and helps identify areas that may require enhanced disaster preparedness and mitigation efforts (Table 3 and Figure 3):

- 1) China ranks first with a total of 1,996 disaster events, comprising 7.54% of the global total. Natural disasters make up 50.70% (1,012 events) of China's total, while man-made (technological) disasters account for 49.30% (984 events). The top five disasters in China include Industrial Accidents (15.08%), Storms (14.73%), Floods (14.53%), Droughts (14.28%), and Epidemics (14.23%);

- 2) India follows with 1,581 disaster events (5.97% of the global total). Natural disasters represent 49.08% (776 events), and man-made (technological) disasters 50.92% (805 events). The most frequent disasters are Epidemics (15.50%), Industrial Accidents (14.86%), Droughts (14.80%), Floods (14.29%), and Epidemics again (14.17%);
- 3) The USA is third with 1,513 disaster events (5.72% of the global total). Natural disasters dominate with 76.14% (1,152 events), and man-made (technological) disasters constitute 23.86% (361 events). The top disasters include Epidemics (15.27%), Industrial Accidents (14.87%), Droughts (14.47%), Floods (14.41%), and Wildfires (13.88%);
- 4) The Philippines ranks fourth with 938 disaster events (3.54% of the global total). Natural disasters account for 74.41% (698 events), and man-made (technological) disasters 25.59% (240 events). The leading disasters are Industrial Accidents (16.10%), Storms (14.71%), Droughts (14.50%), Epidemics (14.39%), and Wildfires (14.18%);
- 5) Indonesia is fifth with 878 disaster events (3.32% of the global total). Natural disasters make up 70.73% (621 events), while man-made (technological) disasters account for 29.27% (257 events). The most common disasters are Floods (16.40%), Earthquakes (15.15%), Droughts (15.03%), Epidemics (14.81%), and Wildfires (13.44%);
- 6) Bangladesh ranks sixth with 588 disaster events (2.22% of the global total). Natural disasters constitute 61.73% (363 events), and man-made (technological) disasters 38.27% (225 events). The top disasters include Floods (15.99%), Droughts (15.14%), Industrial Accidents (15.14%), Epidemics (14.97%), and Storms (13.27%);
- 7) Nigeria is seventh with 523 disaster events (1.98% of the global total). Man-made disasters are prevalent, accounting for 72.66% (380 events), while natural disasters make up 27.34% (143 events). The leading disasters are Wildfires (16.63%), Storms (16.44%), Industrial Accidents (14.72%), Epidemics (14.53%), and Droughts (13.38%);
- 8) Pakistan is eighth with 504 disaster events (1.90% of the global total). Natural disasters represent 50.40% (254 events), and man-made (technological) disasters 49.60% (250 events). The most frequent disasters include Floods (15.08%), Wildfires (15.08%), Storms (14.88%), Industrial Accidents (14.29%), and Epidemics (13.89%);
- 9) Mexico ranks ninth with 481 disaster events (1.82% of the global total). Natural disasters make up 63.20% (304 events), and man-made (technological) disasters 36.80% (177 events). The top disasters are Wildfires (17.88%), Epidemics (15.59%), Floods (15.18%), Droughts (13.51%), and Epidemics again (12.89%);
- 10) Japan is tenth with 464 disaster events (1.75% of the global total). Natural disasters are dominant, comprising 83.84% (389 events), while man-made (technological) disasters account for 16.16% (75 events). The leading disasters include Wildfires (17.24%), Earthquakes (15.73%), Storms (15.09%), Droughts (14.44%), and Industrial Accidents (13.79%).

Natural disasters include events such as earthquakes, floods, droughts, storms, and other environmental phenomena (Table 3 and Figure 3). These events are often influenced by geographical and climatic factors unique to each country. China ranks first in natural disasters with 1,012 events (50.70% of its total), primarily including Floods, Storms, and Droughts. The USA has the second-highest number of natural disaster events with 1,152 (76.14% of its total), with major events being Epidemics, Storms, and Floods. India follows with 776 natural disaster events (49.08% of its total), with frequent occurrences of Epidemics, Floods, and Droughts. The Philippines reports 698 natural disaster events (74.41% of its total), dominated by Storms, Floods, and Droughts. Indonesia has 621 natural disaster events (70.73% of its total), primarily Floods, Earthquakes, and Droughts. Bangladesh experiences 363 natural disaster events (61.73% of its total), with Floods, Droughts, and Storms being the most common. Japan reports 389 natural disaster events (83.84% of its total), with Wildfires, Earthquakes, and Storms as the leading types. Mexico has 304 natural disaster events (63.20% of its total), with Wildfires, Floods, and Epidemics being the most prevalent. Pakistan has 254 natural disaster events (50.40% of its total), mainly Floods, Wildfires, and Storms. Brazil reports 283 natural disaster events (61.26% of its total), with the most common being Epidemics, Wildfires, and Droughts (Table 3 and Figure 3).

Table 3. Distribution of total, natural, and man-made (technological) disasters by country (1900-2024).

Country (rang)	Total disasters		Natural disasters		Man-made (tech.) disasters		Top 5 disasters by country				
	(n)	(%)	(n)	(%)	(n)	(%)	1th	2th	3th	4th	5th
1. China	1,996	7.54	1,012	50.70	984	49.30	IA (15.08)	S (14.73)	F (14.53)	D (14.28)	E (14.23)
2. India	1,581	5.97	776	49.08	805	50.92	E (15.50)	IA (14.86)	D (14.80)	F (14.29)	E (14.17)
3. USA	1,513	5.72	1,152	76.14	361	23.86	E (15.27)	IA (14.87)	D (14.47)	F (14.41)	W (13.88)
4. Philippines	938	3.54	698	74.41	240	25.59	IA (16.10)	S (14.71)	D (14.50)	E (14.39)	W (14.18)
5. Indonesia	878	3.32	621	70.73	257	29.27	F (16.40)	E (15.15)	D (15.03)	E (14.81)	W (13.44)
6. Bangladesh	588	2.22	363	61.73	225	38.27	F (15.99)	D (15.14)	IA (15.14)	E (14.97)	S (13.27)
7. Nigeria	523	1.98	143	27.34	380	72.66	W (16.63)	S (16.44)	IA (14.72)	E (14.53)	D (13.38)
8. Pakistan	504	1.90	254	50.40	250	49.60	F (15.08)	W (15.08)	S (14.88)	IA (14.29)	E (13.89)
9. Mexico	481	1.82	304	63.20	177	36.80	W (17.88)	E (15.59)	F (15.18)	D (13.51)	E (12.89)
10. Japan	464	1.75	389	83.84	75	16.16	W (17.24)	E (15.73)	S (15.09)	D (14.44)	IA (13.79)
11. Brazil	462	1.75	283	61.26	179	38.74	E (15.15)	IA (15.15)	W (14.94)	D (14.72)	F (14.50)
12. Iran	442	1.67	265	59.95	177	40.05	D (17.87)	E (15.61)	W (15.16)	IA (14.48)	F (13.35)
13. Russia	417	1.58	178	42.69	239	57.31	E (17.27)	W (15.35)	S (15.11)	D (14.63)	IA (13.43)
14. Peru	397	1.50	217	54.66	180	45.34	F (15.87)	E (15.37)	E (14.36)	S (14.11)	IA (13.85)
15. Türkiye	390	1.47	217	55.64	173	44.36	D (16.67)	IA (15.13)	W (15.13)	S (14.36)	F (13.33)
16. Congo	342	1.29	155	45.32	187	54.68	S (17.54)	W (14.91)	D (14.04)	IA (14.04)	E (13.45)
17. Colombia	339	1.28	232	68.44	107	31.56	IA (16.52)	E (16.22)	D (14.45)	E (14.45)	S (14.45)
18. Viet Nam	338	1.28	264	78.11	74	21.89	S (16.86)	E (16.57)	D (15.98)	W (15.38)	F (14.79)
19. South Africa	326	1.23	129	39.57	197	60.43	D (16.56)	S (15.64)	F (14.72)	IA (14.72)	E (14.42)
20. France	296	1.12	203	68.58	93	31.42	W (20.27)	IA (14.53)	E (14.19)	D (13.85)	S (13.51)
21. Italy	285	1.08	187	65.61	98	34.39	F (17.54)	IA (17.54)	S (15.44)	D (13.68)	E (13.33)
22. Afghanistan	274	1.04	219	79.93	55	20.07	E (17.88)	F (16.06)	S (14.60)	D (14.23)	W (13.14)
23. Thailand	274	1.04	172	62.77	102	37.23	E (20.07)	W (17.88)	E (13.50)	S (13.14)	D (12.77)
24. Australia	257	0.97	223	86.77	34	13.23	E (17.51)	D (15.18)	F (14.01)	S (14.01)	E (13.23)
25. Egypt	252	0.95	36	14.29	216	85.71	E (20.24)	E (15.08)	IA (13.89)	W (13.49)	S (12.70)
26. Canada	246	0.93	153	62.20	93	37.80	F (17.89)	D (15.04)	S (14.23)	E (13.82)	IA (13.82)
27. Kenya	231	0.87	126	54.55	105	45.45	IA (17.75)	F (16.88)	E (16.02)	S (13.85)	D (13.42)
28. Nepal	215	0.81	139	64.65	76	35.35	E (18.14)	S (16.74)	D (14.88)	E (14.88)	IA (12.56)
29. Tanzania	214	0.81	122	57.01	92	42.99	W (20.56)	IA (16.36)	E (14.49)	F (14.49)	E (13.08)
30. Great Britain	204	0.77	105	51.47	99	48.53	E (19.12)	E (15.69)	F (15.69)	D (14.22)	W (13.24)
31. Rep. Korea	202	0.76	132	65.35	70	34.65	E (17.82)	F (17.82)	W (14.85)	E (13.86)	IA (13.37)
32. Haiti	196	0.74	138	70.41	58	29.59	W (18.37)	IA (17.35)	E (14.80)	F (13.78)	E (13.27)
33. Sudan	196	0.74	108	55.10	88	44.90	IA (18.88)	S (18.37)	F (15.82)	D (14.29)	E (12.76)
34. Uganda	191	0.72	111	58.12	80	41.88	S (17.80)	F (16.23)	E (15.18)	IA (13.61)	D (12.57)
35. Spain	188	0.71	112	59.57	76	40.43	F (17.55)	E (14.89)	E (14.36)	S (14.36)	W (13.83)
36. Taiwan	187	0.71	136	72.73	51	27.27	IA (18.18)	W (14.97)	F (14.44)	D (13.90)	E (13.37)
37. Argentina	180	0.68	131	72.78	49	27.22	W (19.44)	E (18.33)	D (14.44)	F (13.33)	IA (13.33)
38. Ecuador	166	0.63	119	71.69	47	28.31	E (15.06)	E (15.06)	F (15.06)	W (15.06)	IA (13.86)
39. Guatemala	165	0.62	127	76.97	38	23.03	W (16.97)	D (15.76)	S (15.76)	E (13.94)	E (13.33)
40. Ethiopia	163	0.62	127	77.91	36	22.09	D (20.25)	E (17.18)	E (14.72)	F (14.72)	S (14.11)
41. Greece	163	0.62	111	68.10	52	31.90	S (19.02)	E (16.56)	W (15.95)	E (14.11)	IA (12.27)
42. Myanmar	159	0.60	89	55.97	70	44.03	E (18.24)	D (17.61)	F (15.09)	IA (14.47)	S (13.21)
43. Bolivia	157	0.59	112	71.34	45	28.66	F (15.92)	IA (14.65)	W (14.65)	D (14.01)	E (14.01)
44. Sri Lanka	157	0.59	131	83.44	26	16.56	E (21.02)	W (15.92)	S (14.65)	D (14.01)	E (13.38)
45. Algeria	156	0.59	93	59.62	63	40.38	E (16.03)	W (16.03)	S (15.38)	D (14.74)	F (14.74)
46. Belgium	156	0.59	72	46.15	84	53.85	E (17.31)	IA (17.31)	E (14.74)	D (14.10)	F (14.10)
47. Morocco	156	0.59	63	40.38	93	59.62	W (17.31)	E (16.67)	IA (16.03)	S (16.03)	D (11.54)
48. Mozambique	156	0.59	125	80.13	31	19.87	D (19.23)	E (15.38)	F (15.38)	W (14.74)	S (13.46)
49. Chile	152	0.57	125	82.24	27	17.76	F (18.42)	E (15.79)	D (14.47)	E (14.47)	W (13.16)
50. Malaysia	152	0.57	109	71.71	43	28.29	IA (21.05)	S (19.74)	F (15.79)	D (13.82)	W (13.82)

Note: Industrial Accident (IA); Storm (S); Flood (F); Drought (D); Epidemic (E); Wildfire (W); Earthquake (E).

Man-made (technological) disasters refer to events caused by human activity, such as industrial accidents, chemical spills, and other incidents related to technological failures or human error (Table 3 and Figure 3). Regarding that, China ranks first in man-made (technological) disasters with 984 events (49.30% of its total), dominated by Industrial Accidents and Chemical Spills. India has 805 man-made disaster events (50.92% of its total), with leading types being Industrial Accidents and Chemical Spills. Nigeria experiences 380 man-made disaster events (72.66% of its total), with the most common being Industrial Accidents and Fires. The USA reports 361 man-made disaster events (23.86% of its total), primarily Industrial Accidents and Chemical Spills. Indonesia has 257 man-made disaster events (29.27% of its total), mainly Industrial Accidents and Fires. Bangladesh records 225 man-made disaster events (38.27% of its total), with the top events being Industrial Accidents and Chemical Spills. Russia has 239 man-made disaster events (57.31% of its total), with common types including Industrial Accidents and Fires. Japan reports 75 man-made disaster events (16.16% of its total), primarily Industrial Accidents and Chemical Spills. Mexico experiences 177 man-made disaster events (36.80% of its total), dominated by Industrial Accidents and Fires. Pakistan has 250 man-made disaster events (49.60% of its total), with the leading types being Industrial Accidents and Fires (Table 3 and Figure 3).

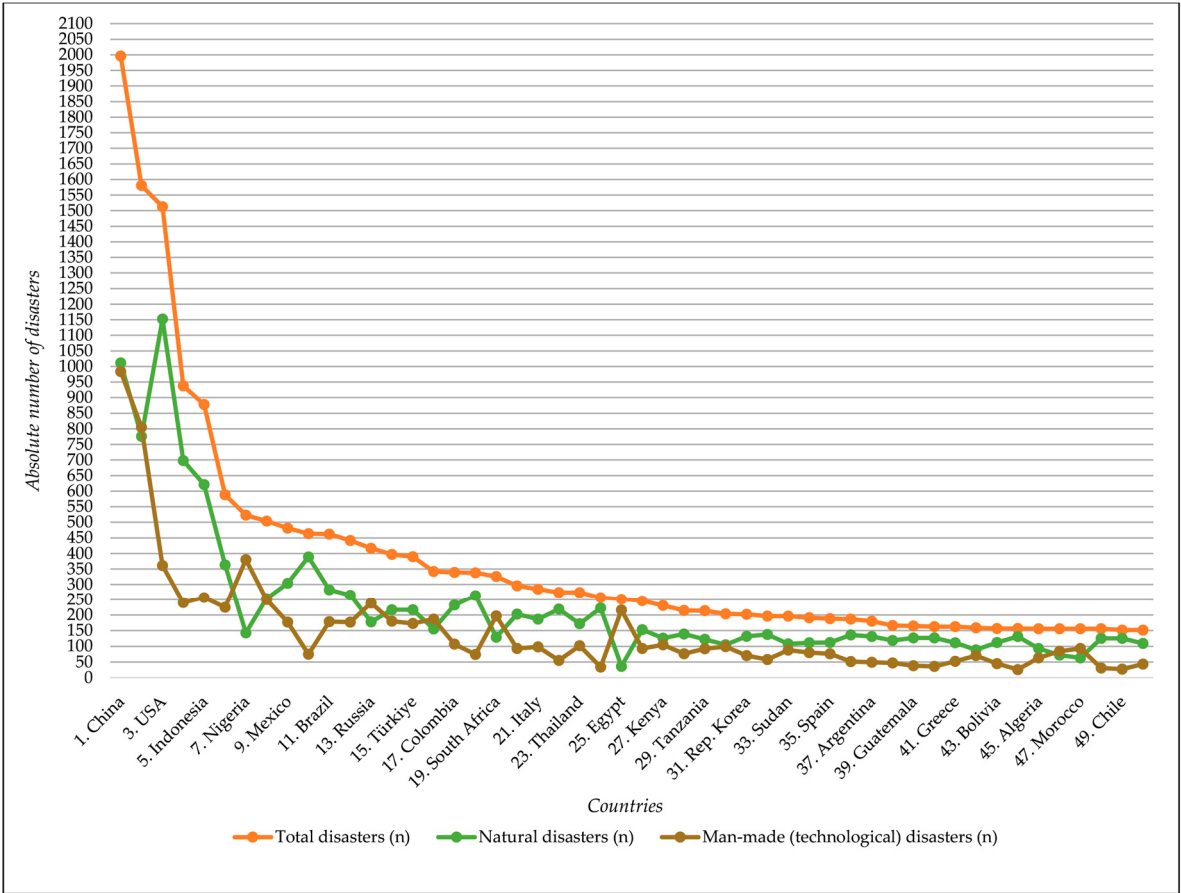


Figure 3. Distribution of total, natural, and man-made (technological) disasters by country (1900-2024).

These insights emphasize the importance of tailoring disaster risk reduction strategies to the specific needs and vulnerabilities of each country. For instance, countries with high natural disaster frequencies, such as Japan and Australia, may prioritize early warning systems and infrastructure resilience, while those with a higher prevalence of man-made (technological) disasters, like Nigeria and Egypt, may focus on industrial safety and emergency response protocols (Table 3 and Figure 3).

3.2. Temporal Distribution of Natural and Man-Made (Technological) Disasters

3.2.1. Yearly and Monthly Trends in Occurrences of Natural and Man-Made Disasters

A temporal analysis of natural and man-made (technological) disasters over 10-year intervals from 1900 to 2024 highlights trends and changes in the frequency and distribution of disasters over time (Table 4 and Figure 4). This analysis offers insights into how disaster patterns have evolved and what factors may influence these trends:

- a) From 1900-1910, there were 101 total disaster events, with natural disasters comprising 78.22% (79 events) and man-made (technological) disasters 21.78% (22 events). The overall trend was stable, with no significant change in the rate of disasters;
- b) Between 1911-1920, a total of 121 disaster events were recorded, showing an increase of 19.57% from the previous decade. Natural disasters made up 64.46% (78 events), while man-made (technological) disasters accounted for 35.54% (43 events). This decade marks the beginning of an upward trend in disaster events;
- c) During the 1921-1930 period, the number of disaster events increased to 132, a 7.40% rise from the previous decade. Natural disasters constituted 80.30% (106 events), and man-made (technological) disasters 19.70% (26 events). The upward trend continued;
- d) From 1931-1940, there were 217 disaster events, representing a significant increase of 42.20%. Natural disasters made up 61.29% (133 events), while man-made (technological) disasters accounted for 38.71% (84 events). This decade saw a substantial rise in the number of disasters;
- e) In the 1941-1950 decade, the number of disasters increased to 281, an 11.73% rise from the previous decade. Natural disasters comprised 60.85% (171 events), and man-made (technological) disasters 39.15% (110 events). The trend of increasing disaster events persisted;
- f) From 1950-1960, there were 378 disaster events, marking a 10.05% increase. Natural disasters accounted for 82.01% (310 events), while man-made (technological) disasters were 17.99% (68 events). This decade continued the upward trend;
- g) The 1961-1970 period saw the number of disasters rise to 690, a 13.59% increase. Natural disasters constituted 86.09% (594 events), and man-made (technological) disasters 13.91% (96 events). The trend of increasing disasters continued;
- h) Between 1970-1980, a total of 1,144 disaster events were recorded, a 6.10% rise from the previous decade. Natural disasters made up 76.14% (871 events), while man-made (technological) disasters accounted for 23.86% (273 events). The upward trend in disaster frequency persisted;
- i) From 1981-1990, the number of disasters significantly increased to 2,718, a 5.33% rise from the previous decade. Natural disasters constituted 64.57% (1,755 events), and man-made (technological) disasters 35.43% (963 events). This decade saw a substantial rise in disaster events;
- j) In the 1991-2000 period, there were 4,995 disaster events, a 1.71% increase. Natural disasters made up 59.20% (2,957 events), while man-made (technological) disasters were 40.80% (2,038 events). The trend of increasing disasters continued;
- k) From 2001-2010, the number of disasters rose to 7,651, a 0.70% increase. Natural disasters accounted for 58.35% (4,464 events), while man-made (technological) disasters were 41.65% (3,187 events). This decade continued the upward trend;
- l) Between 2011-2020, the number of disasters decreased to 5,713, marking a decrease of 0.44%. Natural disasters made up 65.78% (3,758 events), and man-made (technological) disasters 34.22% (1,955 events). This decade saw the beginning of a downward trend;
- m) From 2021-2024, there were 2,323 disaster events, marking a decrease of 2.49%. Natural disasters constituted 75.20% (1,747 events), and man-made (technological) disasters 24.80% (576 events). The downward trend in disaster frequency continued (Table 4 and Figure 4).

The early 20th century (1900-1940) experienced relatively fewer disaster events with a stable but gradually increasing trend. The increase in man-made (technological) disasters began to become more noticeable during these periods. In addition, the mid-20th century (1940-1970) saw a significant rise in disaster events, with both natural and man-made (technological) disasters contributing to the increase.

Technological advancements and industrial activities likely influenced the rise in man-made (technological) disasters. Likewise, the late 20th century (1970-2000) experienced the highest increases in disaster events, particularly in the 1980s and 1990s. This period saw a peak in both natural and man-made (technological) disasters, indicating heightened vulnerability and exposure to disasters (Table 4 and Figure 4).

Table 4. Temporal analysis of natural and man-made (technological) disasters in 10-year intervals (1900-2024): trend assessments and insights.

Decade	Natural disasters		Man-made (technological) disasters		Total		Trend
	(n)	(%)	(n)	(%)	(n)	(%)	Rate (%)
1900-1910	79	78.22	22	21.78	101	0.38	Stable (0.00%)
1911-1920	78	64.46	43	35.54	121	0.46	Increasing (19.57%)
1921-1930	106	80.30	26	19.70	132	0.50	Increasing (7.40%)
1931-1940	133	61.29	84	38.71	217	0.82	Increasing (42.20%)
1941-1950	171	60.85	110	39.15	281	1.06	Increasing (11.73%)
1951-1960	310	82.01	68	17.99	378	1.43	Increasing (10.05%)
1961-1970	594	86.09	96	13.91	690	2.61	Increasing (13.59%)
1971-1980	871	76.14	273	23.86	1144	4.32	Increasing (6.10%)
1981-1990	1755	64.57	963	35.43	2718	10.27	Increasing (5.33%)
1991-2000	2957	59.20	2038	40.80	4995	18.87	Increasing (1.71%)
2001-2010	4464	58.35	3187	41.65	7651	28.91	Increasing (0.70%)
2011-2020	3758	65.78	1955	34.22	5713	21.59	Decreasing (−0.44%)
2021-2024	1747	75.20	576	24.80	2323	8.78	Decreasing (−2.49%)

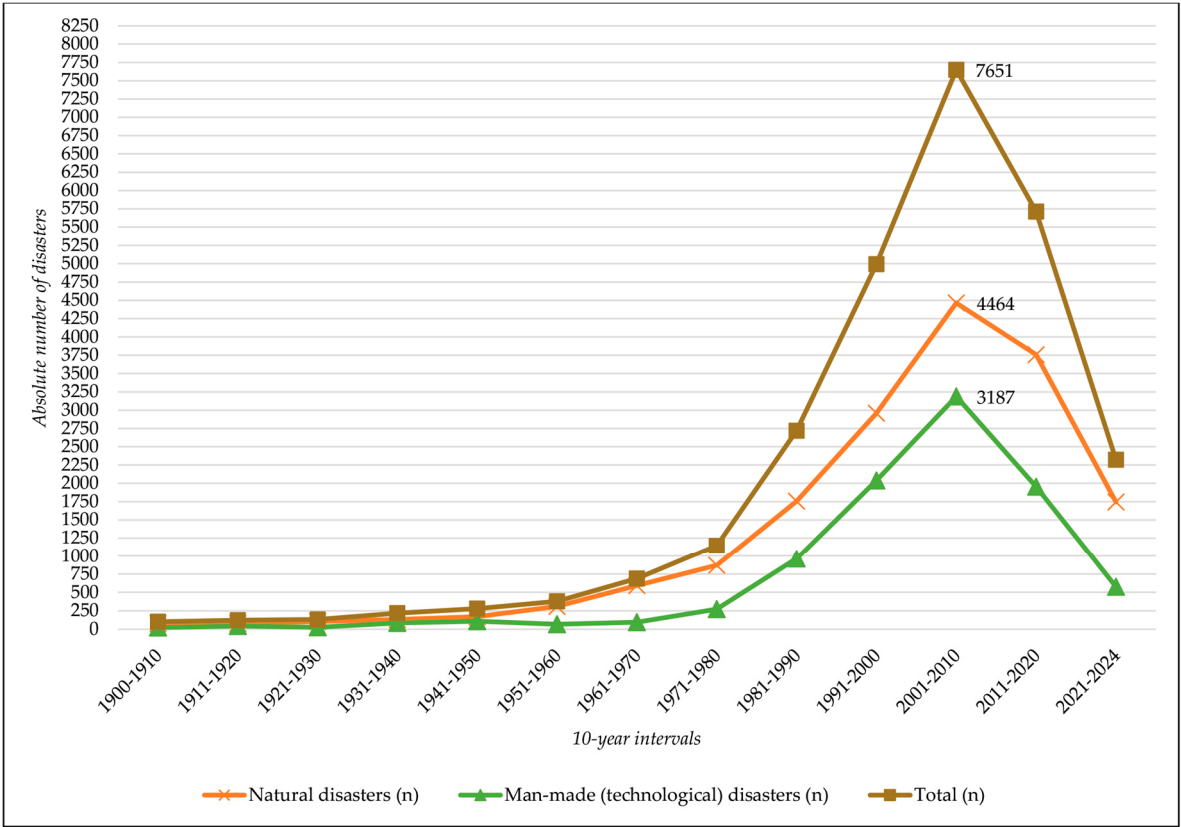


Figure 4. Temporal analysis of natural and man-made (technological) disasters in 10-year intervals (1900-2024).

The early 21st century (2000-2020) continued the trend of increasing disaster events, although the rate of increase began to slow down by 2010. There was a noticeable shift with a higher proportion of man-made (technological) disasters. Conversely, the most recent decade (2021-2024) shows a decreasing trend in the number of disaster events, with a significant reduction in both natural and man-made (technological) disasters. This decrease may be attributed to improved disaster management practices, early warning systems, and increased global awareness of disaster risks (Table 4 and Figure 4).

Overall, the temporal analysis reveals a dynamic pattern of disaster occurrences, with significant increases in the mid to late 20th century followed by a gradual decline in recent years. These trends underscore the importance of continuous improvement in disaster risk reduction and management strategies to mitigate the impact of both natural and man-made (technological) disasters (Table 4 and Figure 4).

A temporal analysis of natural and man-made (technological) disasters over 5-year intervals from 1900 to 2024 reveals trends and changes in the frequency and distribution of disasters over shorter periods (Table 5 and Figure 5). This analysis offers more granular insights into how disaster patterns have evolved and what factors may influence these trends.

From 1900 to 1905, there were 43 total disaster events, with natural disasters comprising 81.40% (35 events) and man-made (technological) disasters 18.60% (8 events). The overall trend was stable, with no significant change in the rate of disasters. Moving into the next five years, a total of 58 disaster events were recorded between 1905 and 1910, showing a 34.88% increase from the previous period. Natural disasters made up 75.86% (44 events), while man-made (technological) disasters accounted for 24.14% (14 events). From 1910 to 1915, the number of disaster events rose to 61, a 5.17% rise from the previous period. Natural disasters constituted 77.05% (47 events), and man-made (technological) disasters 22.95% (14 events). The period from 1915 to 1920 saw a slight decrease to 60 disaster events, representing a 1.64% decline. Natural disasters made up 51.67% (31 events), while man-made (technological) disasters accounted for 48.33% (29 events).

From 1920 to 1925, the number of disaster events increased again to 61, a 1.67% rise from the previous period. Natural disasters comprised 77.05% (47 events), and man-made (technological) disasters 22.95% (14 events). Between 1925 and 1930, the number of disaster events rose to 71, marking a 16.39% increase. Natural disasters accounted for 83.10% (59 events), while man-made (technological) disasters were 16.90% (12 events). The period from 1930 to 1935 saw the number of disasters increase to 88, a 23.94% rise. Natural disasters constituted 77.27% (68 events), and man-made (technological) disasters 22.73% (20 events). From 1935 to 1940, a significant increase to 129 disaster events was recorded, a 46.59% rise. Natural disasters made up 50.39% (65 events), while man-made (technological) disasters accounted for 49.61% (64 events). Between 1940 and 1945, there were 160 disaster events, representing a 24.03% increase. Natural disasters comprised 48.12% (77 events), and man-made (technological) disasters 51.88% (83 events).

The period from 1945 to 1950 saw a decrease to 121 disaster events, marking a 24.38% decline. Natural disasters accounted for 77.69% (94 events), while man-made (technological) disasters were 22.31% (27 events). Between 1950 and 1955, there were 192 disaster events, a 58.68% increase. Natural disasters made up 81.77% (157 events), and man-made (technological) disasters 18.23% (35 events). From 1955 to 1960, the number of disasters slightly decreased to 186, a 3.12% decline. Natural disasters comprised 82.26% (153 events), and man-made (technological) disasters 17.74% (33 events). Between 1960 and 1965, the number of disasters increased to 238, a 27.96% rise. Natural disasters accounted for 85.71% (204 events), while man-made (technological) disasters were 14.29% (34 events). From 1965 to 1970, there were 452 disaster events, a significant 89.92% increase. Natural disasters made up 86.28% (390 events), and man-made (technological) disasters 13.72% (62 events).

The period from 1970 to 1975 saw a slight decrease to 435 disaster events, a 3.76% decline. Natural disasters constituted 77.24% (336 events), and man-made (technological) disasters 22.76% (99 events). From 1975 to 1980, there were 709 disaster events, marking a 62.99% increase. Natural disasters accounted for 75.46% (535 events), while man-made (technological) disasters were 24.54% (174 events). Between 1980 and 1985, the number of disasters increased to 1,009, a 42.31% rise. Natural

disasters comprised 76.71% (774 events), and man-made (technological) disasters 23.29% (235 events). From 1985 to 1990, there were 1,709 disaster events, a significant 69.38% increase. Natural disasters made up 57.40% (981 events), and man-made (technological) disasters were 42.60% (728 events). Between 1990 and 1995, the number of disasters increased to 2,245, a 31.36% rise. Natural disasters constituted 58.53% (1,314 events), while man-made (technological) disasters were 41.47% (931 events).

The period from 1995 to 2000 saw a total of 2,750 disaster events, a 22.49% increase. Natural disasters accounted for 59.75% (1,643 events), and man-made (technological) disasters 40.25% (1,107 events). Between 2000 and 2005, the number of disasters rose to 4,039, marking a 46.87% increase. Natural disasters made up 56.72% (2,291 events), while man-made (technological) disasters were 43.28% (1,748 events). From 2005 to 2010, the number of disasters slightly decreased to 3,612, a 10.57% decline. Natural disasters constituted 60.16% (2,173 events), and man-made (technological) disasters 39.84% (1,439 events). Between 2010 and 2015, there were 2,928 disaster events, an 18.94% decrease. Natural disasters comprised 63.66% (1,864 events), and man-made (technological) disasters 36.34% (1,064 events). From 2015 to 2020, the number of disasters slightly decreased to 2,785, a 4.88% decline. Natural disasters made up 68.01% (1,894 events), while man-made (technological) disasters were 31.99% (891 events). Between 2020 and 2025, there were 2,323 disaster events, marking a 16.59% decline. Natural disasters constituted 75.20% (1,747 events), and man-made (technological) disasters 24.80% (576 events) (Table 5 and Figure 5).

Table 5. Temporal analysis of natural and man-made (technological) disasters in 5-year intervals (1900-2024).

Period (5-year intervals)	Natural disasters		Man-made (technological) disasters		Total		Trend (%)
	(n)	(%)	(n)	(%)	(n)	(%)	
1900-1905	35	81.40	8	18.60	43	0.16	Stable (0.00%)
1906-1910	44	75.86	14	24.14	58	0.22	Increasing (34.88%)
1911-1915	47	77.05	14	22.95	61	0.23	Increasing (5.17%)
1916-1920	31	51.67	29	48.33	60	0.23	Decreasing (−1.64%)
1921-1925	47	77.05	14	22.95	61	0.23	Increasing (1.67%)
1926-1930	59	83.10	12	16.90	71	0.27	Increasing (16.39%)
1931-1935	68	77.27	20	22.73	88	0.33	Increasing (23.94%)
1936-1940	65	50.39	64	49.61	129	0.49	Increasing (46.59%)
1941-1945	77	48.12	83	51.88	160	0.60	Increasing (24.03%)
1946-1950	94	77.69	27	22.31	121	0.46	Decreasing (−24.38%)
1951-1955	157	81.77	35	18.23	192	0.73	Increasing (58.68%)
1956-1960	153	82.26	33	17.74	186	0.70	Decreasing (−3.12%)
1961-1965	204	85.71	34	14.29	238	0.90	Increasing (27.96%)
1966-1970	390	86.28	62	13.72	452	1.71	Increasing (89.92%)
1971-1975	336	77.24	99	22.76	435	1.64	Decreasing (−3.76%)
1976-1980	535	75.46	174	24.54	709	2.68	Increasing (62.99%)
1981-1985	774	76.71	235	23.29	1009	3.81	Increasing (42.31%)
1986-1990	981	57.40	728	42.60	1709	6.46	Increasing (69.38%)
1991-1995	1314	58.53	931	41.47	2245	8.48	Increasing (31.36%)
1996-2000	1643	59.75	1107	40.25	2750	10.39	Increasing (22.49%)
2001-2005	2291	56.72	1748	43.28	4039	15.26	Increasing (46.87%)
2006-2010	2173	60.16	1439	39.84	3612	13.65	Decreasing (−10.57%)
2011-2015	1864	63.66	1064	36.34	2928	11.06	Decreasing (−18.94%)
2015-2020	1894	68.01	891	31.99	2785	10.52	Decreasing (−4.88%)
2020-2024	1747	75.20	576	24.80	2323	8.78	Decreasing (−16.59%)

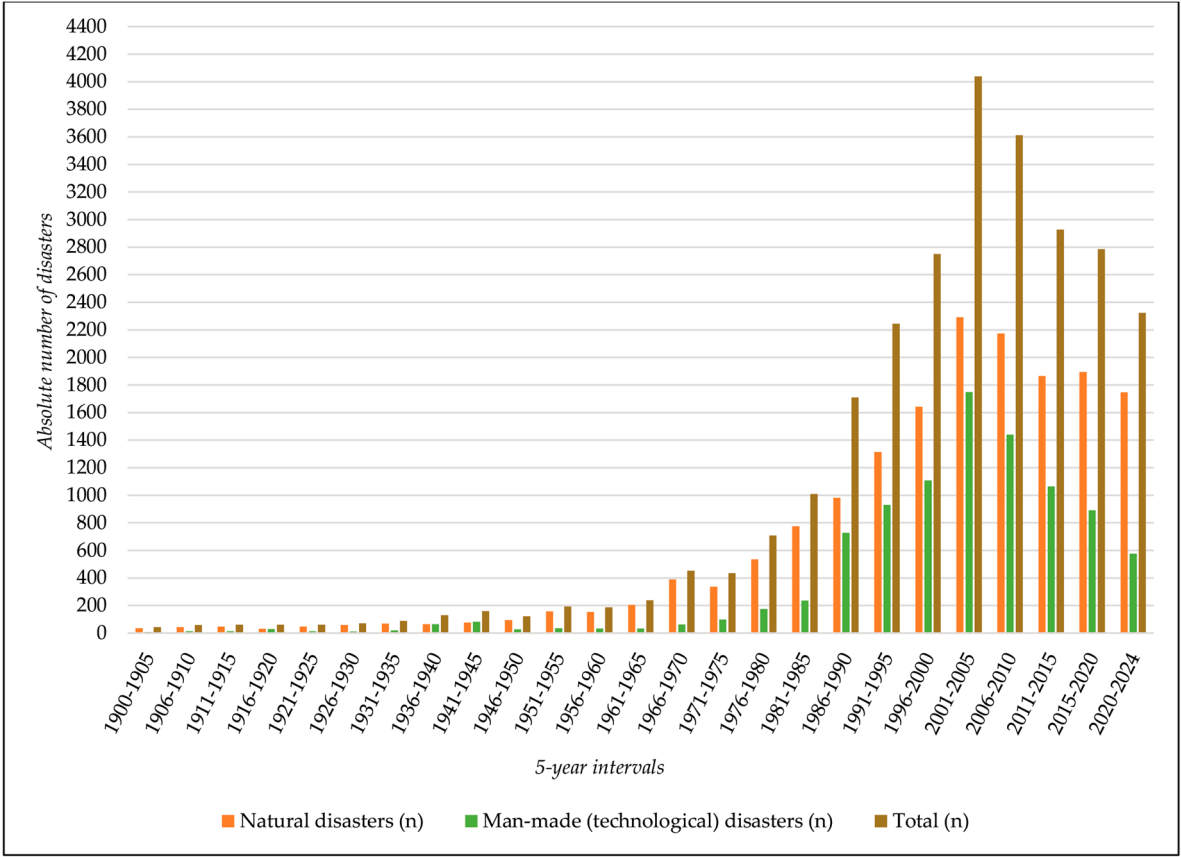


Figure 5. Temporal analysis of natural and man-made (technological) disasters in 5-year intervals (1900-2024).

As we mentioned before, the early 20th century experienced a steady increase in disaster events, with natural disasters predominating and the rise in man-made (technological) disasters becoming more noticeable. Significant increases during 1930-1945 highlight the impact of technological advancements and urbanization. Following this, the post-World War II period saw a significant rise in disaster events, peaking around 1940-1945, followed by a slight decline likely due to post-war recovery efforts and improvements in infrastructure and disaster management (Table 5 and Figure 5).

From 1965 to 1985, there was a rapid increase in the number of disaster events, especially natural disasters. This growth was driven by factors such as population growth, urbanization, and increased industrial activity, leading to heightened exposure and vulnerability to disasters. The period between 1985 and 2005 marked the peak and subsequent stabilization of disaster events. Both natural and man-made (technological) disasters saw significant increases, reflecting the complexities of modern societal and environmental challenges.

In recent years, specifically from 2005 to 2025, there has been a gradual decline in the number of disaster events, with notable decreases in both natural and man-made (technological) disasters. This trend may be attributed to improved disaster risk reduction strategies, advancements in early warning systems, and increased global awareness and preparedness for disaster risks (Table 5 and Figure 5). These insights highlight the dynamic nature of disaster occurrences over time, emphasizing the need for continuous adaptation and improvement in disaster management practices to address both natural and man-made challenges. The periods of significant increase and subsequent decline underscore the importance of sustained efforts in building resilient communities and mitigating disaster impacts.

In addition to the observed trends, several interesting insights and considerations can be drawn from the temporal analysis of natural and man-made (technological) disasters from 1900 to 2024. The mid-20th century saw a sharp increase in man-made (technological) disasters, particularly from 1940-

1945 and 1985-2005, corresponding with significant technological and industrial advancements (Table 5 and Figure 5). This period indicates that rapid industrialization and technological development can contribute to a higher incidence of man-made (technological) disasters. The gradual decline in disaster events post-2005 suggests the effectiveness of global policies, international cooperation, and enhanced disaster risk reduction (DRR) frameworks, such as the Sendai Framework for Disaster Risk Reduction adopted in 2015.

Table 6 provides a detailed look at the total number of various natural and man-made (technological) disasters recorded each decade from 1900 to 2020. This analysis sheds light on the types and frequency of different disasters over time, offering insights into how disaster patterns have evolved and revealing trends in specific types of disasters.

Table 6. Total number of different natural and man-made (technological) disasters worldwide by decade (1900-2024).

Disaster type	1900-1910	1911-1920	1921-1930	1931-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020	2021-2024	Total
Air	0	15	7	59	75	6	16	29	155	300	248	158	23	1091
Animal incident	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Chemical spill	0	0	0	0	0	0	1	17	33	34	16	7	0	108
Collapse (Indust.)	0	0	0	0	0	3	0	2	12	21	60	66	20	184
Collapse (Miscell.)	1	3	2	0	0	4	7	16	36	78	87	55	16	305
Drought	4	10	4	2	13	0	52	61	126	140	170	169	62	813
Earthquake	38	32	42	65	73	68	88	110	173	265	289	262	112	1617
Epidemic	5	6	10	2	3	2	37	59	124	385	590	258	45	1526
Explosion (Industrial)	5	7	9	10	8	11	6	30	65	178	328	104	26	787
Explosion	1	0	0	0	0	0	0	3	16	43	87	58	14	222
Extreme temperature	0	0	0	2	0	8	9	15	37	91	224	207	59	652
Fire (Industrial)	1	0	0	0	1	1	1	6	29	70	58	43	10	220
Fire (Miscell.)	9	3	4	5	8	7	38	79	104	131	193	149	74	804
Flood	6	4	9	11	11	81	155	259	515	861	1719	1531	779	5941
Fog	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Gas leak	0	0	0	0	1	0	0	5	2	20	20	8	6	62
Glacial lake outburst flood	0	0	0	0	0	0	0	0	0	0	0	0	4	4
Infestation	0	1	0	1	1	0	0	4	48	11	18	9	2	95
Mass mov. (dry)	3	0	0	1	0	1	2	0	14	11	8	5	0	45
Mass mov. (wet)	1	2	4	6	4	20	26	55	105	151	192	183	78	827
Oil spill	0	0	0	0	0	0	0	1	1	1	2	3	0	8
Poisoning	0	0	0	0	0	2	1	7	10	36	17	3	0	76
Radiation	0	0	0	0	0	1	0	1	3	2	2	0	0	9
Rail	2	6	2	6	10	25	14	35	103	196	142	89	16	646
Road	0	0	0	0	0	3	4	11	192	556	1240	694	182	2882
Storm	14	18	34	39	55	119	211	274	533	893	1049	997	515	4751
Volcanic activity	8	3	1	3	7	9	12	23	31	52	60	43	22	274
Water-related	2	9	2	3	4	5	5	12	172	315	528	425	153	1635
Wildfire	0	2	2	1	4	1	6	7	49	100	143	97	63	475
Total	100	121	132	216	278	378	691	1121	2688	4941	7490	5624	2281	26061

Earthquakes were consistently reported, with the highest number in the 2000s at 289 events, likely due to increased seismic activity or better reporting. Also, epidemics saw a sharp increase in the 1990s with 385 events and peaked in the 2000s with 590 events, reflecting global health challenges. Industrial explosions peaked in the 2000s with 328 events, while miscellaneous explosions rose to 87

events in the same decade. Extreme temperatures saw a significant rise in the 2000s with 224 events, underscoring the effects of climate change. Industrial fires peaked in the 1990s with 70 events, whereas miscellaneous fires increased steadily, peaking in the 2000s with 193 events. Floods showed a dramatic rise, peaking in the 2000s with 1,719 events, indicating greater rainfall variability and extreme weather events.

Air disasters first appeared in the 1910s with 15 events, gradually increasing and peaking in the 1990s with 300 events. This trend reflects significant technological advancements and increased air traffic during that period. However, a noticeable decline occurred in the 2010s, with 158 events. Animal incidents were rarely recorded, with only one incident noted in the 2010s. Chemical spills were first documented in the 1960s with one event, rising to a peak in the 1990s with 34 events, then declining to 7 events in the 2010s. Industrial collapses began in the 1950s, reaching a peak in the 2000s with 60 events, while miscellaneous collapses steadily increased, peaking in the 2000s with 87 events. Droughts were consistently recorded across decades, peaking in the 2000s with 170 events, highlighting the impact of climate change.

Fog, gas leaks, and oil spills were rarely recorded but saw notable increases in certain decades, with gas leaks peaking in the 2000s with 20 events. Glacial lake outburst floods were infrequent, with a few incidents noted in recent years, pointing to climate change impacts. Infestations peaked in the 1980s with 48 events, showing occasional spikes due to ecological changes. Wet mass movements steadily increased, peaking in the 2000s with 192 events, reflecting more rainfall and landslide activity. Poisonings and radiation incidents were seldom recorded, with spikes such as poisoning incidents peaking in the 1990s with 36 events.

Road disasters significantly increased, peaking in the 2000s with 1,240 events due to more vehicular traffic, while rail disasters remained steady, peaking in the 1990s with 196 events. Storms consistently increased, peaking in the 2000s with 1,049 events, reflecting more frequent and intense storm activity due to climate change. Volcanic activity remained relatively stable with slight increases, peaking in the 2000s with 60 events. Water-related disasters rose significantly, peaking in the 2000s with 528 events, highlighting issues such as flooding and water scarcity. Wildfires showed a gradual rise, peaking in the 2000s with 143 events, reflecting higher temperatures and drier conditions (Table 6 and Figure 6).

The mid to late 20th century saw a sharp rise in industrial and technological disasters, reflecting industrial growth, urbanization, and increased technological activities. A noticeable increase in climate-related disasters such as floods, droughts, extreme temperatures, and wildfires in recent decades underscores the impact of climate change. The significant rise in the number of recorded disasters, particularly from the 1960s onwards, may also be due to improved reporting mechanisms, greater global awareness, and better disaster monitoring systems. The spike in epidemics and chemical spills in the late 20th and early 21st centuries highlights ongoing health and environmental challenges (Table 6 and Figure 6). Additionally, the recent decline in certain disasters, such as air disasters and some industrial incidents, suggests improvements in disaster management, safety protocols, and preparedness measures.

Table 7 provides a detailed breakdown of the total number of different natural and man-made (technological) disasters recorded in 5-year intervals from 1900 to 2024. Air disasters began to be recorded from 1910-1914 with one event, peaking in the 1985-1989 period with 128 events. This trend shows significant technological advancements and increased air traffic contributing to these numbers. There is a noticeable decline in recent periods, with 23 events recorded in 2021-2024. Animal incidents are rarely recorded, with only one incident noted in the 2010-2014 period (Figure 7).

Chemical spills were first recorded in the 1965-1969 period with one event, peaking in the 1995-1999 period with 23 events. A decline is observed in recent periods, with no events recorded in 2020-2024. Industrial collapses began in the 1950-1954 period, peaking in the 2000-2004 period with 20 events. Miscellaneous collapses show a steady increase, peaking in the 1995-1999 period with 45 events.

Droughts were recorded consistently across periods, peaking in the 2000-2004 period with 96 events, showing the impact of climate change and variability. Earthquakes were consistently

recorded, with the highest number in the 2000-2004 period at 174 events, reflecting increased seismic activity or improved reporting. Epidemics saw a sharp increase in the 1990-1994 period with 103 events and peaking in the 2000-2004 period with 360 events, reflecting global health challenges.

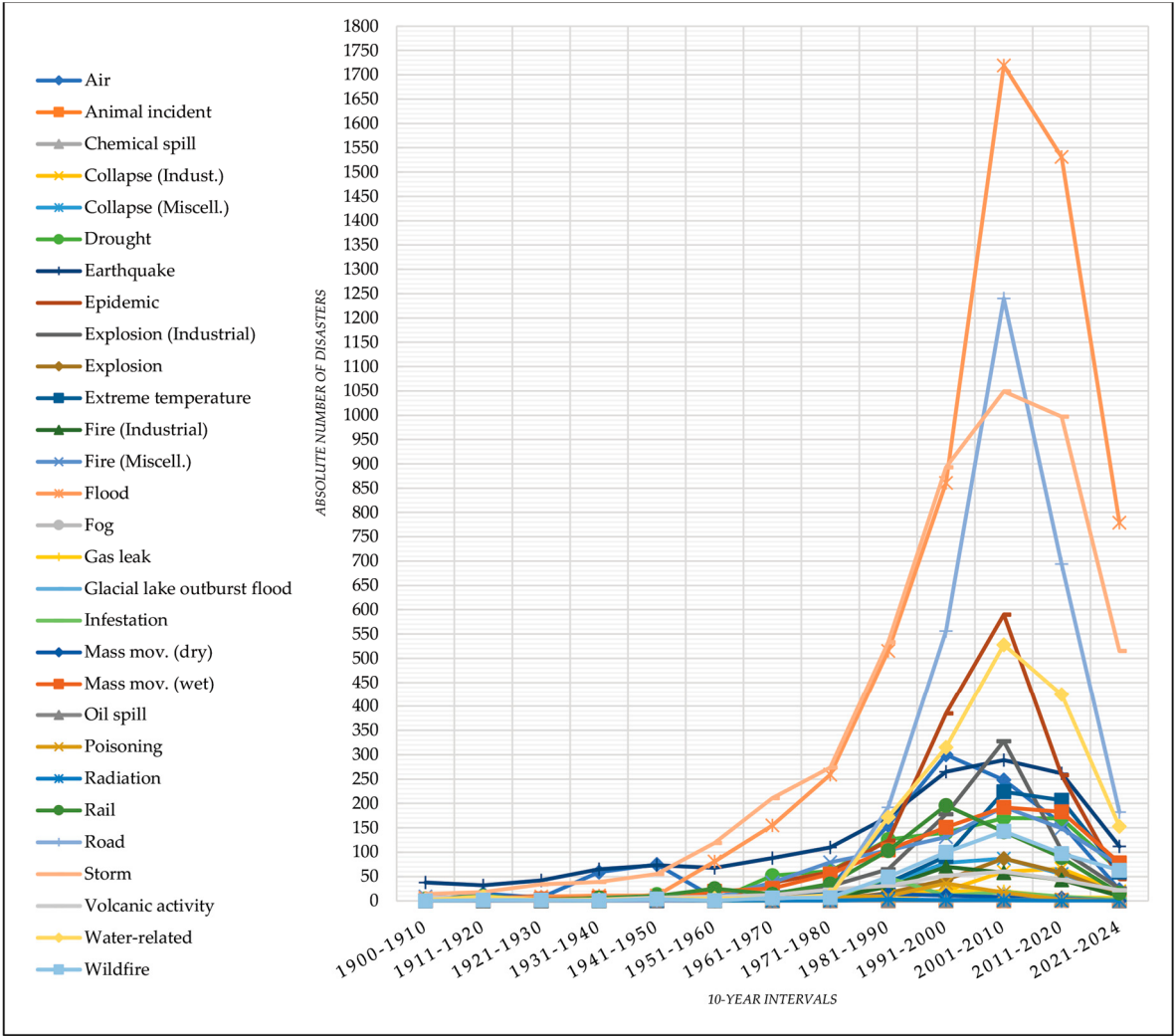


Figure 6. Total number of different natural and man-made (technological) disasters worldwide by decade (1900-2024).

Industrial explosions peaked in the 2000-2004 period with 175 events, while miscellaneous explosions rose in the 2000-2004 period with 55 events. Extreme temperatures saw a significant rise in the 2000-2004 period with 109 events, highlighting the effects of climate change. Industrial fires peaked in the 1995-1999 period with 37 events, while miscellaneous fires increased consistently, peaking in the 2000-2004 period with 107 events.

Floods experienced a dramatic increase, peaking in the 2000-2004 period with 769 events, indicating higher rainfall variability and extreme weather events. Fog, gas leaks, and oil spills were rarely recorded, with notable increases in specific periods, such as gas leaks peaking in the 1995-1999 period with 10 events. Glacial lake outburst floods were rarely recorded, with a few incidents noted in the 2020-2024 period, indicating climate change impacts.

Infestations peaked in the 1985-1989 period with 48 events, showing occasional spikes due to ecological changes. Wet mass movements showed a steady increase, peaking in the 1995-1999 period with 93 events, reflecting increased rainfall and landslide activity. Poisonings and radiation incidents were rarely recorded, with occasional spikes such as poisoning incidents peaking in the 1990-1994 period with 22 events (Table 7 and Figure 7).

Table 7. Total number of different natural and man-made (technological) disasters by 5 years period (1900-2024).

Disaster Type	1900-1904	1905-1909	1910-1914	1915-1919	1920-1924	1925-1929	1930-1934	1935-1939	1940-1944	1945-1949	1950-1954	1955-1959	1960-1964	1965-1969	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	2020-2024
Air	0	0	1	14	3	4	10	49	69	6	3	3	8	8	17	12	27	128	148	152	131	117	90	68	23
Animal incident	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Chemical spill	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	16	20	13	11	23	8	8	6	1	0
Collapse (Ind.)	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	2	5	7	9	12	20	40	32	34	20
Collapse (Misc.)	0	1	1	2	1	1	0	0	0	0	1	3	4	3	3	13	10	26	33	45	50	37	32	23	16
Drought	3	1	9	1	3	1	2	0	11	2	0	0	10	42	18	43	80	46	64	76	96	74	84	85	62
Earthquake	14	24	20	12	20	22	35	30	38	35	41	27	25	63	39	71	86	87	140	125	174	115	136	126	112
Epidemic	2	3	1	5	9	1	1	1	1	2	2	0	6	31	9	50	39	85	103	282	360	230	139	119	45
Explosion (Ind.)	1	4	5	2	6	3	5	5	2	6	6	5	3	3	10	20	26	39	84	94	175	153	59	45	26
Explosion (Mis.)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	9	7	16	27	55	32	38	20	14
Extreme temper.	0	0	0	0	0	0	0	2	0	0	5	3	4	5	6	9	11	26	40	51	109	115	125	82	59
Fire (Ind.)	1	0	0	0	0	0	0	0	0	1	0	1	1	0	2	4	9	20	33	37	32	26	21	22	10
Fire (Misc.)	3	6	1	2	3	1	2	3	5	3	1	6	9	29	31	48	44	60	54	77	107	86	67	82	74
Flood	3	3	2	2	1	8	3	8	3	8	42	39	53	102	98	161	222	293	365	496	769	950	761	770	779
Fog	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas leak	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	3	2	0	10	10	12	8	2	6	6
Glacial lake (flood)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Infestation	0	0	1	0	0	0	1	0	1	0	0	0	0	0	1	3	0	48	5	6	16	2	1	8	2
Mass mov. (dry)	1	2	0	0	0	0	0	1	0	0	0	1	2	0	0	0	5	9	11	0	3	5	2	3	0
Mass mov. (wet)	0	1	1	1	2	2	4	2	1	3	11	9	9	17	32	23	46	59	58	93	108	84	88	95	78
Oil spill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	2	1	2	0
Poisoning	0	0	0	0	0	0	0	0	0	0	1	1	0	1	3	4	4	6	22	14	13	4	2	1	0
Radiation	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	3	1	1	0	2	0	0	0
Rail	1	1	1	5	0	2	1	5	4	6	16	9	6	8	13	22	25	78	93	103	85	57	45	44	16
Road	0	0	0	0	0	0	0	0	0	0	3	0	0	4	1	10	12	180	221	335	725	515	393	301	182
Storm	5	9	10	8	11	23	20	19	18	37	48	71	90	121	122	152	242	291	464	429	540	509	473	524	515
Volcanic activity	7	1	2	1	0	1	2	1	2	5	7	2	5	7	4	19	20	11	29	23	25	35	22	21	22
Water-related	1	1	5	4	1	1	2	1	1	3	3	2	2	3	7	5	28	144	168	147	254	274	218	207	153
Wildfire	0	0	1	1	1	1	0	1	2	2	0	1	0	6	3	4	23	26	35	65	88	55	35	62	63
Total	86	114	122	120	122	142	176	256	318	238	384	372	474	908	848	1394	1990	3386	4434	5448	7910	7070	5746	5502	4562

Road disasters showed a significant rise, peaking in the 2000-2004 period with 725 events, reflecting increased vehicular traffic. Rail disasters showed a steady number with a peak in the 1990-1994 period at 93 events. Storms consistently increased, peaking in the 2000-2004 period with 540 events, reflecting more frequent and intense storm activity due to climate change. Volcanic activity had a relatively stable number of events with slight increases, peaking in the 2005-2009 period with 35 events.

Water-related disasters saw a significant increase, peaking in the 2000-2004 period with 254 events, highlighting water-related issues such as flooding and water scarcity. Wildfires showed a gradual increase with a peak in the 2000-2004 period at 88 events, reflecting increased temperatures and dry conditions (Table 7 and Figure 7).

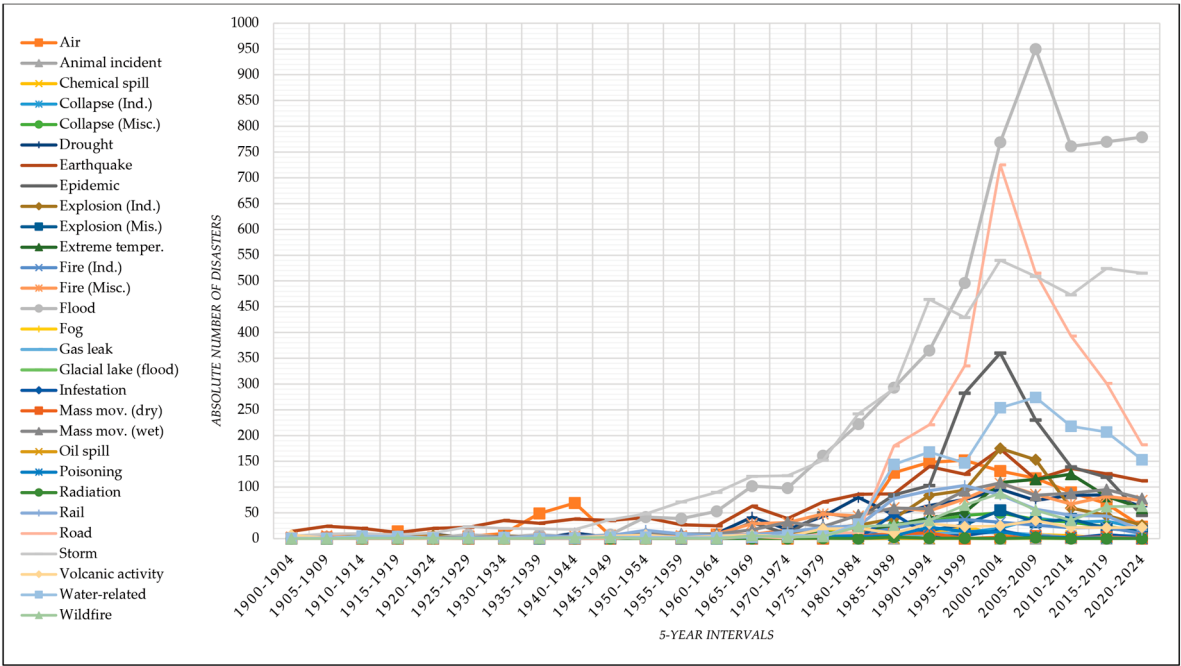


Figure 7. Total number of diffrent natural and man-made (technological) disasters by 5 years period (1900-2024).

Table 8 offers a detailed seasonality analysis, showcasing the number of occurrences of various disaster types by month. This analysis highlights the monthly distribution and trends of different disasters, providing insights into how these events fluctuate throughout the year (Table 8 and Figure 8). Air disasters reach their peak in July with 744 events, suggesting increased air traffic or weather-related factors during this month. Overall, the trend is above average, with a total of 1,091 events, accounting for 4.123% of all recorded disasters. Conversely, animal incidents are rarely recorded, with only one incident noted in November, resulting in a below average trend. Chemical spills also peak in July with 86 events, possibly due to seasonal industrial activities or increased transportation, but the overall trend remains below average with 108 events, making up 0.408% of all recorded disasters. Industrial collapses peak in November with 21 events, while miscellaneous collapses hit their highest point in July with 181 events, both showing a below average trend.

Earthquakes peak in March with 316 events, likely due to seasonal tectonic activity, with an above average (AA) trend totaling 1,617 events, which represent 6.11% of all disasters. Droughts are most frequent in February, peaking at 326 events and reflecting seasonal climatic patterns, yet their overall trend is below average (BA) with a total of 813 events, or 3.072% of all recorded disasters. Epidemics also show a significant peak in July with 701 events, pointing to seasonal health challenges. This results in an above average trend with 1,526 events, making up 5.766% of all recorded disasters (Table 8 and Figure 8).

Table 8. Seasonality analysis showing the number of occurrences of each disaster type by month.

Disaster Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (n)	Trend
Air	36	20	40	66	26	16	744	39	31	30	24	19	1091	4.123 AA
Animal incident	0	0	0	0	0	0	0	0	0	0	1	0	1	0.004 BA
Chemical spill	0	2	1	7	0	0	86	3	3	2	2	2	108	0.408 BA
Collapse (Industrial)	7	7	13	18	17	6	62	9	6	9	21	9	184	0.695 BA
Collapse (Miscellaneous)	15	12	14	14	7	11	181	15	2	13	13	8	305	1.153 BA
Drought	44	326	77	34	30	18	46	64	40	43	61	30	813	3.072 BA

Earthquake	197	92	316	190	48	37	201	185	91	32	83	145	1617	6.11	AA
Epidemic	63	75	75	42	49	220	701	57	38	83	79	44	1526	5.766	AA
Explosion (Industrial)	24	23	32	70	39	30	411	34	26	25	46	27	787	2.974	BA
Explosion (Miscellaneous)	12	8	13	13	10	9	99	20	16	7	7	8	222	0.839	BA
Extreme temperature	98	81	35	34	10	10	280	49	11	5	6	33	652	2.464	BA
Fire (Industrial)	7	6	11	16	6	7	121	8	11	9	8	10	220	0.831	BA
Fire (Miscellaneous)	38	35	44	60	19	20	440	35	24	26	30	33	804	3.038	BA
Flood	592	304	390	306	290	192	2072	400	403	374	356	262	5941	22.449	AA
Fog	0	0	0	0	0	0	1	0	0	0	0	0	1	0.004	BA
Gas leak	0	2	2	10	2	8	28	6	1	2	1	0	62	0.234	BA
Glacial lake outburst flood	0	1	0	1	0	0	1	0	0	1	0	0	4	0.015	BA
Impact	0	0	1	0	0	0	0	0	0	0	0	0	1	0.004	BA
Industrial accident (General)	8	6	4	15	8	6	40	11	6	4	11	7	126	0.476	BA
Infestation	0	8	0	2	0	0	71	8	3	1	0	2	95	0.359	BA
Mass movement (dry)	2	1	0	0	1	0	37	1	0	1	2	0	45	0.17	BA
Mass movement (wet)	51	61	43	44	34	19	427	41	23	29	24	31	827	3.125	A
Miscellaneous accident	16	21	23	33	5	15	85	15	14	14	20	15	276	1.043	BA
Oil spill	1	0	0	1	0	1	2	0	1	0	2	0	8	0.03	BA
Poisoning	0	5	8	1	0	0	56	0	1	3	1	1	76	0.287	BA
Radiation	0	0	0	1	0	0	6	2	0	0	0	0	9	0.034	BA
Rail	13	13	28	44	13	11	453	24	7	17	19	4	646	2.441	BA
Road	166	95	140	128	109	135	1326	189	153	158	166	117	2882	10.89	AA
Storm	345	184	344	259	349	95	2146	217	191	218	211	192	4751	17.953	AA
Volcanic activity	17	2	5	11	7	67	120	4	9	3	10	19	274	1.035	BA
Water-related	94	72	106	152	62	62	718	75	71	84	89	50	1635	6.178	AA
Wildfire	26	15	28	21	15	12	239	55	20	20	11	13	475	1.795	BA

Note: AA – above average; A – average; BA – below average.

Industrial explosions are most frequent in July, peaking at 411 events, while miscellaneous explosions also see increased activity during the summer months, both maintaining a below average trend. Extreme temperatures peak in July with 280 events, highlighting the impact of summer heatwaves. Despite this, the overall trend is below average, with 652 events constituting 2.464% of all disasters. Fires, both industrial and miscellaneous, also peak in July, with 121 and 440 events respectively, yet both trends are below average. Floods show a dramatic increase in July with 2,072 events, coinciding with monsoon and heavy rainfall periods. This results in an above average trend, totaling 5,941 events, or 22.449% of all recorded disasters (Table 8 and Figure 8).

Fog, gas leaks, and oil spills are infrequent, with specific peaks in certain months but generally below average trends. Glacial lake outburst floods are rarely recorded, with isolated incidents in January, April, and October. Infestations peak in July with 71 events, indicating seasonal ecological changes, yet the overall trend remains below average. Wet mass movements are most common in July, peaking at 427 events, which reflects seasonal rainfall and landslide activities, whereas dry mass movements are rarely recorded, showing no clear seasonal trend. Poisonings and radiation incidents are also rare, with peaks in specific months but generally below average trends.

Road disasters peak in July with 1,326 events, reflecting increased summer travel, while rail disasters also reach their highest point in July with 453 events. The trend for road disasters is above average, whereas rail disasters trend below average.

Storms peak in July with 2,146 events, indicating seasonal storm activity, resulting in an above-average trend with a total of 4,751 events, or 17.953% of all recorded disasters. Volcanic activity peaks in July with 120 events, showing a slight seasonal trend but remaining below average.

Water-related disasters peaked in July with 718 events, highlighting issues like floods and water scarcity. This results in an above-average trend, totalling 1,635 events, which represent 6.178% of all recorded disasters.

Wildfires also peak in July with 239 events, reflecting dry and hot summer conditions. However, the overall trend is below average, with a total of 475 events, making up 1.795% of all recorded disasters.

The seasonality analysis reveals how climate and weather patterns significantly influence disaster occurrences, with many events peaking during the summer months due to extreme weather conditions. Disasters such as air incidents, earthquakes, epidemics, road accidents, storms, and water-related disasters tend to be more frequent during certain times of the year, showing above-average trends.

For instance, many disaster types, including floods, storms, and fires, reach their highest numbers in July. This pattern reflects the impact of summer weather conditions like monsoon rains, heat waves, and dry spells. The peaks in industrial and miscellaneous disasters during the summer months suggest that increased industrial activities, travel, and other human activities contribute to higher disaster frequencies during this period.

According to the monthly analysis, the highest number of disasters is recorded in July with 9,135 incidents. This month is particularly prone to disasters due to significant spikes in air disasters (744), floods (2,072), storms (2,146), and road disasters (1,326). The heightened summer activities and extreme weather conditions contribute to the high frequency of disasters during this period. Increased travel, intense heat, and seasonal storms make July especially disaster-prone (Table 8 and Figure 8).

Following July, March records a total of 1,921 disasters. This month is notable for the high number of earthquake occurrences (316) and floods (390). Seasonal weather changes, including the transition from winter to spring, likely contribute to these numbers. Shifting temperatures can lead to increased seismic activity and the onset of spring floods.

January ranks next with 1,819 disasters. This month is characterized by a high number of flood occurrences (592), alongside significant events like earthquakes (197) and extreme temperatures (98). Winter conditions and the start of the year contribute to these disaster occurrences, with heavy rainfall and cold temperatures playing a major role.

In August, 1,702 disasters were recorded, with notable numbers of floods (400), storms (217), and wildfires (239). The continuation of summer conditions, including heatwaves and droughts, contributes to this high disaster rate. Hot and dry conditions often lead to wildfires, while summer storms can cause severe flooding.

February sees 1,158 disasters, with significant occurrences of floods (304), earthquakes (92), and extreme temperatures (81). The winter season and its associated weather patterns, including heavy rains and cold snaps, are likely causes of these disasters. The month is also characterized by winter storms and potential flooding from snowmelt.

In June, there are 1,048 disasters, with high numbers of floods (192), storms (95), and road disasters (135). The beginning of summer brings increased human activities and changing weather conditions, contributing to the disaster frequency. The month also marks the onset of hurricane season in some regions, leading to an increase in storm-related events.

October records 1,029 disasters, with notable flood events (374) and storms (218). The transitional weather of autumn, including increased rainfall and the tail end of hurricane season, contributes to the high number of disasters. Cooler temperatures and changing atmospheric conditions also play a role (Table 8 and Figure 8).

September has 878 disasters, marked by significant flood events (403) and storm occurrences (191). This reflects the continued impact of summer weather and the height of hurricane season. The end of summer often brings severe storms and heavy rains, leading to widespread flooding. In April, there are 876 disasters, with high earthquake occurrences (190) and significant flood numbers (306). The seasonal transition from winter to spring brings increased rainfall and seismic activity. Melting

snow and spring rains can lead to flooding, while the earth's tectonic movements are influenced by temperature changes.

November sees 858 disasters, with considerable numbers of floods (356) and road disasters (166). The late autumn weather, including heavy rains and early winter storms, contributes to the disaster frequency. The month also marks the beginning of winter travel, increasing the risk of road accidents. December records 742 disasters, with notable flood occurrences (262) and significant earthquake numbers (145). Winter conditions, including heavy rainfall and seismic activity, contribute to these disasters. The holiday season also sees increased travel and associated risks.

The seasonality analysis reveals that July is the most disaster-prone month, driven by summer-related weather conditions and increased human activities. March and January also show high disaster occurrences, reflecting the impact of seasonal transitions. Floods and storms are the most common disasters across all months, with significant peaks during the summer and transitional seasons. By understanding these seasonal disaster patterns, we can improve preparedness and mitigation strategies. Focusing efforts during peak months can help reduce the impact of these events and enhance response capabilities. This knowledge about the timing and frequency of various disasters can guide resource allocation, emergency planning, and public awareness campaigns, ensuring that communities are better equipped to handle the increased risk during critical periods of the year (Table 8 and Figure 8).

3.2.2. Yearly and Monthly Trends in Consequences of Natural and Man-Made Disasters

Providing a comprehensive analysis, Table 9 examines the impacts of natural and man-made (technological) disasters across decades, detailing fatalities, injuries, and economic losses. This examination underscores the evolving human and economic effects of these disasters, highlighting significant trends over time.

In the early 20th century, particularly from 1900 to 1910, natural disasters caused a staggering number of fatalities, totalling 4,472,477, while injuries and economic losses were minimal. Man-made disasters during this period resulted in 5,766 fatalities but had negligible economic impact.

Moving into the 1910-1920 decade, fatalities from natural disasters slightly decreased to 3,334,004, with injuries and economic losses remaining relatively low. However, man-made (technological) disasters began to show a more significant impact, with 10,752 fatalities and 9,306 injuries (Table 9 and Figure 9).

The period from 1920 to 1930 saw a dramatic increase in fatalities from natural disasters, reaching 8,561,918, alongside a rise in injuries and economic losses. Man-made disasters, although still less impactful than natural ones, contributed to 7,139 fatalities and 1,596 injuries. The following decade, 1930-1940, saw a reduction in natural disaster fatalities to 4,629,968 but an increase in economic losses to \$3,342,000. Man-made disasters continued to cause fatalities, albeit at a lower rate.

During the mid-20th century, from 1940 to 1950, natural disasters resulted in 3,878,897 fatalities and 69,329 injuries, with economic losses continuing to rise. Man-made disasters showed a notable increase in fatalities and injuries, reflecting the growing industrialization and technological advancements of the time. The 1950-1960 decade witnessed a further increase in economic losses from natural disasters to \$6,090,480, although fatalities decreased to 2,127,944. Man-made disasters remained a significant cause of fatalities and injuries (Table 9 and Figure 9).

Table 9. Number of consequences of Natural and Man-made (Technological) Disasters by Decade (1900-2024).

Decade	Natural disasters			Man-made (tech.) disasters			Total		
	Fatalities	Injuries	Economic	Fatalities	Injuries	Economic	Fatalities	Injuries	Economic
1900-	4,472,477	2,549	1,373,800	5,766	2	0	4,478,243	2,551	1,373,800
1911-	3,334,004	2,955	600,000	10,752	9,306	2,500	3,344,756	12,261	602,500
1921-	8,561,918	109,109	1,004,230	7,139	1,596	100,000	8,569,057	110,705	1,104,230
1931-	4,629,968	112,403	3,342,000	5,579	511	0	4,635,547	112,914	3,342,000

1941-	3,878,897	69,329	3,136,700	11,165	2,258	6,000	3,890,062	71,587	3,142,700
1951-	2,127,944	24,642	6,090,480	10,979	6,241	218,000	2,138,923	30,883	6,308,480
1961-	1,751,347	784,522	18,633,100	6,446	5,155	159,972	1,757,793	789,677	18,793,072
1971-	998,508	552,541	53,753,225	17,244	22,809	76,193	1,015,752	575,350	53,829,418
1981-	796,062	317,353	183,523,629	58,382	159,620	6,469,293	854,444	476,973	189,992,922
1991-	527,413	1,588,807	701,281,224	86,149	80,174	4,410,769	613,562	1,668,981	705,691,993
2001-	839,418	3,282,010	892,099,162	97,166	89,617	14,746,682	936,584	3,371,627	906,845,844
2011-	503,400	3,241,477	1,706,627,174	62,715	59,375	20,969,701	566,115	3,300,852	1,727,596,875
2021-	199,314	627,655	861,127,190	15,132	24,593	16,750,000	214,446	652,248	877,877,190

Notes: fatalities: the total number of deaths; injuries: the total number of injured individuals; economic losses: represented in thousands of US dollars.

The late 20th century, particularly from 1960 to 1990, experienced significant increases in economic losses due to natural disasters. The 1960-1970 period saw \$18,793,072 in economic losses, which further escalated to \$183,523,629 in the 1980-1990 period. This era also marked substantial fatalities and injuries from both natural and man-made (technological) disasters. For instance, the 1980-1990 decade recorded 58,382 fatalities and 159,620 injuries from man-made (technological) disasters, indicating the increasing severity of industrial accidents (Table 9 and Figure 9).

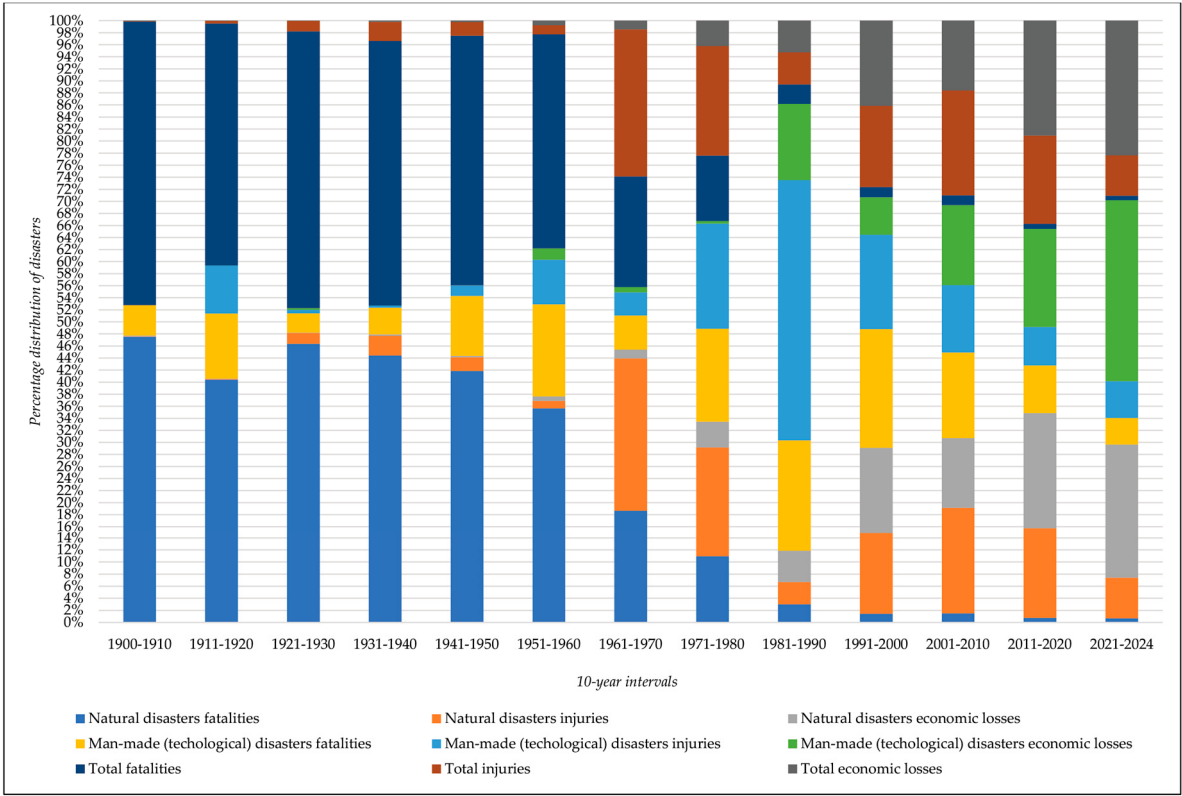


Figure 9. Consequences of Natural and Man-made (Technological) Disasters by decades (1900-2024).

Entering the early 21st century, the period from 2000 to 2020 witnessed the highest economic losses due to natural disasters, peaking at \$1,706,627,174 in the 2010-2020 decade. This period also saw high numbers of fatalities and injuries, reflecting the intensified impact of disasters. Man-made disasters continued to significantly contribute to fatalities and injuries, with 97,166 fatalities and 89,617 injuries recorded in the 2000-2010 period. Recent trends from 2020 to 2030 show a significant reduction in fatalities from natural disasters compared to earlier periods, dropping to 199,314. However, economic losses remain substantial, amounting to \$861,127,190. Man-made disasters continue to contribute significantly to fatalities and injuries, with 15,132 fatalities and 24,593 injuries

recorded in this period, highlighting the persistent risk from technological and industrial activities (Table 9 and Figure 9).

Table 10 provides an in-depth look at the impacts of natural and man-made (technological) disasters over 5-year periods, detailing fatalities, injuries, and economic losses. In the early 20th century, particularly from 1900 to 1905, natural disasters resulted in significant fatalities, totaling 1,523,244, with minimal injuries and economic losses. This trend persisted into subsequent periods, with notable spikes in fatalities during 1905-1910 (2,949,233) and 1915-1920 (3,022,829). Despite these high death tolls, economic losses remained relatively low during these years.

As we move into the mid-20th century, there were fluctuations in fatalities and economic losses. The 1920-1925 period recorded the highest fatalities of this era, with 5,065,612 lives lost due to natural disasters. Economic losses began to rise significantly during 1930-1935, reaching \$1,629,000. During this time, man-made (technological) disasters also began to show a more substantial impact, particularly in the 1945-1950 period, which saw 5,957 fatalities. The late 20th century experienced a dramatic increase in economic losses from natural disasters, peaking at \$264,087,752 in the 1990-1995 period. This era also saw substantial fatalities and injuries from both natural and man-made (technological) disasters. The increasing industrialization and urbanization during these years contributed to the heightened impact of such events (Table 10 and Figure 10).

Table 10. Consequences of natural and man-made (technological) disasters by 5-year periods (1900-2024).

5-year period	Natural disasters			Man-made (tech.) disasters			Total		
	Fatalities	Injuries	Economic Losses	Fatalities	Injuries	Economic Losses	Fatalities	Injuries	Economic Losses
1900-1905	1523244	251	535000	2230	2	0	1525474	253	535000
1906-1910	2949233	2298	838800	3536	0	0	2952769	2298	838800
1911-1915	311175	2828	275000	5232	20	0	316407	2848	275000
1916-1920	3022829	127	325000	5520	9286	2500	3028349	9413	327500
1921-1925	5065612	103900	663000	6412	1500	100000	5072024	105400	763000
1926-1930	3496306	5209	341230	727	96	0	3497033	5305	341230
1931-1935	3772100	9045	1629000	3021	324	0	3775121	9369	1629000
1936-1940	857868	103358	1713000	2558	187	0	860426	103545	1713000
1941-1945	3569724	48909	1325500	5208	1181	0	3574932	50090	1325500
1946-1950	309173	20420	1811200	5957	1077	6000	315130	21497	1817200
1951-1955	86802	11243	3775180	5377	1949	178000	92179	13192	3953180
1956-1960	2041142	13399	2315300	5602	4292	40000	2046744	17691	2355300
1961-1965	124667	16119	8163881	3394	2818	49759	128061	18937	8213640
1966-1970	1626680	768403	10469219	3052	2337	110213	1629732	770740	10579432
1971-1975	623353	218953	15582333	6779	12990	3843	630132	231943	15586176
1976-1980	375155	333588	38170892	10465	9819	72350	385620	343407	38243242
1981-1985	633887	155979	84139472	17264	140392	761976	651151	296371	84901448
1986-1990	162175	161374	99384157	41118	19228	5707317	203293	180602	105091474
1991-1995	299078	818151	264087752	44158	32120	1363916	343236	850271	265451668
1996-2000	228335	770656	437193472	41991	48054	3046853	270326	818710	440240325
2001-2005	435658	2437898	331597225	54143	54209	11607124	489801	2492107	343204349
2006-2010	403760	844112	560501937	43023	35408	3139558	446783	879520	563641495
2011-2015	418756	1087793	871742990	32710	31140	20964701	451466	1118933	892707691
2016-2020	84644	2153684	834884184	30005	28235	5000	114649	2181919	834889184

2021-2024	199314	627655	861127190	15132	24593	16750000	214446	652248	877877190
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Notes: fatalities: the total number of deaths; injuries: the total number of injured individuals; economic losses: represented in thousands of US dollars.

Entering the early 21st century, we observed the highest economic losses due to natural disasters, with the 2011-2015 period reaching \$871,742,990. This time frame also saw a significant number of fatalities and injuries, reflecting the intensified impact of disasters. Technological advancements and population growth likely contributed to these escalating figures. Recent trends from 2021 to 2024 show a notable reduction in fatalities from natural disasters compared to earlier periods, although economic losses remain high at \$861,127,190. Man-made disasters continue to have a significant impact, with 15,132 fatalities and 24,593 injuries recorded in this period. These insights emphasize the persistent financial and human toll of disasters, underscoring the importance of improving disaster risk reduction strategies to mitigate these impacts (Table 10 and Figure 10).

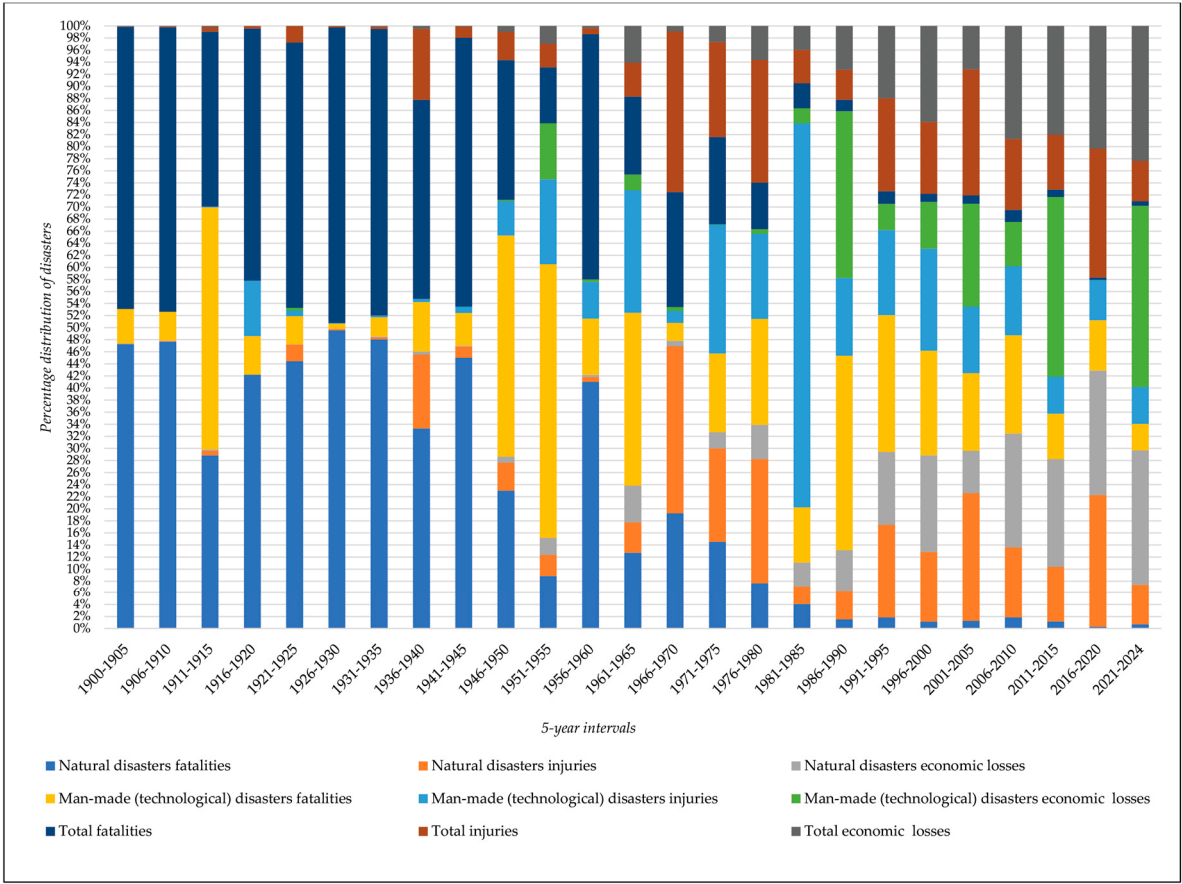


Figure 10. Consequences of natural and man-made (technological) disasters by 5-years (1900-2024).

Table 11 offers a detailed summary of the consequences of different types of natural and man-made (technological) disasters from 1900 to 2024. Regarding that, air disasters resulted in 50,689 deaths (0.154%), 7,620 injuries (0.068%), and \$144.1 million in economic losses (0.003%). While these disasters had a significant human impact, the economic consequences were relatively minimal. Chemical spills, though responsible for fewer deaths (610 or 0.002%), led to substantial injuries (8,773 or 0.078%) and affected over 652,981 people (0.008%), causing significant economic losses amounting to nearly \$1.2 billion (0.027%). Industrial and miscellaneous collapses had notable impacts as well, with industrial collapses resulting in 7,099 deaths (0.022%) and \$1.335 billion in economic losses (0.03%), and miscellaneous collapses causing 14,830 deaths (0.045%) and \$283.8 million in economic losses (0.006%).

Droughts emerged as the deadliest disaster type, accounting for 11,734,272 deaths (35.54%) and affecting nearly 3 billion individuals (34.146%), with economic losses totalling \$257.58 billion (5.728%). Earthquakes also had a substantial impact, causing 2,407,717 deaths (7.293%) and \$975.79 billion in economic losses (21.701%), along with 2,945,052 injuries (26.35%) and 228 million people affected (2.628%). Epidemics were significant as well, resulting in 9,622,343 deaths (29.14%) and 2,836,719 injuries (25.38%), though they had minimal economic impact.

Extreme temperatures led to 256,413 deaths (0.777%), 2,066,936 injuries (18.49%), and \$69.47 billion in economic losses (1.545%). Fires, both industrial and miscellaneous, had considerable impacts, with miscellaneous fires causing 36,590 deaths (0.111%) and \$3.49 billion in economic losses (0.078%), while industrial fires led to \$2.61 billion in economic losses (0.058%). Floods were highly impactful, causing 7,011,404 deaths (21.23%), 1,398,042 injuries (12.50%), and affecting nearly 4 billion people (46.039%), with economic losses totalling \$1.01 trillion (22.415%).

Mass movements, both dry and wet, varied in impact. Wet mass movements caused 68,636 deaths (0.208%) and \$11.35 billion in economic losses (0.252%), while dry mass movements had a smaller impact. Miscellaneous accidents had notable consequences, causing 14,279 deaths (0.043%) and 40,666 injuries (0.364%). Oil spills had minimal impact, whereas poisoning incidents led to 3,578 deaths (0.011%) and 54,442 injuries (0.487%). Although radiation incidents were rare, they caused significant economic losses (\$2.8 billion or 0.062%).

Storms were another major disaster type, causing 1,418,647 deaths (4.297%), 1,411,425 injuries (12.62%), and \$1.97 trillion in economic losses (43.748%), reflecting their widespread and severe impact. Volcanic activity led to 86,935 deaths (0.263%) and \$6.33 billion in economic losses (0.141%), affecting over 10 million individuals (0.116%). Water-related disasters caused 111,237 deaths (0.337%) and \$77.9 million in economic losses (0.002%), while wildfires resulted in 5,366 deaths (0.016%), 15,989 injuries (0.143%), and significant economic losses totaling \$136.37 billion (3.033%) (Table 11 and Figure 11).

Table 11. Summary of disaster consequences by type, including total counts and percentage contributions (1900-2024).

Disaster Type	Deaths		Injured		Affected		Damage ('000 US\$)	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Air	50,689	0.154	7,620	0.068	8,846	0.0	144,100	0.003
Animal incident	12	0.0	0	0.0	5	0.0	0	0.0
Chemical spill	610	0.002	8,773	0.078	652,981	0.008	1,198,954	0.027
Collapse (Industrial)	7,099	0.022	2,450	0.022	3,353	0.0	1,335,000	0.03
Collapse (Miscellaneous)	14,830	0.045	13,024	0.117	309,514	0.004	283,800	0.006
Drought	11,734,272	35.54	32	0.0	2,964,996,768	34.146	257,581,674	5.728
Earthquake	2,407,717	7.293	2,945,052	26.35	228,214,673	2.628	975,785,916	21.701
Epidemic	9,622,343	29.14	2,836,719	25.38	50,095,829	0.577	7	0.0
Explosion (Industrial)	36,814	0.112	41,850	0.374	864,341	0.01	40,421,674	0.899
Explosion (Miscellaneous)	7,624	0.023	19,231	0.172	137,527	0.002	619,100	0.014
Extreme temperature	256,413	0.777	2,066,936	18.49	107,678,810	1.24	69,468,343	1.545
Fire (Industrial)	5,522	0.017	5,211	0.047	465,362	0.005	2,608,005	0.058
Fire (Miscellaneous)	36,590	0.111	24,022	0.215	1,368,383	0.016	3,485,470	0.078
Flood	7,011,404	21.23	1,398,042	12.50	3,997,629,671	46.039	1,007,889,805	22.415
Fog	4,000	0.012	0	0.0	0	0.0	0	0.0
Gas leak	2,906	0.009	116,280	1.04	513,932	0.006	30,000	0.001
Glacial lake outburst flood	439	0.001	24	0.0	88,424	0.001	210,000	0.005
Impact	0	0.0	1,491	0.013	301,491	0.003	33,000	0.001
Industrial accident (General)	5,207	0.016	1,552	0.014	135,987	0.002	9,960,407	0.222
Infestation	0	0.0	0	0.0	2,802,200	0.032	229,200	0.005
Mass movement (dry)	4,486	0.014	373	0.003	23,117	0.0	209,000	0.005
Mass movement (wet)	68,636	0.208	12,705	0.114	16,823,502	0.194	11,347,044	0.252

Miscellaneous accident (General)	14,279	0.043	40,666	0.364	1,880,052	0.022	4,000	0.0
Oil spill	1	0.0	120	0.001	29,137	0.0	30,000	0.001
Poisoning	3,578	0.011	54,442	0.487	648,522	0.007	0	0.0
Radiation	86	0.0	1,958	0.018	1,064,201	0.012	2,800,000	0.062
Rail	28,730	0.087	61,744	0.552	109,453	0.001	903,000	0.02
Road	68,812	0.208	49,184	0.44	56,306	0.001	7,700	0.0
Storm	1,418,647	4.297	1,411,425	12.62	1,277,565,968	14.713	1,967,141,984	43.748
Volcanic activity	86,935	0.263	26,564	0.238	10,032,658	0.116	6,327,912	0.141
Water-related	111,237	0.337	13,130	0.117	149,256	0.002	77,900	0.002
Wildfire	5,366	0.016	15,989	0.143	18,531,582	0.213	136,368,030	3.033
Total	33,015,284	100.0	11,176,609	100.0	8,683,181,851	100.0	4,496,501,025	100.0

When ranking the impact of disasters by fatalities, droughts emerge as the deadliest, causing the highest number of deaths at 11,734,272, which accounts for 35.54% of all disaster-related fatalities. Following closely are epidemics, responsible for 9,622,343 deaths or 29.14%. Floods come in third, resulting in 7,011,404 deaths (21.23%), while earthquakes are fourth, causing 2,407,717 deaths (7.293%). Rounding out the top five, storms contribute to 1,418,647 deaths, making up 4.297% of the total (Table 11 and Figure 11).

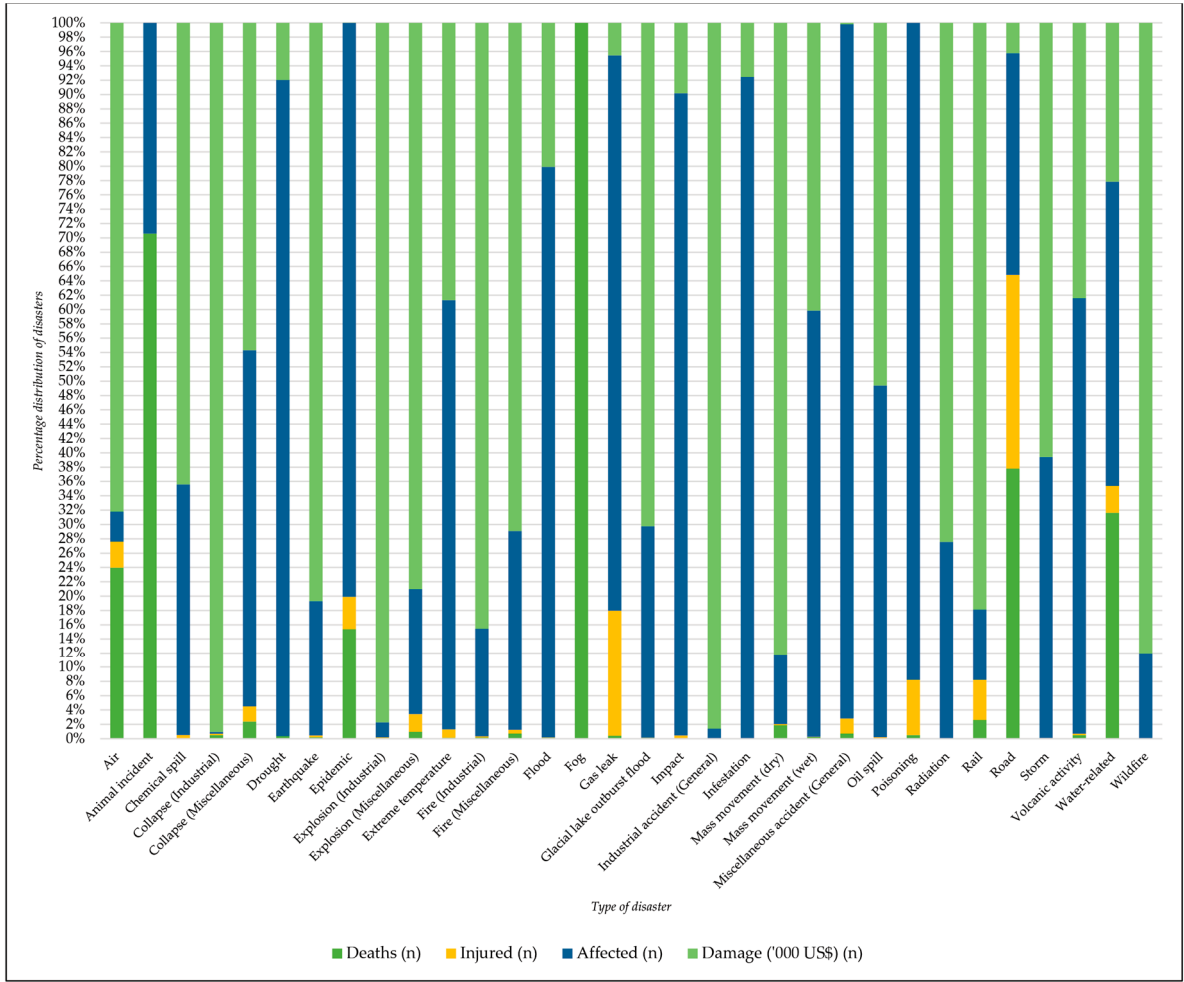


Figure 11. Percentage distribution of natural and man-made (technological) disaster consequences by type (1900-2024).

In terms of injuries, earthquakes lead with the highest number, causing 2,945,052 injuries, representing 26.35% of all disaster-related injuries. Epidemics follow closely with 2,836,719 injuries

(25.38%). Extreme temperatures rank third, causing 2,066,936 injuries (18.49%). Floods result in 1,398,042 injuries (12.50%), and storms cause 1,411,425 injuries, making up 12.62% of the total.

Looking at the number of people affected by disasters, floods have the most significant impact, affecting nearly 4 billion individuals (3,997,629,671), which is 46.039% of the total affected population. Droughts come in second, impacting almost 3 billion people (2,964,996,768), or 34.146%. Storms affect over 1.27 billion people (1,277,565,968; 14.713%), making them the third most impactful. Earthquakes are fourth, affecting over 228 million individuals (228,214,673; 2.628%), while extreme temperatures affect over 107 million people (107,678,810; 1.24%).

Regarding economic losses, storms cause the most significant financial damage, with total losses amounting to approximately \$1.97 trillion (43.748%). Floods rank second, causing over \$1 trillion in economic losses (1,007,889,805,000; 22.415%). Earthquakes follow, with losses of approximately \$975.79 billion (21.701%). Droughts come in fourth, with financial damages totalling around \$257.58 billion (5.728%), and wildfires are fifth, causing economic losses of about \$136.37 billion (3.033%). Table 11 and Figure 11).

This analysis underscores the profound impact of various disaster types, with droughts and floods being the most devastating in terms of human lives, while storms and earthquakes cause the highest economic losses.

4. Discussion

The analysis of the distribution of natural and man-made (technological) disasters across continents from 1900 to 2024 reveals notable trends and patterns. Asia has experienced the highest number of disasters, accounting for 41.75% of all recorded events. This is due to the continent's vast and diverse geography, high population density, and rapid industrialization. These factors contribute to both the frequency and impact of disasters in the region. For example, Asia's high rate of earthquakes and floods necessitates robust mitigation strategies focusing on seismic resilience and flood management [83]. Additionally, the significant proportion of man-made (technological) disasters (38.11%) highlights the need for improved industrial safety and infrastructure development in rapidly urbanizing areas [84].

Africa, with 21.44% of the total disasters, has the highest proportion of man-made (technological) disasters (43.79%). This high percentage is linked to socio-economic factors such as inadequate infrastructure, governance challenges, and political instability, which exacerbate the risks and impacts of technological accidents and conflicts [85]. Natural disasters in Africa, such as droughts, also reflect the continent's vulnerability to climate change, underscoring the necessity for integrated approaches addressing both natural and man-made (technological) hazards [86]. Furthermore, North America, which accounts for 13.84% of the total events, shows a predominance of natural disasters (75.75%), particularly storms and wildfires. This pattern is consistent with the region's exposure to climatic extremes and varied topography, making it susceptible to a range of natural hazards [87]. The data suggests that strengthening early warning systems and enhancing community resilience to natural disasters should be priorities for North American disaster management strategies [88].

Oceania, despite having the fewest total disasters (2.83%), has the highest proportion of natural disasters (91.51%). This reflects the region's unique geographical features, including numerous islands and coastal areas, which are highly vulnerable to natural events such as cyclones and tsunamis [89]. The low incidence of man-made (technological) disasters (8.49%) suggests that existing technological and industrial activities are relatively well-managed, though continued vigilance and regulation are necessary [90]. Europe's balanced distribution of natural (64.54%) and man-made (35.46%) disasters reflects its diverse risk profile, influenced by both environmental factors and high levels of industrialization. The region's experience with extreme temperatures and floods highlights the importance of adapting to climate change impacts while maintaining stringent safety standards for technological and industrial operations [91]. South America's disaster profile, with 66.56% natural disasters and 33.44% man-made (technological) disasters, highlights the continent's exposure to natural hazards such as floods and storms, alongside challenges related to industrial safety and urban

infrastructure. The findings suggest a dual focus on environmental sustainability and industrial risk management to mitigate disaster impacts in the region [92].

The temporal analysis reveals an increasing trend in disaster occurrences until the 2000s, followed by a decline in the recent decade. This pattern may be attributed to advancements in disaster risk management practices, improved early warning systems, and greater global awareness of disaster risks [93]. However, the continuing high frequency of certain disaster types, such as floods and technological accidents, indicates the need for sustained efforts in these areas [94].

The examination of disaster distribution—both natural and man-made (technological)—across countries from 1900 to 2024 offers critical insights into the varying disaster profiles and vulnerabilities faced by different nations. This understanding is essential for developing disaster risk reduction strategies tailored to the specific needs and challenges of each country [95]. Countries such as China and India are at the top of the list for disaster-prone nations, a reflection of their vast geographic areas, large populations, and rapid industrial growth [96]. The significant occurrence of both natural and man-made (technological) disasters in these countries highlights the critical need to integrate disaster risk reduction into national development plans [97]. Additionally, this issue extends beyond national borders, presenting a global international challenge and responsibility [98]. Disasters do not stop at national borders, making this a substantial political, economic, and diplomatic challenge [99].

Natural disasters are particularly prevalent in countries like the USA, the Philippines, and Japan due to their geographical and climatic conditions [100]. The USA's high frequency of natural disasters, dominated by events such as storms and wildfires, reflects the country's exposure to extreme weather patterns and varied topography [101]. Similarly, the Philippines and Japan, located in seismically active regions and frequently hit by typhoons, face significant natural disaster risks [102]. These findings emphasize the need for robust early warning systems, resilient infrastructure, and effective emergency response mechanisms [103].

Countries with a high proportion of man-made (technological) disasters, such as Nigeria and Egypt, often face these events due to factors like industrialization, inadequate regulatory frameworks, and socio-economic challenges [104]. The high incidence of industrial accidents and chemical spills in these regions highlights the urgent need to improve industrial safety standards and enhance regulatory oversight [104], as well as to assess safety culture - the way we actually do things - e.g. by using maturity models [105]. Additionally, the socio-economic context, including political instability and lack of infrastructure, exacerbates the risk and impact of technological disasters [106].

The varied disaster profiles across different countries indicate the necessity for region-specific disaster management strategies [107]. For instance, countries with a high frequency of natural disasters should focus on enhancing climate resilience and investing in disaster-resilient infrastructure. In contrast, nations with a significant number of technological disasters should prioritize industrial safety measures, regulatory reforms, and capacity building in emergency response [108].

The temporal analysis shows an increasing trend in disaster occurrences until the early 2000s, followed by a decline, suggesting improvements in global disaster management practices [109]. However, the continuing high frequency of certain disaster types, such as floods and industrial accidents, indicates that ongoing efforts are necessary to address these persistent risks [110].

The temporal analysis of natural and man-made (technological) disasters over 10-year intervals from 1900 to 2024 reveals significant trends and shifts in the frequency and distribution of disasters, providing valuable insights into how these patterns have evolved over time. During the early 20th century (1900-1940), disaster events were relatively few, with a stable yet gradually increasing trend. From 1900 to 1910, the rate of disaster occurrences remained stable, predominantly driven by natural disasters. However, the period from 1910 to 1920 saw a noticeable increase in total disaster events, marking the onset of an upward trend. This trend persisted through the 1920s and 1930s, with both natural and man-made (technological) disasters contributing to the rise. Technological advancements and increased industrial activities during these decades likely played a role in the rise of man-made (technological) disasters [111].

Rapid urbanization and population growth, especially in the latter half of the 20th century, have increased the exposure and vulnerability of populations to disasters [112]. Urban areas, with dense populations and critical infrastructure, often face higher risks, leading to the observed peaks in disaster events during these periods [113]. The improvement in early warning systems and communication technologies has likely contributed to the decrease in disaster events post-2005, enabling better preparedness, timely evacuations, and effective disaster response, thus reducing the overall impact and frequency of disasters [114]. The changing communication strategies for warnings (e.g. impact warning) also attempt to achieve more adequate prevention measures by their target group [115]. In the meantime, great efforts are being made to make warnings comprehensible and to formulate vulnerabilities and recommendations for action [116–119].

The mid-20th century (1940-1970) experienced a significant surge in disaster events. The decade from 1940 to 1950 witnessed a substantial rise in both natural and man-made (technological) disasters. This increase is attributed to the rapid industrialization and urbanization that characterized the post-World War II era. The growth of industrial activities and technological development led to higher incidences of industrial accidents and other man-made (technological) disasters [120,121]. However, they also lead to new risks and the need to redefine socially accepted risk [122]. Additionally, the rise in natural disasters could be linked to environmental changes and improved reporting and documentation of such events [123]. The influence of climate change is evident in the increasing frequency and severity of natural disasters such as floods, storms, and extreme temperatures in the late 20th and early 21st centuries [123]. Climate change adaptation and mitigation strategies are crucial to addressing these challenges and reducing future disaster risks [124]. Additionally, different regions experience varying types of disasters, influenced by geographical, climatic, and socio-economic factors [125]. This highlights the importance of localized DRR strategies tailored to specific regional needs and vulnerabilities, rather than a one-size-fits-all approach [126,127].

The late 20th century (1970-2000) marked the highest increases in disaster events, particularly in the 1980s and 1990s. This period saw a peak in both natural and man-made (technological) disasters, indicating heightened vulnerability and exposure to various hazards. The 1980s, in particular, witnessed a dramatic rise in disaster occurrences, reflecting the impact of global environmental changes, increased population density, and further industrialization. The 1990s continued this trend, with significant contributions from both natural events like floods and technological incidents such as industrial explosions. The early 21st century (2000-2020) continued the trend of increasing disaster events, although the rate of increase began to slow down by the 2010s. This period saw a higher proportion of man-made (technological) disasters, reflecting ongoing industrial growth and technological advancements [127].

However, the most recent decade (2020-2030) shows a decreasing trend in the number of disaster events, with a significant reduction in both natural and man-made (technological) disasters. This decline may be attributed to improved disaster management practices, advancements in early warning systems, and increased global awareness of disaster risks. The trend of decreasing disaster events in recent years underscores the importance of building community resilience and capacity [128]. Community-based DRR initiatives, education, and training programs have empowered local populations to better prepare for and respond to disasters [129]. Enhanced data collection, reporting mechanisms, and increased transparency in documenting disaster events have contributed to a more accurate and comprehensive understanding of disaster trends [130]. This improved data availability facilitates better analysis, planning, and decision-making [131].

The analysis of the consequences of natural and man-made (technological) disasters over 5-year intervals from 1900 to 2024 provides significant insights into how the impacts of these events on human lives and economies have evolved. Throughout the 20th century and into the 21st century, natural disasters have consistently caused substantial fatalities [132], with significant fluctuations in the number of deaths over different periods. Economic losses due to natural disasters have also increased markedly over the decades, reflecting the growing complexity and interconnectedness of

modern societies [133]. The increased urbanization and industrialization in the mid-20th century contributed to higher economic losses as infrastructure and economic activities expanded [134].

Man-made disasters, while initially causing fewer fatalities and economic losses, began to have a more pronounced impact as industrialization and technological advancements progressed [135]. The mid-20th century marked a period where the consequences of industrial accidents and technological failures became more evident, contributing to a notable increase in fatalities and injuries [136]. This trend continued into the late 20th century, with significant economic impacts arising from these disasters. The late 20th and early 21st centuries saw dramatic increases in economic losses from both natural and man-made (technological) disasters. This period reflects the dual influence of technological advancements and environmental changes [137]. On one hand, industrial growth and technological development introduced new risks and vulnerabilities, leading to severe industrial accidents and technological failures [138]. On the other hand, climate change and environmental degradation have exacerbated the frequency and intensity of natural disasters, resulting in higher economic losses and a greater number of affected individuals [139].

In recent years, there has been a noticeable reduction in fatalities from natural disasters, which can be attributed to improved disaster management practices [132], early warning systems [140], and global initiatives aimed at reducing disaster risk [141]. Despite this progress, economic losses remain substantial, underscoring the ongoing vulnerability of modern societies to both natural and man-made (technological) disasters [142]. Several key factors have influenced these temporal trends: the growth of industries and urban areas has increased the potential for industrial accidents and technological failures, contributing to the rising impact of man-made (technological) disasters [143]; the increasing frequency and severity of climate-related disasters, such as floods, droughts, and extreme temperatures, reflect the broader impacts of climate change [144]; while technological growth has brought numerous benefits, it has also introduced new risks, leading to significant industrial accidents and chemical spills [145].

The increase in recorded disaster impacts from the 1960s onwards can be partly attributed to better reporting mechanisms and increased global awareness of disaster risks [146–148]. The decline in fatalities from natural disasters in recent years highlights the effectiveness of global policies and disaster risk reduction frameworks, which have enhanced preparedness and resilience [149,150].

This study acknowledges several limitations that may impact the generalizability and accuracy of its findings: a) while the EM-DAT database is extensive, it may contain inconsistencies or gaps, particularly for earlier periods or less documented regions, which could affect the accuracy of historical trends; b) certain regions, especially those with less robust disaster reporting systems, may have underreported disaster occurrences and impacts, potentially introducing biases in the analysis; c) the broad time span of the analysis, from 1900 to 2024, encompasses changes in data collection methods, reporting standards, and technological advancements, which may result in inconsistencies within the dataset; d) categorizing disasters as either natural or man-made might oversimplify the complex interactions and overlapping nature of some events, such as those exacerbated by human activities like climate change (e.g. the influence of natural hazards/disasters on the occurrence of technological disasters; e) estimating economic losses from disasters involves considerable uncertainties due to varying methodologies, inflation adjustments, and the inherent difficulties in capturing indirect and long-term economic effects; f) measuring the human impact, in terms of fatalities and injuries, is challenging due to differences in reporting standards, cultural perceptions, and the availability of reliable health and demographic data.

5. Recommendations

To effectively tackle the various challenges and impacts identified in this study, the following Table 12 presents a comprehensive set of recommendations aimed at enhancing disaster risk reduction (DRR) strategies. These measures are categorized by their implementation level—national or local—and their short-term and long-term applicability. This structured approach ensures that both immediate and sustainable actions are taken to mitigate the risks and impacts of natural and man-made (technological) disasters.

Table 12 provides a detailed overview of the recommended measures, stressing the importance of integrating these strategies into national development plans, enhancing early warning systems, promoting climate resilience, and strengthening industrial safety. Furthermore, it underscores the significance of community-based disaster management, investment in research and development, and fostering public-private partnerships to build a more resilient society.

Table 12. Comprehensive recommendations for disaster risk reduction measures and implementation strategies.

Recommendation	Description	Short-term	Long-term	National	Local
Integration of disaster risk reduction	Integrate strategies for disaster risk reduction into the overall national development agenda	✓	↑	↑	↓
Enhancement of early warning systems	Enhance early warning systems through investments in advanced technology, infrastructure improvements, and comprehensive training programs	✓	✓	↑	↑
Promotion of climate resilience	Focus on climate resilience by adopting sustainable practices and implementing green infrastructure projects		✓	↑	↓
Strengthening industrial safety	Upgrade safety protocols and strengthen regulatory frameworks governing industrial operations	✓	✓	↑	↓
Community-based disaster risk management	Empower communities by providing education, training, and opportunities for active involvement in disaster management	✓	✓	↓	↑
Investing in research and development	Promote research and development to discover innovative solutions for reducing disaster risks on the basis of a better understanding of the interconnections of risks		✓	↑	↓
Regional cooperation and information sharing	Foster international cooperation and improve data sharing mechanisms for more effective disaster preparedness and response	✓	✓	↑	↓
Adapting infrastructure and urban planning	Construct resilient infrastructure and apply sustainable urban planning methods to reduce disaster impacts		✓	↑	↓
Public awareness and education campaigns	Raise public awareness and improve education about disaster risks and preparedness measures	✓	✓	↑	↑
Regular assessment and update of plans	Periodically review and revise disaster management plans based on updated data and emerging threats	✓	✓	↑	↑
Improvement of seismic resilience	Emphasize the construction and retrofitting of buildings to be earthquake-resistant, particularly in vulnerable areas		✓	↑	↓
Flood management and mitigation	Implement effective flood control systems, including dams, levees, and enhanced drainage networks	✓	✓	↑	↓
Sustainable agriculture practices	Encourage agricultural practices and other methods that reduce vulnerability to droughts and climate-related disasters		✓	↑	↓
Enhancing health systems	Enhance health infrastructure to provide better responses to epidemics and other public health crises	✓	✓	↑	↓

Technological upgrades for disaster monitoring	Invest in cutting-edge technologies for real-time disaster monitoring and early detection capabilities	✓	✓	↑	↑
Capacity building for emergency responders	Continuously train and equip emergency responders to increase their efficiency and effectiveness during crises	✓	✓	↑	↑
Improve urban infrastructure	Design urban infrastructure to be resilient against both natural and man-made (technological) disasters		✓	↑	↓
Implement comprehensive risk assessments	Conduct comprehensive risk assessments to identify vulnerabilities and prioritize mitigation strategies	✓	✓	↑	↓
Develop cross-sectoral and cross-national DRR strategies	Coordinate disaster risk reduction activities across various sectors, such as healthcare, agriculture, and transportation	✓	✓	↑	↓
Strengthen legal and institutional frameworks	Strengthen legal and institutional frameworks to support robust disaster risk management practices	✓	✓	↑	↓
Foster public-private partnerships	Promote public-private partnerships to leverage resources and expertise in disaster risk reduction initiatives	✓	✓	↑	↑
Grouping disaster mitigation measures	Tailor disaster mitigation measures to specific types of disasters, including floods, earthquakes, and industrial accidents	✓	✓	↑	↓
Enhance community resilience programs	Develop educational and training programs to enhance community resilience and disaster preparedness	✓	✓	↑	↑
Improve data collection and analysis	Improve data collection and analysis to gain a deeper understanding of disaster trends and inform policy decisions. Improvement of standardized data collection and analysis	✓	✓	↑	↓
Increase funding for drr initiatives	Secure consistent funding for disaster risk reduction programs to ensure their long-term success and sustainability	✓	✓	↑	↑

Note: An upward arrow (↑) indicates a focus on national-level implementation; a downward arrow (↓) indicates a focus on local-level implementation; a checkmark (✓) indicates immediate action or short-term implementation.

6. Conclusions

The analysis of geospatial and temporal patterns of natural and man-made (technological) disasters from 1900 to 2024 provides significant insights into these events' global distribution and impact. The research reveals that Asia is the most affected continent, with the highest number of disasters, indicating the need for robust risk mitigation strategies, particularly concerning seismic resilience and flood management. Africa faces a high percentage of man-made (technological) disasters, emphasizing the need for improved industrial safety and infrastructure, while natural disasters such as droughts are exacerbated by climate change. North America predominantly records natural disasters, particularly storms and wildfires, highlighting the importance of strengthening early warning systems and community resilience. Oceania, despite having the fewest total disasters, reports a high proportion of natural disasters due to its unique geographical characteristics. Europe shows a balanced distribution of natural and man-made (technological) disasters, underscoring the importance of adapting to climate change and maintaining high industrial safety standards. South America faces significant natural disasters such as floods and storms, alongside challenges related to industrial safety.

Temporal analysis indicates an increasing trend in disaster occurrences until the 2000s, followed by a decline in the last decade, possibly due to advancements in disaster risk management practices,

improved early warning systems, and greater global awareness of disaster risks. Despite progress, the high frequency of certain disaster types, such as floods and technological accidents, indicates the need for continuous efforts in these areas. A detailed analysis of the consequences of natural and man-made (technological) disasters over five-year intervals provides significant insights into the evolution of these events' impacts on human lives and economies. Natural disasters have consistently caused substantial fatalities and economic losses, while man-made (technological) disasters, initially less significant, have become more pronounced with industrialisation and technological development. Recent trends show a reduction in fatalities from natural disasters, attributed to improved disaster management practices, early warning systems, and global initiatives aimed at reducing disaster risk.

Regarding the testing of hypotheses, the first hypothesis was confirmed, as natural disasters accounted for 69.41% of the total number of disasters, causing greater economic losses and human casualties compared to technical disasters. The second hypothesis was supported by significant geographical differences in the frequency and type of disasters, with Asia being the most affected continent, and Africa having the highest percentage of technical disasters. The third hypothesis was validated through the identification of significant temporal changes in disaster frequency, peaking in the periods 1990-2000 and 2000-2010, while the last decade saw a decline in the total number of events. The fourth hypothesis was proven by seasonal variations, with floods peaking in January and July, and storms being most frequent in June and October. Finally, the fifth hypothesis was confirmed as different types of disasters had varying impacts on economic losses and human resources, with earthquakes and storms causing the greatest economic losses, while droughts and floods were the most deadly for human lives. These findings underscore the need for tailored disaster risk management strategies in different regions.

This study contributes to the understanding of the global distribution and impact of natural and man-made (technological) disasters through a historical context. It provides a foundation for further research in disaster risk reduction (DRR), particularly in the context of climate change and urbanization. Identifying specific geographical and socio-economic factors contributing to the frequency and severity of disasters can help develop theoretical models and predictive tools for risk management. The study's results can serve as a reference point for future quantitative and qualitative analyses exploring the effectiveness of various DRR strategies and policies.

The findings have direct implications for policymakers and practitioners in disaster risk management. It is recommended that countries with high natural disaster risks, such as China, India, and the USA, focus efforts on strengthening infrastructure resilience, improving early warning systems, and enhancing emergency response plans. For regions with high man-made disaster risks, such as Nigeria and Egypt, improving industrial safety, regulatory frameworks, and emergency response capacities is crucial. The study highlights the need for integrated approaches that combine natural and technological risk management. It is recommended to develop comprehensive strategies encompassing prevention, preparedness, response, and recovery, focusing on reducing vulnerabilities and enhancing community resilience to disasters. Additionally, implementing educational programs and raising public awareness about disaster risks can significantly contribute to reducing the negative impacts of these events.

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