WMO ATLAS OF MORTALITY AND ECONOMIC LOSSES FROM WEATHER, CLIMATE AND WATER EXTREMES (1970–2019)

WEATHER CLIMATE WATER

WORLD
METEOROLOGICAL
ORGANIZATION

WMO-No. 1267

Cover: A lone mother with a baby on her back walks along a flooded street after Tropical Cyclone *Idai* (2019) devastated the port city of Beira, Mozambique on 14 March 2019.

Cover photo by Josh Estey/CARE International

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TABLE OF CONTENTS

FOREWORD

Between 1970 and 2019, there were more than 11 000 disasters attributed to weather, climate and water-related hazards, which accounted for just over 2 million deaths and US$ 3.64 trillion in losses, according to new data presented in this *WMO Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes*.

Economic losses are mounting as exposure increases. But, behind the stark statistics, lies a message of hope. This second edition of the *WMO Atlas* shows that implementation of multi-hazard early warning systems (MHEWSs) has led to a significant reduction in mortality. Quite simply, we are better than ever before at saving lives.

WMO is playing a pioneering role in promoting impact-based forecasts that inform the public of what the weather will do as well as what it will be and in fostering greater coordination between national meteorological services and their counterparts in disaster management agencies. This is leading to better prevention, preparedness and response.

But much more remains to be done. There are severe gaps in weather observations, especially in Africa and island states, which undermine the accuracy of early warnings locally and globally. Additionally, only half of 193 WMO Members have multi-hazard early warning systems. The Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework) recognizes the significant benefits of MHEWSs by incorporating them into one of its seven global targets: "Substantially increase the availability and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030".

Much has evolved since the production of the first edition in 2014 of the *WMO Atlas of Mortality and Economic Losses from Weather, Climate, and Water Extremes*, which provided an analysis of the Centre for Research on the Epidemiology of Disasters' (CRED) Emergency Events Database (EM-DAT). For this second edition, WMO set the bar even higher, disaggregating the data further down to the hazard level for more granularity. It was paramount that WMO, a scientific organization, present statistics on the exposure and impacts that can and should be used as a basis for capacity development, policy development and decision-making to protect lives and livelihoods.

This report reveals a few key lessons learned during the past 50 years. These include:

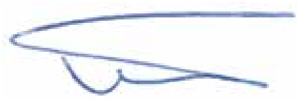
- *Review hazard exposure and vulnerability considering* a changing climate to reflect that tropical cyclones may have different tracks, intensity and speed than in the past.
- *Strengthen disaster risk financing mechanisms at national to international levels, especially for* Least Developed Countries and Small Island Developing States and Territories.
- *Develop integrated and proactive policies on slow-onset disasters such as drought.*

The WMO Cataloguing of Hazardous Weather, Climate, Water, and Space Weather Events is also introduced. When fully implemented, this will strengthen the statistical basis for national development, planning and prevention and provide a solid foundation for understanding hazard exposure and impacts from national to global levels.

The number of weather, climate and water extremes are increasing and will become more frequent and severe in many parts of the world as a result of climate change. The WMO community is therefore striving to increase capacities to identify and reduce the risks associated with such extremes and to strengthen the early warning systems for these hazardous events.

I want to thank our partners, the United Nations Office for Disaster Risk Reduction and the World Health Organization, as well as the authors and contributors. I would also like to thank CRED for working with us during the analysis phase.

The *WMO Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes* provides invaluable insight and important information on weather, climate and water-related hazards and their impacts as we all strive to achieve the targets of the Sendai Framework.



Prof. Petteri Taalas
Secretary-General

BACKGROUND AND METHODOLOGY

Background

The impacts of weather-, climate- and water-related hazards continue to adversely affect health and economic and social development worldwide. Some of these impacts have cascaded up from local to national and even international levels due to the growing interdependence of our societies and countries.

The analysis provided in this Atlas is based on Centre for Research on the Epidemiology of Disasters' (CRED) Emergency Events Database (EM-DAT). EM-DAT contains data on disasters associated with several types of natural hazards – geophysical, meteorological, climatological, hydrological, biological and extra-terrestrial – and technological disasters dating back to the year 1900. For more information on CRED see Annexes I and II.

According to CRED EM-DAT,[1] from 1970 to 2019 there were 22 326 disasters that met their criteria for recording. These reported 4 607 671 deaths and US$ 4.92 trillion in economic losses (Figure 1).

An analysis of the EM-DAT records indicates that 62% of all recorded disasters, 80% of all deaths and almost all (99%) economic losses were associated with natural hazards.

Of the 22 326 disasters, 11 072 have been attributed to weather, climate and water hazards. These disasters resulted in 2.06 million deaths and US$ 3.64 trillion in losses. Thus, over the last 50 years, 50% of all recorded disasters, 45% of related deaths and 74% of related economic losses were due to weather, climate and water hazards. (Figure 4).

The United Nations 2030 Agenda for Sustainable Development and the Sendai Framework call for countries to increase their resilience through the strengthening of risk reduction processes.

This publication focuses on the impacts that weather-, climate- and water-related hazards have on society, highlighting areas of disparity where more work is needed to support implementation of the Sendai Framework. It also calls attention to the significant benefits that can be achieved in strengthening disaster accounting processes through more systematic attribution of losses to the underlying hazard.

It is hoped that this publication will underscore the importance of partnerships among different international organizations and stakeholders in loss and damage accounting to increase awareness and strengthening of standards in loss accounting and related disaster databases.

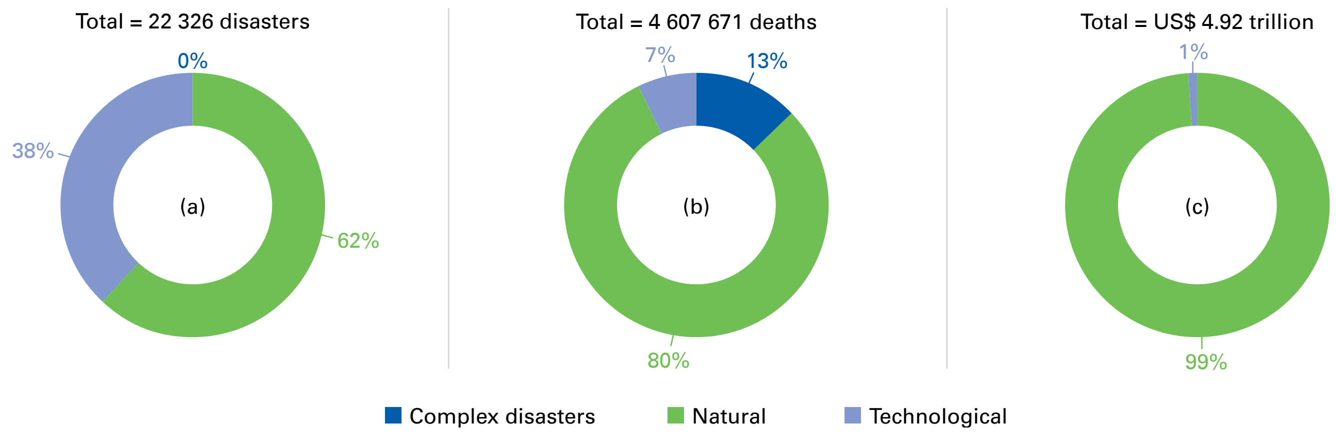


Figure 1. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses during 1970–2019 from all hazards recorded within EM-DAT. Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

1 US$ prices are adjusted to 2018: http://www.emdat.be/database.

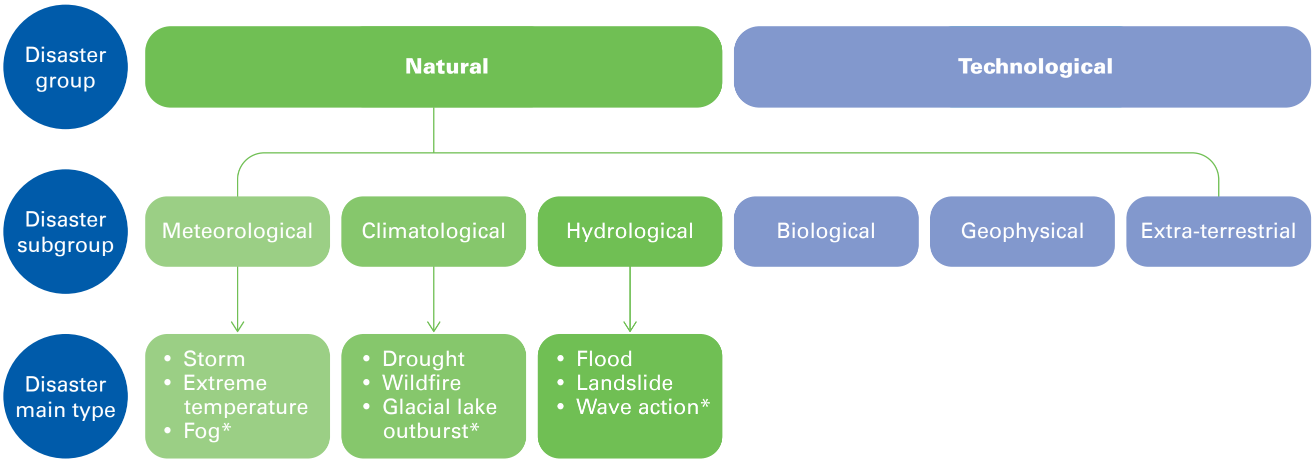


Figure 2. EM-DAT classification scheme;[2] * indicates that the disaster type has been suppressed from the analyses due to no data being available

Methodology

This Atlas provides statistical analyses of recorded disasters in EM-DAT spanning the 50-year period from 1970 to 2019 and describes the distribution and impacts of weather-, climate- and water-related disasters. To highlight impacts of specific weather, climate and water hazards, we have disaggregated the data where possible to the disaster subtype and sub-subtype (see Figure 2 and Annex II Table 10).

Quality control and verification were performed. The process consisted of: (a) comparison of the full dataset received from EM-DAT in late January 2020 to the dataset used to publish the 2014 Atlas to verify consistency and identify changes and updates; (b) dataset quality review to ensure that event records are verified and attributed to the correct associated hazards where possible; (c) preparation of data for analysis; (d) analysis and visualization of the data.

The analysis conducted follows the EM-DAT classification schema as shown in Figure 2 and Annex II Table 10. Additionally, at the time of publication of this Atlas, there were no disaster records in EM-DAT for the main disaster types fog, glacial lake outburst and wave action, thus these hazards have been suppressed in the analysis and related graphics.

Analysis was carried out at the global scale as well as for each of the six WMO regions (see Annex III Figure 42 and Table 17). The number of disasters, related deaths and economic losses recorded in the database were assessed for the 50-year period as well as by decade (1970–1979, 1980–1989, 1990–1999, 2000–2009 and 2010–2019) to highlight significant disasters and areas of disparity, as well as any discernible trends over time. Lists of the 10 worst recorded disasters in terms of human deaths and economic losses during these periods are provided globally and for each WMO region. EM-DAT provides a country-centric view of the impacts of hazards. This means that when a tropical cyclone impacts several countries, there are event records for each country. This is clearly seen in the tables in this Atlas containing top-10 rankings for deaths and economic losses where multiple disasters in different countries are attributed to a single tropical cyclone. In the section "Focus on tropical cyclones" a hazard-centric view is taken, and all event records related to the hazard are aggregated into one single hazard event.

To ensure that all weather-, water-, and climate-related disasters were included in this publication, the technological hazard group was also reviewed to identify where natural hazards were listed as a primary or main contributor. This review found 60 disasters in the technological group fitting this criteria:

- 51 transport accidents – total 67 deaths, no economic losses recorded;
- 6 miscellaneous accidents – total 145 deaths, no economic losses recorded;
- 3 industrial accidents – total 2 519 deaths, US$ 15 823 losses.

An example of these includes 46 transportation accidents (for example, a boat sinking, an aviation accident) associated with natural hazards such as

2 This publication reflects analysis on weather, climate and water extremes within the natural hazards group as shown in various shades of green. Boxes in light blue are not included with the exception of technological hazards that had specific attribution to weather, climate and water extremes in the event record.

"bad weather". These disaster records have been included in the natural group under the appropriate hazard type.

The EM-DAT data were also analysed utilizing two different economic classifications – the United Nations country classification[3] and the World Bank country classification by income group[4] – to document, where possible, any disproportionate impacts by various economic groupings (Annex IV).

In the section "Focus on tropical cyclones" a detailed analysis of the EM-DAT data was conducted to extract all tropical cyclone-related records. EM-DAT classifies storms into three types: tropical cyclones, extratropical storms and convective storms. To extract the data for this section the following steps were performed: (a) all records were extracted with a disaster subtype of tropical cyclone, which yielded a total of 1 945 disaster records; (b) EM-DAT was reviewed for any reference to a tropical cyclone within other database parameters such as date, location and associated disaster; (c) because disasters in EM-DAT are recorded at the national level and a specific tropical cyclone that impacts multiple countries would have multiple disaster records (one per country), in this analysis, for the section "Focus on tropical cyclones" we have aggregated all related disaster records to the specific tropical cyclone with which they are associated.

Atlas outline

This Atlas consists of the following parts:

- Background and methodology
- Disaster-event attribution to natural hazards and climate change
- Status of mortality and economic losses due to weather, climate and water hazards from 1970 to 2019. This includes outcomes from the EM-DAT record from 1970 to 2019 at the global and WMO regional levels and a special section "Focus tropical cyclones" that details impacts associated with these phenomena.
- Role and potential of disaster loss databases. This part includes contributions from two WMO partners: UNDRR on how disaster loss and damage data will be developed and utilized in monitoring the Sendai Framework; WHO on the health impacts of emergencies, quantifying mortality, challenges and opportunities for the improvement of monitoring disaster mortality in the health sector.

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3 United Nations, 2019: World Economic Situation and Prospects, https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/WESP2019_BOOK-ANNEX-en.pdf.
4 World Bank, https://datahelpdesk.worldbank.org/knowledgebase/topics/19280-country-classification.

ABOUT THE WORLD METEOROLOGICAL ORGANIZATION

The World Meteorological Organization (WMO) is a specialized agency of the United Nations with 193 Member States and Territories. It is the United Nations system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the land and oceans, the weather and climate it produces and the resulting distribution of water resources.

As weather, climate and the water cycle know no national boundaries, international cooperation at a global scale is essential for the development of meteorology and operational hydrology as well as to reap the benefits from their application. WMO provides the framework for such international cooperation.

WMO originated from the International Meteorological Organization, which was founded in 1873 to facilitate the exchange of weather information across national borders. Established in 1950, WMO became a specialized agency of the United Nations in 1951. Its mandate is in the areas of meteorology (weather and climate), operational hydrology and related geophysical sciences. Since its establishment, WMO has played a unique and powerful role in contributing to the safety and welfare of humanity. It has fostered collaboration between the National Meteorological and Hydrological Services (NMHSs) of its Members and furthered the application of meteorology in many areas.

The Organization continues to facilitate free and unrestricted exchange of data and information, products and services – in real or near-real time – on matters relating to safety and security of society, economic welfare and the protection of the environment. It contributes to policy formulation in these areas at national and international levels.

The Organization plays a leading role in international efforts to monitor and protect the environment. In collaboration with other United Nations agencies and NMHSs, WMO supports the implementation of several environmental conventions and is instrumental in providing advice and assessments to governments on related matters. These activities contribute towards ensuring the sustainable development and well-being of nations.

NMHSs work around the clock to provide vital weather-, climate- and water-related information worldwide. Their early and reliable warnings of severe weather and fluctuations in air quality, as well as of climate variability and change, allow decision makers, communities and individuals to be better prepared for weather-, climate- and water-related extreme events. Their warnings help save lives and property, protect resources and the environment and support socioeconomic growth. WMO supports NMHSs with this work and helps them meet their international commitments in the areas of disaster risk reduction, climate change mitigation and adaptation, and sustainable development.

In particular WMO facilitates and promotes:

- The establishment of networks of observational stations to provide weather-, climate- and water-related data;
- The establishment and maintenance of data management centres and telecommunication systems for the provision and rapid exchange of weather-, climate- and water-related data;
- The creation of standards for observation and monitoring in order to ensure adequate uniformity in the practices and procedures employed worldwide and, thereby, ascertain the homogeneity of data and statistics;
- The application of science and technology in operational meteorology and hydrology to transport (air, land and maritime), water resource management, agriculture, energy, health and other focus areas;
- Activities in operational hydrology as well as closer cooperation between NMHSs in States and Territories where these are separated;
- The coordination of research and training in meteorology and related fields.

Further information about WMO can be found at its website: https://public.wmo.int/en.

DISASTER-EVENT ATTRIBUTION TO NATURAL HAZARDS AND CLIMATE CHANGE

Attribution of disasters to natural hazards

Documenting the impacts of natural hazards on communities and societies, including people and livelihoods, requires data that detail the human and economic costs as well as the hazard event with which they are associated. A crucial aspect of this work is carried out at the national level and the quality of the information depends on how hazardous weather events and loss data are recorded and attributed to the underlying physical phenomena and registered in national loss and damage databases. These records are aggregated at the regional and global levels and support a wide array of research, development and disaster prevention initiatives and measures at all levels.

An essential part of these databases is the process by which data are collected and registered into the databases, a process called disaster loss accounting. Loss accounting processes should ensure that all relevant loss data are collected and attributed to the appropriate underlying phenomena at a sufficiently disaggregated level to be able to inform disaster prevention and mitigation measures.

Traditionally, the disaster loss recording process has involved compiling the loss and damage in terms of deaths and economic losses, and then attributing them to a hazard event based on various sources such as newspaper reports and other literature, as well as national scientific and technical agencies or services that have hazard-monitoring mandates, such as NMHSs. Critical challenges in this process include absence of a globally accepted methodology to uniquely identify an event in terms of its begin and end times and spatial extent, and also of a standardized global event terminology that allows for comparison at the national, regional and global scales. Another critical challenge is a lack of application of a standardized methodology (applicable to all scales, national, regional and global) for systematically recording loss and damage and related attribution to the causal factors. These causal factors include not only the hazard event and its characteristics but also the degree of societal exposure and vulnerability.

The Sendai Framework encourages countries "to systematically evaluate, record, share and publicly account for disaster losses and understand the economic, social, health, education, environmental and cultural heritage impacts, as appropriate, in the context of event-specific hazard-exposure and vulnerability information" (IV. Priorities for action, paragraph 24 (d)). It also in its Priority 4 calls for countries "to establish a mechanism of case registry and a database of mortality caused by disaster in order to improve the prevention of morbidity and mortality" (Priority 4, paragraph 33 (n)).

WMO support to the loss and damage accounting community

To meet the challenges described above, in 2019, the World Meteorological Congress approved the methodology called the WMO Cataloguing of Hazardous Weather, Climate, Water and Space Weather Events (WMO-CHE). It provides the basis for NMHSs to better serve stakeholders in loss and damage accounting by systematically recording, as part of the NMHS observing and monitoring function, the Earth's atmosphere, weather, climate, water and space weather events (Resolution 12 (Cg-18)). This methodology, when put into operation, will

Key definitions

Hazard: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.

Disaster: A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.

Source: UNDRR open-ended intergovernmental expert working group on indicators and terminology, https://www.undrr.org/terminology.

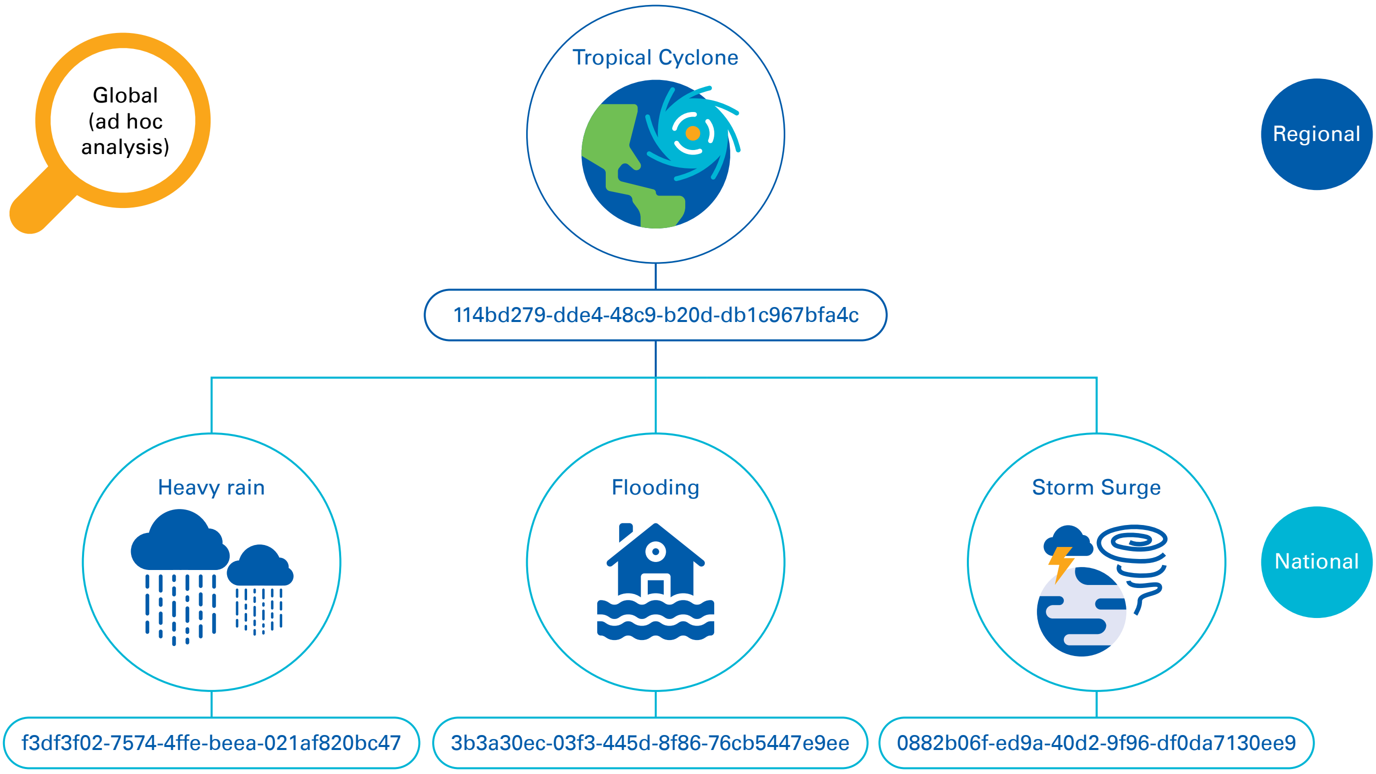

Figure 3. Example of cross-linkage of events through unique identifiers (blue lines indicate links)

address the challenges stated above by ensuring each event is recorded uniquely with a standardized event name, begin and end times, spatial area of impacts, and the capability to link events to larger-scale phenomena (for example, linking heavy rain, strong winds, storm surge flooding and landslides to a tropical cyclone) as well as the linking of cascading events. The linking feature makes this methodology scalable from local (micro events) to larger phenomena, including climate time scales (Figure 3), enabling loss and damage data to be disaggregated at the small or micro level hazard, such as a storm surge, or aggregated to the larger scale such as a tropical cyclone. The methodology encourages NMHSs to develop or maintain partnerships with the agencies and organizations that are mandated to record loss and damage information, such as disaster management agencies, to ensure that the data and information on the scientific phenomena are systematically linked with the related impact data.

It is important to ensure that event (underlying hazard) names are standardized globally to ensure comparison of events regionally and globally. In this regard, WMO has approved an initial list of events (natural hazards) to be included in the methodology and its implementation. The list consists of hazards under the WMO mandate for which names have been agreed upon by WMO Members; additional natural hazards will be added through an official WMO intergovernmental process.

In May 2019, UNDRR and the International Science Council (ISC) jointly established a technical working group to identify the full scope of hazards relevant to the Sendai Framework as a basis for countries to review and strengthen their risk reduction policies and operational risk management practices. This Atlas presents the first results of this international collaborative effort. The technical working group used an iterative process of developing and reviewing the hazards listed through extensive consultation with over 500 technical experts from relevant science groups, United Nations agencies, the private sector and other partners. The hazard list comprises 302 hazards grouped in 8 clusters: meteorological and hydrological, extra-terrestrial, geohazards, environmental, chemical, biological, technological, societal. Although this hazard list is considered to be the most useful at the present time, it is not a definitive list and will need regular review and updating. The list has been incorporated into the UNDRR/ISC *Hazard Definition and Classification Review Technical Report* to strengthen consistency in hazard terminology and to contribute to the implementation of the Sendai Framework.[5] It is intended that this review will be updated yearly to incorporate additional hazards and latest hazard research and information. Hazards coming under the WMO mandate will be updated through the WMO constituent bodies and included and updated in the Review.

5 The Review can be consulted at https://council.science/wp-content/uploads/2020/06/UNDRR_Hazard-Report_DIGITAL.pdf.

Box 1. WMO contribution to Sendai Framework Priorities

Priority 1: Understanding disaster risk

WMO addresses two of the four priorities of the Sendai Framework for Disaster Risk Reduction 2015–2030. In partnership with stakeholders in loss and damage accounting, such as the United Nations Office for Disaster Risk Reduction (UNDRR), the World Bank, the Centre for Research on the Epidemiology of Disasters Emergency Events Database (CRED EM-DAT), and stakeholders in the private sector, WMO is developing the WMO Cataloguing of Hazardous Weather, Climate, Water and Space Weather Events (WMO-CHE). The Catalogue will provide a record of hazardous weather, climate, water and space weather events at the national level that can be scaled up to the global level. WMO-CHE is being implemented by the National Meteorological and Hydrological Services (NMHSs) of the WMO's 193 Members, as well as by its regional centres, which systematically record hazardous events as a routine duty of their operational observation and monitoring capacities. The datasets generated from WMO-CHE include a unique identifier for each event that will facilitate more accurate loss and damage accounting at the local to national levels through a more consistent and standardized methodology for attribution of losses to associated hazards as required to address Priority 1 of the Sendai Framework.

Priority 4: Enhancing disaster preparedness for effective response and to "build back better" in recovery, rehabilitation and reconstruction

WMO has contributed to the implementation of early warning systems to protect people and livelihoods since its establishment It has now refocused its assistance to its Members to strengthen their Impact-based Multi-hazard Early Warning Systems (MHEWS) through a number of initiatives such as the Severe Weather Forecasting Programme, the Flash Flood Guidance System, the Coastal Inundation Forecasting Initiative, the Climate Services Information System, the Global Multi-hazard Alert System and the High-Impact Weather Project.

These systems seek to strengthen forecasting and warning for the impacts of weather-, climate- and water-related hazards and, in so doing, will significantly increase WMO Members' capacities to identify and reduce the risks associated with such hazards.

The goal of the WMO-CHE is to provide the national agencies responsible for loss and damage accounting with an authoritative, scientifically reviewed dataset of hazardous events to aid in loss and damage accounting and to enhance risk assessment. The initiative is being implemented through the established WMO global observing, monitoring and forecasting network at the national level as well as the regional and global levels.

Attribution of extreme events to climate change

An extreme event is herein defined as a natural occurrence over a certain time period and space with unusual characteristics in terms of magnitude, location, timing, and/or extent. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (for example, drought or heavy rainfall over a season). Natural climate variability (including phenomena such as El Niño) typically generates weather and climate extremes. Even if there were no anthropogenic changes in climate, a wide variety of natural weather and climate extremes would still occur. A changing climate leads to changes in the frequency, intensity, spatial extent, duration and timing of weather and climate extremes, however, and these can be unprecedented.

A common question when an extreme climate event occurs is "Was this event caused by climate change?". Scientists address this question in a different way: "Was the chance of this event happening affected by human influences on the climate, and if it was, by how much?" Answering this question has become a very active area of research in recent years. While various approaches have been used, the most common one involves running climate models with all known climate forcing, both anthropogenic and natural, and with natural forcing only. The use of two sets of model runs to compare the probability, or characteristics, of the event in question allows the degree to which the event probability or characteristics were influenced by anthropogenic factors to be established. The result is often expressed as the "fraction of attributable risk", which is the probability that the event was the result of anthropogenic influence on climate as opposed to natural variability. Many of these studies appear one to two years after the event, but there is also an increasing interest in attribution of events relatively soon after the event using already established methods.

While very few studies have yet found any human signal in small-scale severe weather events such as thunderstorms and tornadoes, there has been progress in attributing individual extreme events that occur over larger scales. According to recently published peer-reviewed studies in the annual supplement to the *Bulletin of the American Meteorological Society*, over the period 2015 to 2017, 62 of the 77 events reported show a significant anthropogenic influence on the event's occurrence, either directly or indirectly (through, for example, influencing atmospheric circulation patterns that contributed to the event).

Almost every study of significant heatwaves since 2015 has found that probability has been significantly increased by anthropogenic climate change. For example, Imada et al. (2019) found that the heatwave that affected Japan in July 2018 would have been impossible without human influence.

In general, the most clear-cut results are obtained for indicators that cover a large area over a substantial period of time (for example, a national mean monthly temperature), while there is more uncertainty for results at single locations over periods of a few days.

An increasing number of studies are also finding human influence on extreme rainfall events, sometimes in conjunction with other major climate influences such as the El Niño Southern Oscillation (ENSO). One example is the extreme rainfall in eastern China in June and July 2016, where studies by Sun and Miao (2018), and Yuan et al. (2018) found that human influence significantly increased the probability of the event, with the signal less clear in a third study (Zhou et al., 2018).

Unlike heatwaves, the attribution of drought events to anthropogenic factors has not yet lead to clear conclusions. This is due to the strong influence of interannual variability, caused by, for example, large oceanic and atmospheric oscillations such as ENSO, inter alia. Some heatwave events, however, show a direct or indirect human influence. This is the case of the 2016/2017 East African drought (Funk et al., 2019), which was strongly influenced by warm sea-surface temperatures in the western Indian Ocean to which human influence contributed.

Less is known about anthropogenic influences on hurricane or tropical cyclone activity. In the north-west Pacific basin there is emerging evidence for a detectable poleward shift in the latitude of maximum intensity of tropical cyclones.

Anthropogenic climate change has increased (with high confidence) extreme sea level events associated with some tropical cyclones, which have increased the intensity of other extreme events such as flooding and associated impacts. Low-lying megacities, deltas, coasts and islands in many parts of the world will likely experience these events annually by 2050 under all future emission scenarios.

There is medium confidence that anthropogenic climate change has increased observed precipitation. In one notable example, a study concluded that human influence increased the amount of rainfall that occurred during Hurricane *Harvey* – which hit the United States of America in the Houston area in 2017 and was one of the most devastating hurricanes on record, with more than US$ 125 billion in losses – by about 15%, with an estimated uncertainty range between 8% and 19% (Oldenborgh et al., 2017).

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STATUS OF MORTALITY AND ECONOMIC LOSSES DUE TO WEATHER-, CLIMATE- AND WATER-RELATED HAZARDS FROM 1970 TO 2019

This section provides data and statistics on the impacts of weather, climate and water extremes worldwide and by WMO region, based on EM-DAT records except where explicitly stated. Furthermore, a focus on impacts related to tropical cyclones is provided at the end of the section with additional sources incorporated.

Global

According to EM-DAT records from 1970 to 2019, weather, climate and water hazards accounted for 50% of all disasters (including technological hazards), 45% of all reported deaths and 74% of all reported economic losses, that translates to 2.06 million deaths and US$ 3.6 trillion in economic losses.[6]

> A disaster related to either a weather, climate or water hazard occurred every day on average over the 50 years – killing 115 people and causing US$ 202 million in losses daily.

Top 10 deaths and economic losses

Of the top 10 disasters, the hazards that led to the largest human losses during the period have been droughts (650 000 deaths), storms (577 232 deaths), floods (58 700 deaths) and extreme temperature (55 736 deaths) (Table 1(a)). With regard to economic losses, the top 10 events include storms (US$ 521 billion) and floods (US$ 115 billion) (Table 1(b)). All the storm events positioned in top 10 categories in terms of both deaths and economic losses were tropical cyclones.[7] Three of the top 10 disasters in terms of economic losses occurred in 2017: Hurricanes *Harvey* (US$ 96.9 billion), *Maria* (US$ 69.4 billion) and *Irma* (US$ 58.2 billion). These three hurricanes alone accounted for 35% of the total economic losses of the top 10 disasters around the world from 1970 to 2019.

Floods were most common of the weather-, climate, water-related disaster types recorded, but storms had the highest human and economic toll.

Disasters by decade

The number of disasters has increased by a factor of five over the 50 years period: whereas 711 disasters were recorded for 1970–1979, 3 536 were recorded in 2000–2009 (Figure 4).

Deaths by decade

The EM-DAT record reveals that deaths decreased almost threefold by weather-, climate- and water-related disasters from 1970 to 2019. Death tolls have fallen decade by decade – from over 50 thousand deaths in the 1970s to less than 20 thousand in the 2010s. The 1970s and 1980s reported an average of 170 related deaths per day. In the 1990s, that average fell by one third to 90 related deaths per day, then continued to fall in the 2010s to 40 related deaths per day (Figure 4).

> Important advances in early warning systems worldwide have been credited with reducing the deaths from weather, climate and water hazards (Intergovernmental Panel on Climate Change (IPCC) (2012)).

Economic losses by decade

During the 50-year period, US$ 202 million dollars in damage occurred on average every day. Economic losses due to weather, climate and water extremes have increased sevenfold from the 1970s to the 2010s (Figure 4). The reported losses from 2010–2019 (US$ 383 per day on average over the decade) were seven times the amount reported from 1970–1979 (US$ 49 million) (Figure 4). Storms were the most prevalent cause of damage, resulting in the largest economic losses around the globe. It is the sole hazard for which the attributed portion is continually increasing.

6 Note: All references to the term "hazards" in this publication refer to weather, climate and water hazards. When the term hazard is used to refer to or include other hazards such as natural, technical, biological, geological, and the like, it will be specifically stated.

7 EM-DAT categorizes storms into three types: tropical cyclone, extratropical storm and convective storm.

Distribution of disasters and impacts by hazard

Worldwide, 44% of disasters have been associated with floods (riverine floods 24%, general floods 14%) and 17% have been associated with tropical cyclones. Tropical cyclones and droughts were the most prevalent hazards with respect to human losses, accounting for 38% and 34% of disaster related deaths from 1970 to 2019, respectively. In terms of economic losses, 38% were associated with tropical cyclones, while different types of floods account for 31%, riverine floods (20%), general floods (8%) and flash floods (3%) (Figure 5(a–c)).

> Of all of deaths from weather, climate and water hazards, 91% occurred in developing economies according to the United Nations country classification. The proportion remains similar for the World Bank country classification, according to which 82% of deaths occurred in low and lower-middle income countries.

Disaster impacts by United Nations and World Bank country classifications

The two different economic classification methodologies – the United Nations and the World Bank – both reveal that the majority of reported deaths from weather, climate and water extremes occurred in developing countries, while countries with developed economies incurred the majority of economic losses. According to the United Nations country classification, 91% of recorded deaths occurred in developing economies while 59% of economic losses were recorded in developed economies (Figure 6). According to the World Bank country classification, 82% of deaths have occurred in low and lower-middle-income countries and most (88%) of the economic losses have occurred in upper-middle- and high-income countries (Figure 7).

Table 1. Top 10 disasters ranked according to reported (a) deaths and (b) economic losses (1970–2019)[8]

(a)	Disaster type	Year	Country	Deaths
1	Drought	1983	Ethiopia	300 000
2	Storm (*Bhola*)	1970	Bangladesh	300 000
3	Drought	1983	Sudan	150 000
4	Storm (*Gorky*)	1991	Bangladesh	138 866
5	Storm (*Nargis*)	2008	Myanmar	138 366
6	Drought	1973	Ethiopia	100 000
7	Drought	1981	Mozambique	100 000
8	Extreme temperature	2010	Russian Federation	55 736
9	Flood	1999	Bolivarian Republic of Venezuela	30 000
10	Flood	1974	Bangladesh	28 700
(b)	**Disaster type**	**Year**	**Country**	**Economic losses (in US$ billion)**
1	Storm (*Katrina*)	2005	United States	163.61
2	Storm (*Harvey*)	2017	United States	96.94
3	Storm (*Maria*)	2017	United States	69.39
4	Storm (*Irma*)	2017	United States	58.16
5	Storm (*Sandy*)	2012	United States	54.47
6	Storm (*Andrew*)	1992	United States	48.27
7	Flood	1998	China	47.02
8	Flood	2011	Thailand	45.46
9	Storm (*Ike*)	2008	United States	35.63
10	Flood	1995	Democratic People's Republic of Korea	25.17

* Countries with identical death figures are ranked jointly.

8 A drought that lasts for more than a year is recorded with its beginning year (year of onset) following EM-DAT guidance.

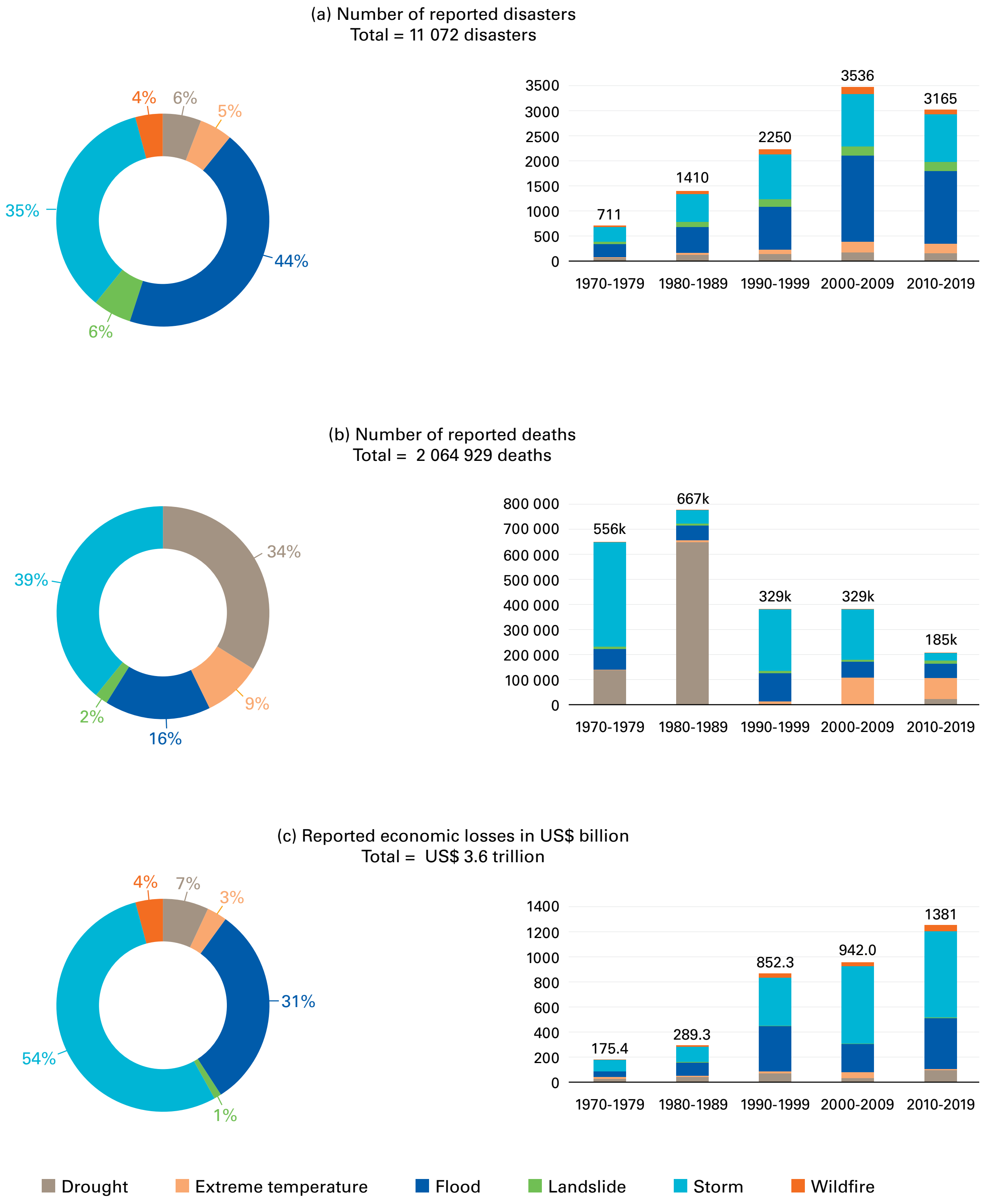


Figure 4. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard type by decade globally

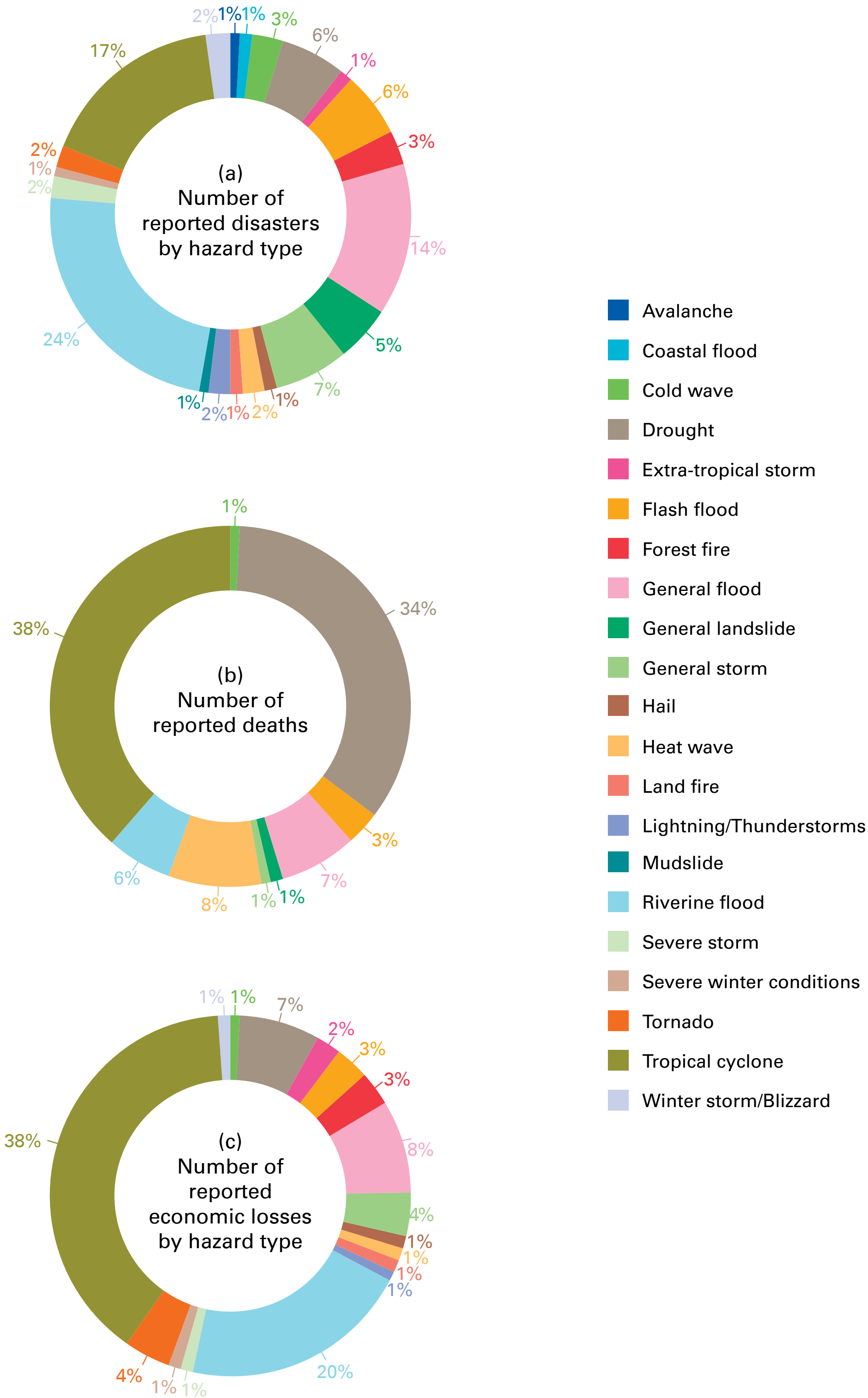


Figure 5. Distibutions of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard globally (1970–2019)

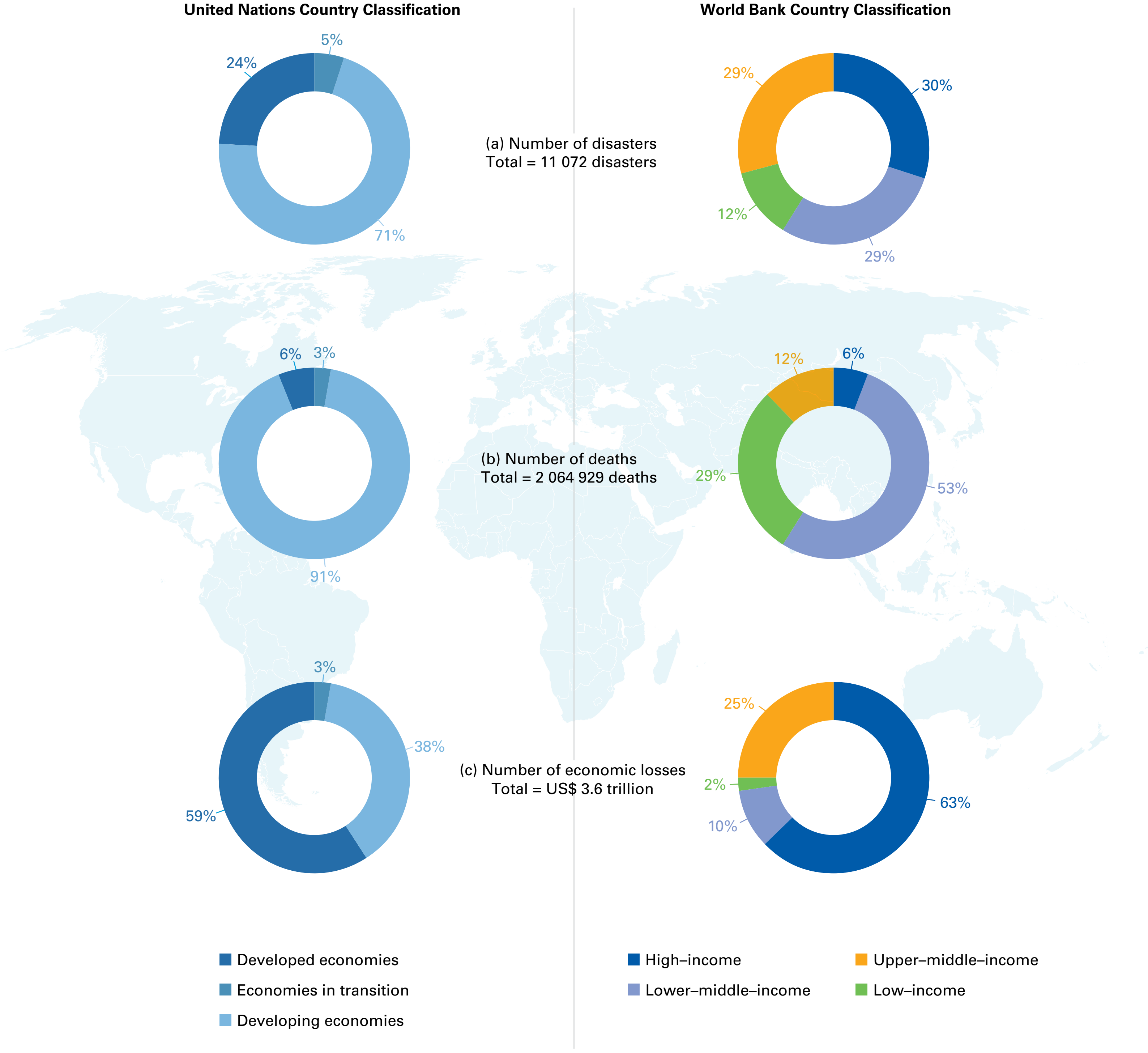


Figure 6. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by United Nations country classification globally (1970–2019)

Figure 7. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by World Bank country classification globally (1970–2019)

AFRICA

Over the 50-year period, 35% of deaths related to weather, climate and water extremes have occurred in Africa although the region accounts for ONLY 1% of global economic losses.

In Africa from 1970 to 2019, 1 695 recorded disasters caused the loss of economic damages 731 747 lives and US$ 38.5 billion. Africa accounts for 15% of weather-, climate- and water-related disasters, 35% of associated deaths and 1% of economic losses reported globally. Although disasters associated with floods were the most prevalent (60%), droughts led to the highest number of deaths, accounting for 95% of all lives lost in the region (Figure 8). The majority of deaths occurred during the severe droughts in Ethiopia in 1973 and 1983 (total 400 000), Mozambique in 1981 (100 000) and Sudan in 1983 (150 000). These four drought events account for 89% of total deaths in Africa from weather, climate and water extremes in the last 50 years (Table 2 (a)). Storms (37%) and floods (34%) led to the highest economic losses in Africa, followed by droughts (26%) (Table 2 (b)). The distributions of deaths and economic losses are indicated by country/territory in Maps 1 and 2.

Top 10 deaths and economic losses

The top 10 deadliest disasters recorded accounted for 95% (696 334 deaths) of the total lives lost over the period. The top 10 recorded events in terms of economic losses accounted for 38% of all losses (US$ 14.37 billion) (Table 2). Four of those events occurred in last 10 years (2010–2019). Tropical Cyclone *Idai*, that hit Mozambique in 2019, and the 1990 drought in South Africa are jointly the two most costly events (both estimated at US$ 1.96 billion) in Africa over the past 50 years.

Disasters and impacts by decade

There was a significant increase in flood-related disasters from 2000 onwards, with floods accounting for 66% of disasters recorded in this period. The number of reported deaths between 1980 and 1989 was extremely high due to four drought related disaster: Ethiopia reported 300 000 deaths, Sudan 150 000, Mozambique 100 000 and Chad 3 000 (Table 2(a)). These four events represent 89% of reported deaths in Africa in the last 50 years. A significant increase in economic losses was recorded during the last decade, 2010–2019, with US$ 12.5 billion in losses compared to the US$ 6.5 billion average losses per decade from 1970 to 2009 (Figure 8).

Distribution of disasters and impacts by hazard

Figure 9 (a–c) shows the distribution in terms of total number, resulting deaths and economic losses as a function of hazard type. The analysis shows that four hazards were prevalent: riverine floods (34% of disasters, 25% of economic losses), droughts (16% of disasters, 26% of economic losses), tropical cyclones (8% of disasters, 25% of economic losses) and general floods (17% of disasters, 7% of economic losses). The impacts from these four hazards combined were responsible for three quarters of weather-, climate- and water-related disasters in Africa (75%) and 83% of economic losses for the region. Deaths were mostly associated with droughts, which account for 95% of disaster-related fatalities.

Distribution of disasters and their impacts by United Nations and World Bank country classification

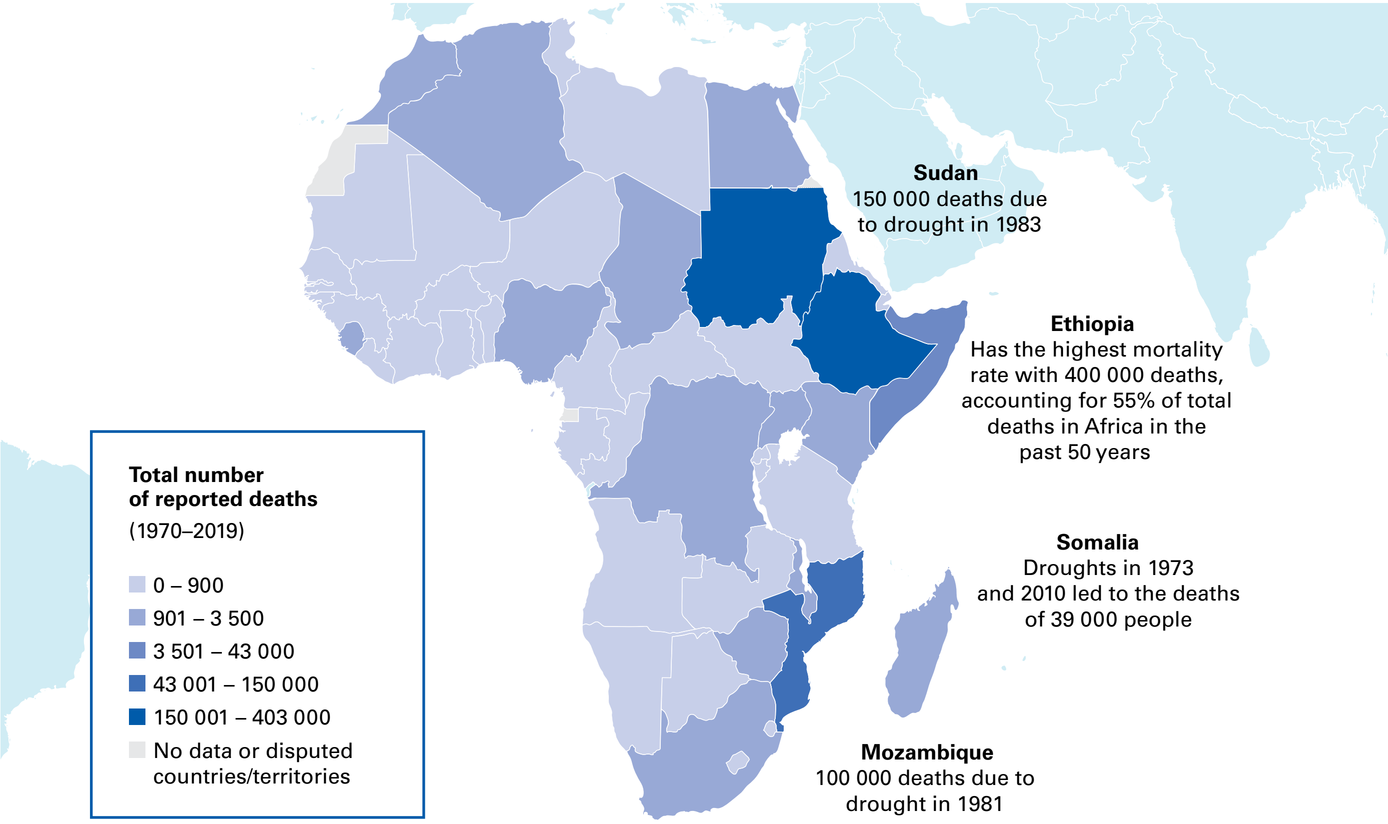
All African countries/territories for which reported disasters are recorded in EM-DAT are considered to be developing economies under the United Nations country classification scheme (Figure 10). The World Bank classifies several African countries/territories in the higher income categories, including the Canary Islands (Spain), Réunion (France) and Seychelles as high income, and Algeria, Botswana, Gabon, Libya, Mauritius, Namibia, Saint Helena, Ascension and Tristan da Cunha (United Kingdom) and South Africa as upper-middle income. According to the World Bank country classification, 51% of disasters were reported to have occurred in low-income countries and 35% in lower-middle-income countries (Figure 11), whereas almost all deaths (99%) from these disasters were reported to have occurred in low- to lower-middle-income countries. Economic losses are rather equally divided: 43% of reported economic losses in Africa occurred in high- to upper-middle-income countries/territories according to the World Bank classification, while more than half (57%) were reported in low to lower-middle-income countries.

Table 2. Top 10 disasters in Africa ranked according to reported (a) deaths and (b) economic losses (1970–2019)

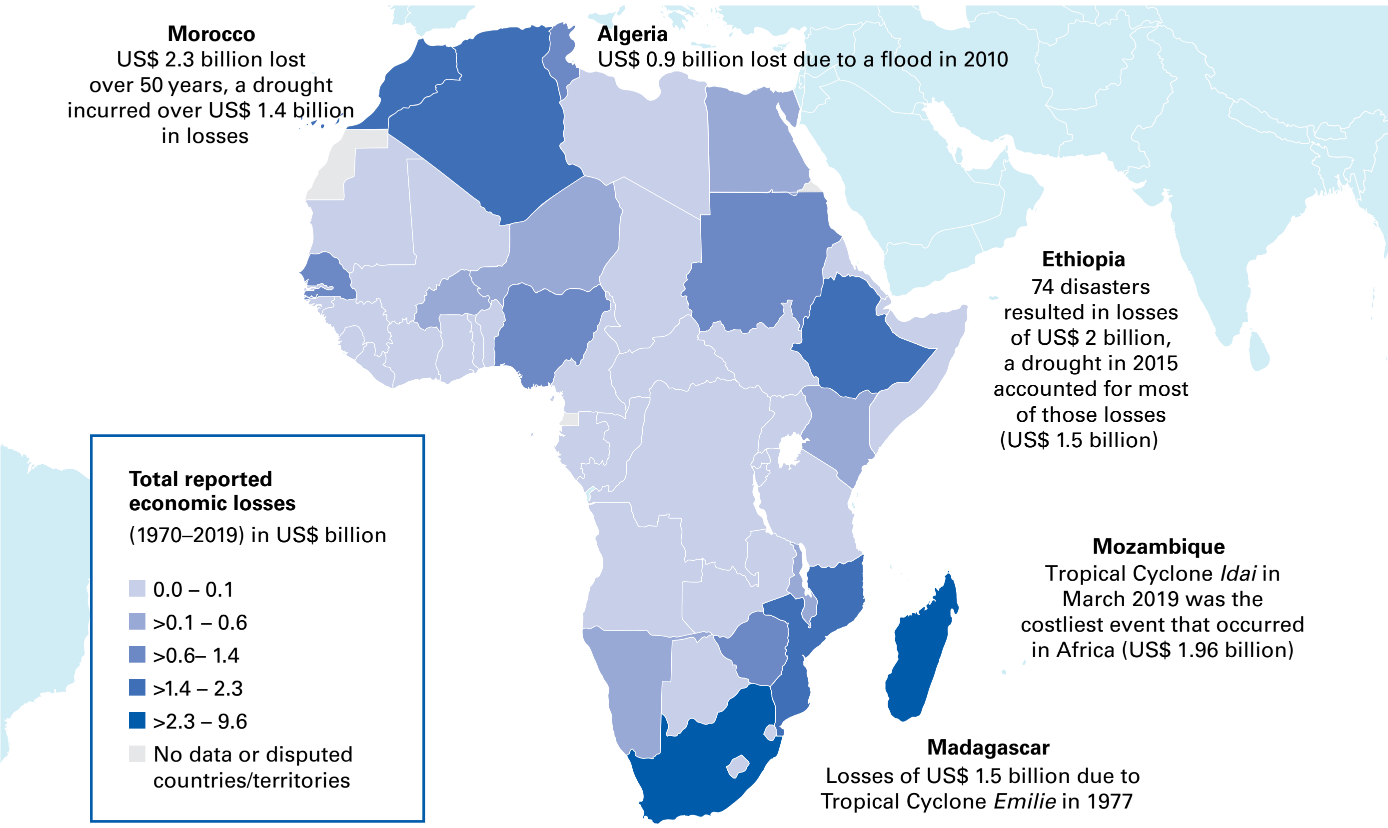
(a)	Disaster type	Year	Country	Deaths
1	Drought	1983	Ethiopia	300 000
2	Drought	1983	Sudan	150 000
3	Drought	1973	Ethiopia	100 000
4	Drought	1981	Mozambique	100 000
5	Drought	2010	Somalia	20 000
6	Drought	1973	Somalia	19 000
7	Drought	1980	Chad	3 000
8	Flood	1997	Somalia	2 311
9	Landslide	2017	Sierra Leone	1 102
10	Flood	2001	Algeria	921
(b)	**Disaster type**	**Year**	**Country**	**Economic losses (in US$ billion)**
1*	Drought	1990	South Africa	1.96
1*	Storm (*Idai*)	2019	Mozambique	1.96
3	Flood	1987	South Africa	1.72
4*	Storm (*Emilie*)	1977	Madagascar	1.48
4*	Drought	2015	Ethiopia	1.48
6	Drought	1999	Morocco	1.38
7	Drought	1976	Senegal	1.35
8	Drought	2017	South Africa	1.22
9	Storm (*Gervaise*)	1975	Mauritius	0.95
10	Flood	2011	Algeria	0.89

* Countries that have identical figures for deaths or economic losses are ranked jointly.

Huge swarm of hungry locust in flight near Morondava in Madagascar. (Pawel Opaska/Alamy Stock Photo)



Map 1. Reported disasters and related deaths in Africa (1970–2019)



Map 2. Reported disasters and related economic losses in Africa (1970–2019)

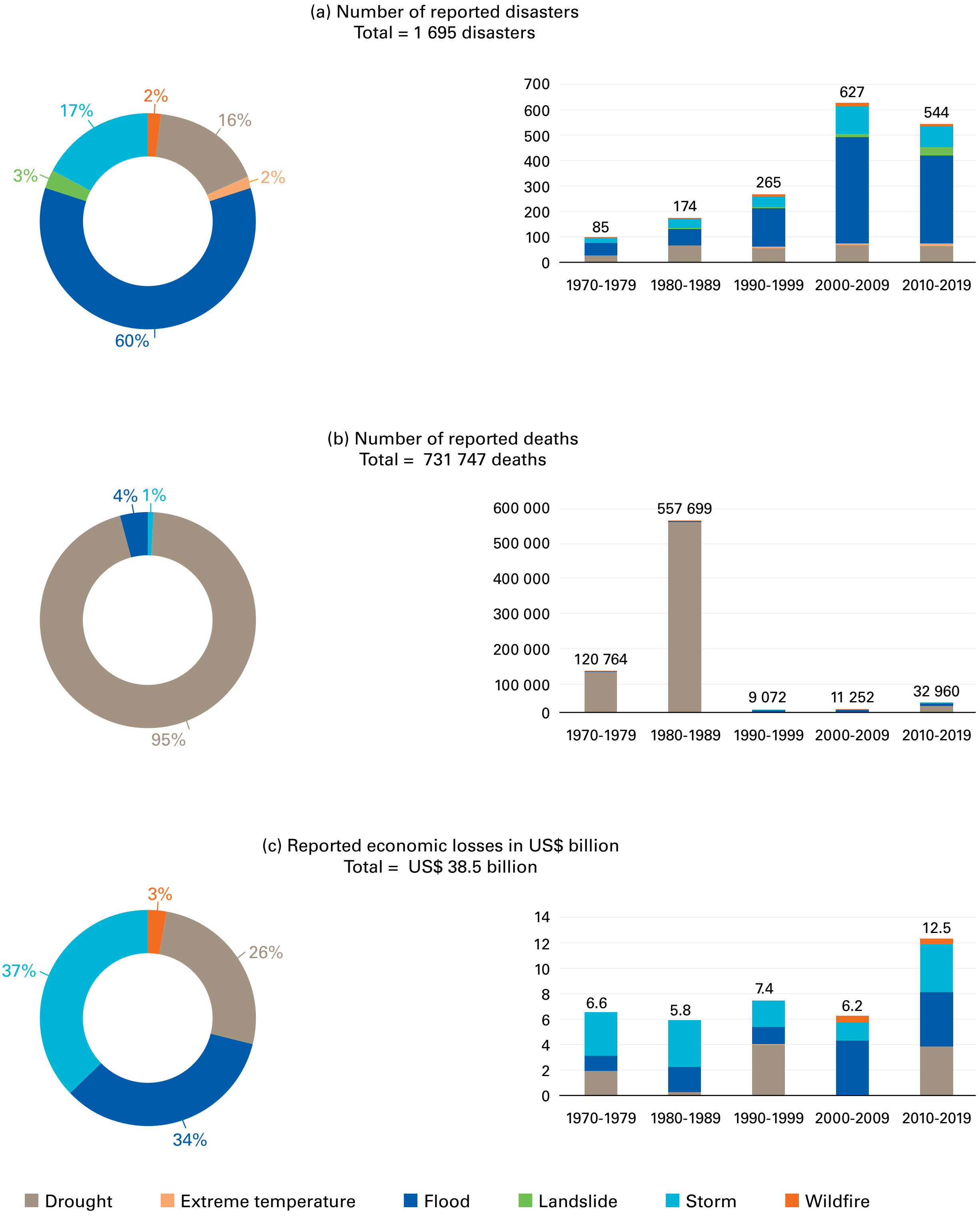


Figure 8. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard type and by decade in Africa

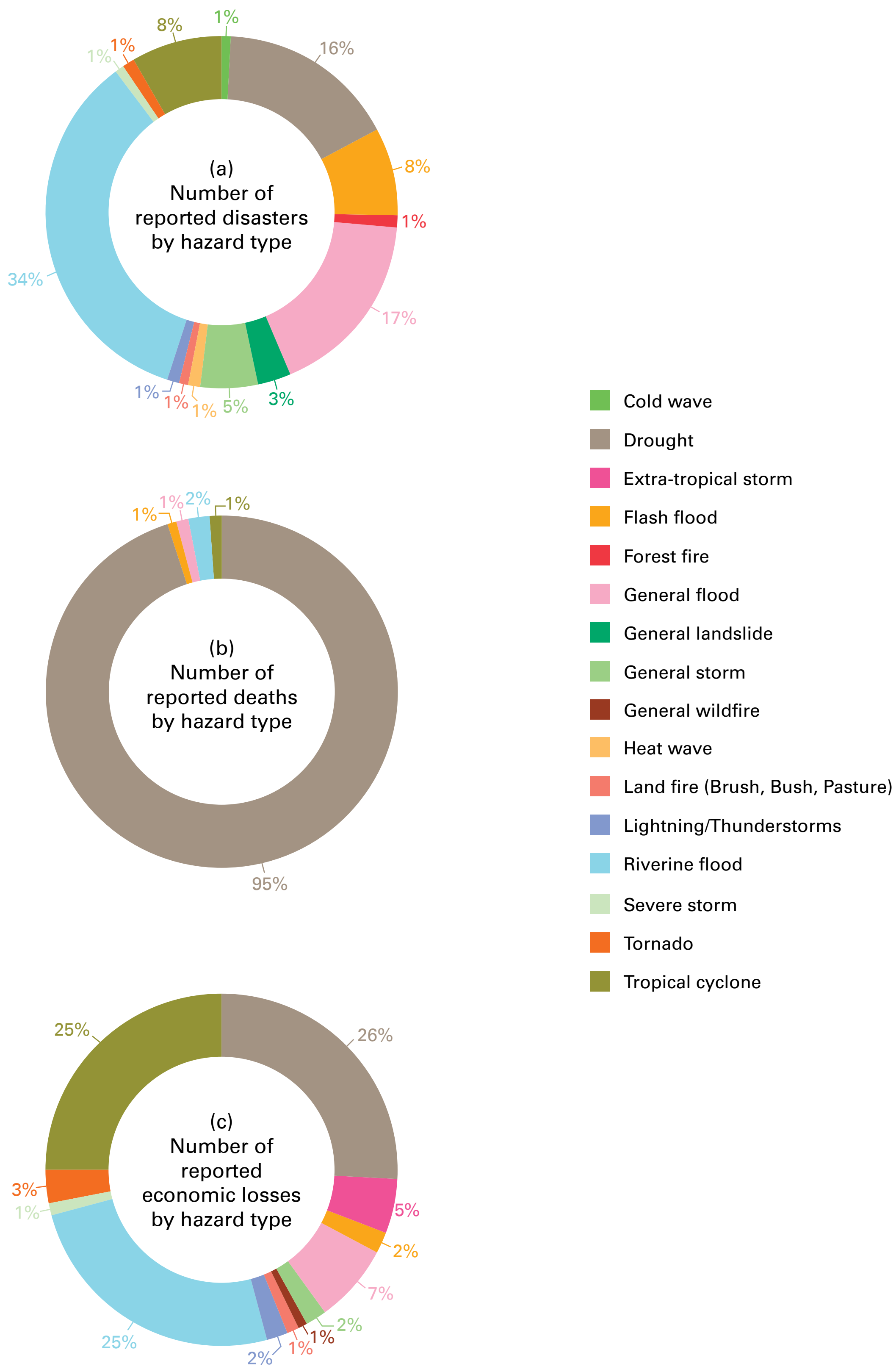


Figure 9. Distibution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard in Africa (1970–2019)

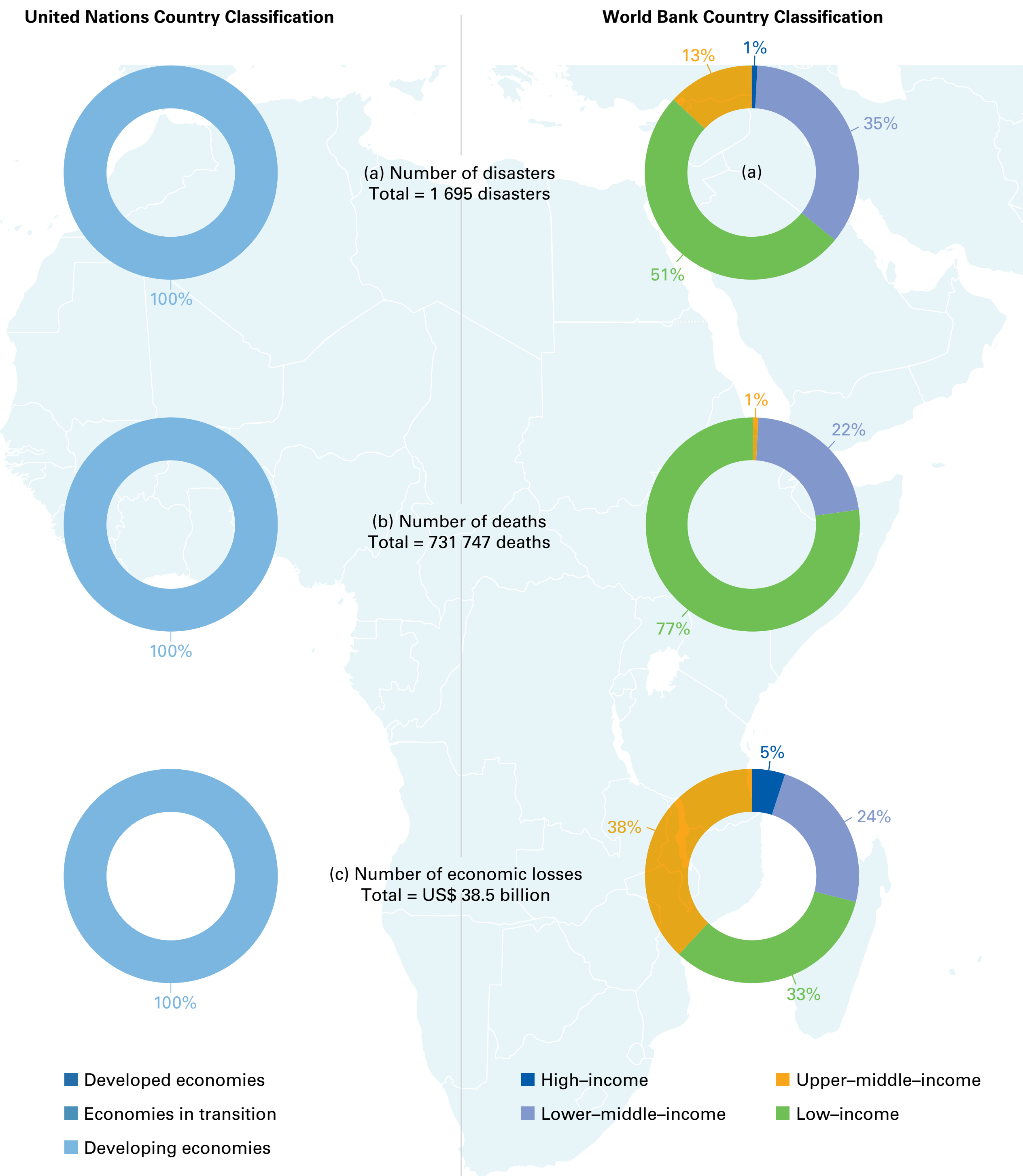


Figure 10. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by United Nations country classification in Africa. Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

Figure 11. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by World Bank country classification in Africa. Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

ASIA

A million lives and US$ 1.2 trillion have been lost in Asia over the 50 years due to weather, climate and water extremes.

In Asia, 3 454 disasters were recorded from 1970–2019, with 975 622 lives lost and US$ 1.2 trillion in reported economic damages. Asia accounts for nearly one third (31%) of weather-, climate- and water-related disasters reported globally, accounting for nearly half of deaths (47%) and one third (31%) of associated economic losses.

Most of these disasters were associated with floods (45%) and storms (36%). Storms had the highest impacts on life, causing 72% of the lives lost, while floods led to the greatest economic losses (57%). The top 10 recorded disasters in Asia account for 70% (680 837 deaths) of the total lives lost and 22% (US$ 266.62 billion) of economic losses for the region. The distributions of deaths and economic losses are indicated by country in Maps 3 and 4.

Top 10 deaths and economic losses

Of the top 10 disasters in Asia in terms of loss of life, tropical cyclones were the most prelavent hazard. Three tropical cyclones, including two in Bangladesh in 1970 and 1991 (total of 438 866 deaths) and one in Myanmar in 2008 (138 366 deaths) distort the overall disaster statistics whereby 0.1% of events account for 60% of deaths reported for the region (Table 3 (a)). Bangladesh, due to the significant loss of life caused by the two tropical cyclones, accounted for more than half of deaths (53%) reported in Asia in the last 50 years (Maps 3 and 4).

The most prevalent hazard in terms of economic losses were floods. Six costliest disasters in the region occurred in China (Table 3 (b)), which accounted for 60% of the top 10 events. China was the most affected country in Asia, suffering half of the economic losses from weather, climate and water events in the region (49.7%), which resulted in losses of US$ 598 billion over the last 50 years.

Disasters and impacts by decade

There was an increase in the number of recorded disasters attributed to weather, climate and water hazards over the period: disasters were reported more frequently by decade, up from one disaster on average every fifteen day to one every three days over the 50 years. One hundred and four disasters were recorded per year on average over the last two decades. This increase may be a result of reporting bias whereby disasters are have been recorded more frequently since the year 2000 than during previous decades due to advances in technology and the international focus on disaster risk reduction.

The number of reported deaths has fluctuated over the period, with increases and decreases by decade, while economic losses have continuously and substantially increased.

Five of the 10 deadliest recorded events occurred in the 1970s and nine prior to the year 2000. Four out of the 10 costliest events occurred in the recent decade 2010–2019 (Figure 12 and Table 3).

Distribution of disasters and impacts by hazard

Figure 13(a–c) shows the distribution in terms of total number, resulting deaths and economic losses as a function of hazard type. The three most prevalent hazards in terms of number of recorded disasters: riverine floods (23%), tropical cyclones (21%) and general floods (14%). Tropical cyclones accounted for the most deaths (70%), while floods (general floods (12%) and riverine floods (9%)) caused 21% of deaths. In terms of economic losses, riverine floods (38%), tropical cyclones (30%) and general floods (15%) were the most prelavent hazards in Asia. These three hazard types combined contributed to 58% of disasters, 91% of deaths and 83% of economic losses for the region.

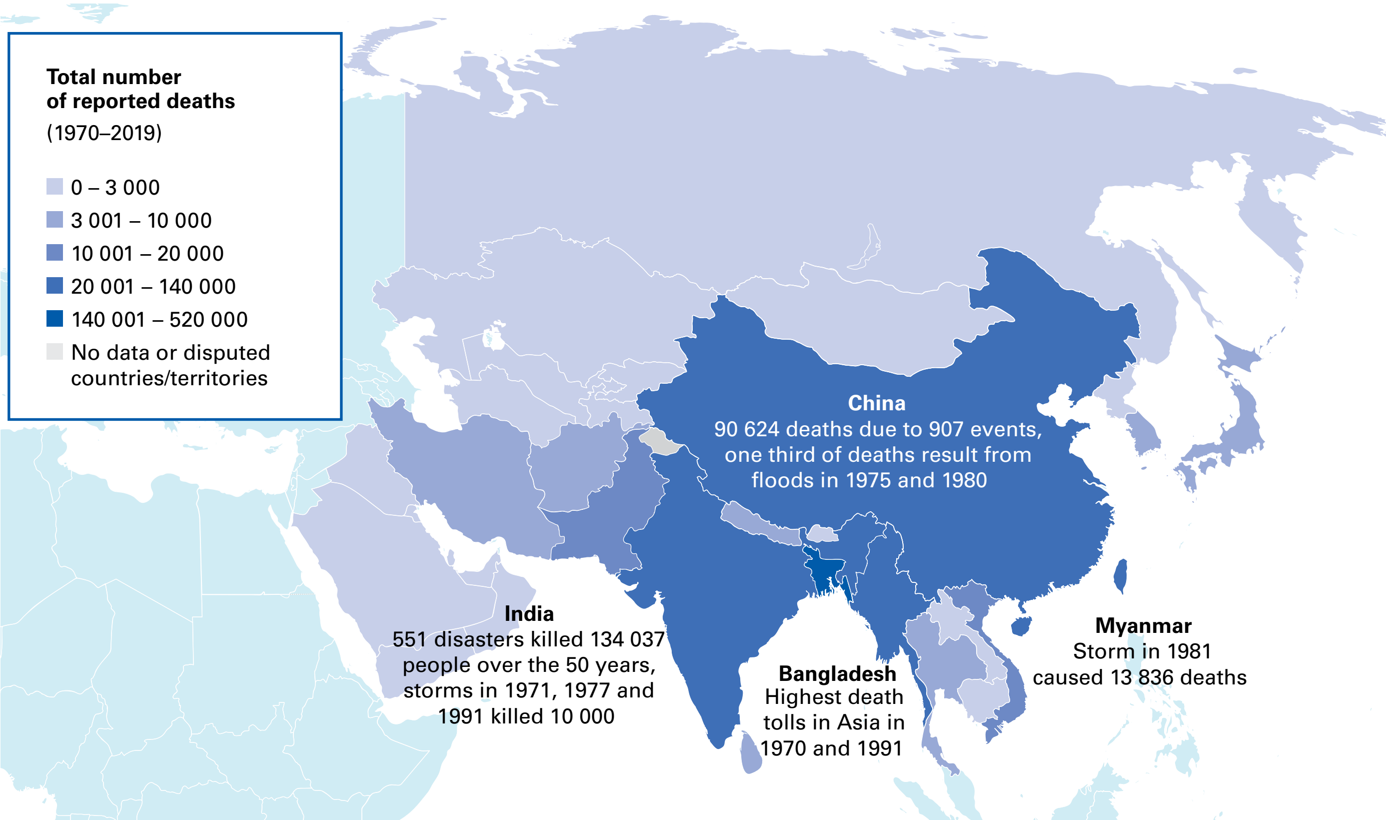
Distribution of disasters and their impacts by United Nations and World Bank country classification

Analysis by the United Nations country classification shows that the vast majority of recorded disasters (89%), related deaths (99%) and economic losses (85%) occurred in countries with developing economies (Figure 14). Nearly nine out of ten recorded disasters, number of deaths and economic losses in Asia occurred in developing economies according the United Nations country classification. Whereas the World Bank country classification shows more granularity with low- to lower-middle-income countries reporting 51% of reported disasters, 89% of related deaths and 25% of economic losses (Figure 15).

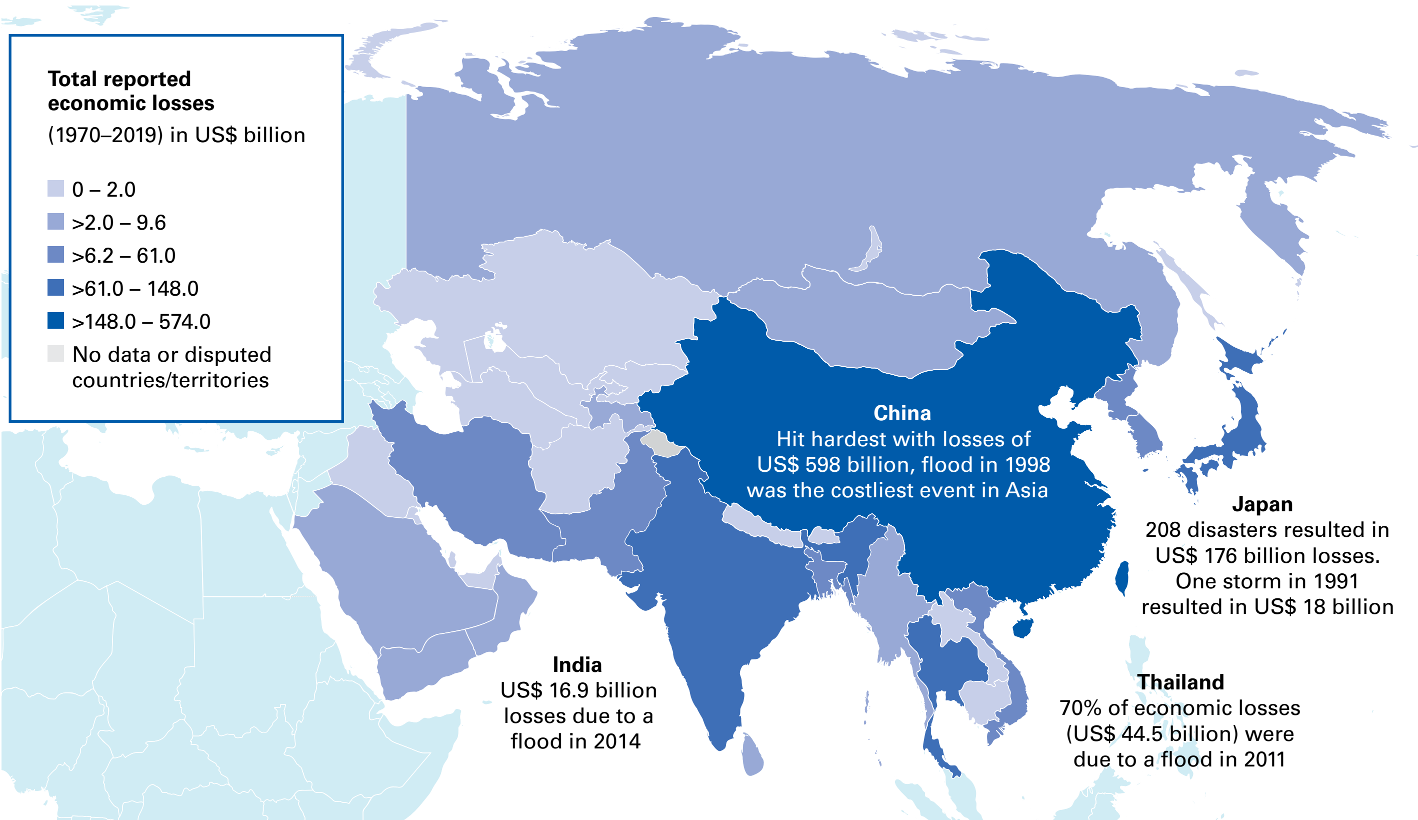
Table 3. Top 10 disasters in Asia ranked according to (a) reported deaths and (b) economic losses (1970–2019). TC indicates disasters caused by tropical cyclones.

(a)	Disaster type	Year	Country	Deaths
1	Storm (*Bhola*)	1970	Bangladesh	300 000
2	Storm (*Gorky*)	1991	Bangladesh	138 866
3	Storm (*Nargis*)	2008	Myanmar	138 366
4	Flood	1974	Bangladesh	28 700
5	Flood	1975	China	20 000
6	Storm (TC)	1985	Bangladesh	15 000
7	Storm (TC)	1977	India	14 204
8	Storm (05B)	1999	India	9 843
9	Storm (TC)	1971	India	9 658
10	Flood	1980	China	6 200
(b)	**Disaster type**	**Year**	**Country**	**Economic losses (in US$ billion)**
1	Flood	1998	China	47.02
2	Flood	2011	Thailand	44.45
3	Flood	1995	Democratic People's Republic of Korea	25.17
4	Extreme temperature	2008	China	25.06
5	Drought	1994	China	23.72
6	Flood	2016	China	22.92
7	Flood	2010	China	21.10
8	Flood	1996	China	20.52
9	Storm (*Mireille*)	1991	Japan	18.76
10	Flood	2014	India	16.90

Boracay Island, Aklan Province, Philippines, Typhoon Ursula left many provinces without electricity. (Michael Wels/Getty Images)



Map 3. Reported disasters and related deaths in Asia (1970–2019)



Map 4. Reported disasters and related economic losses in Asia (1970–2019)

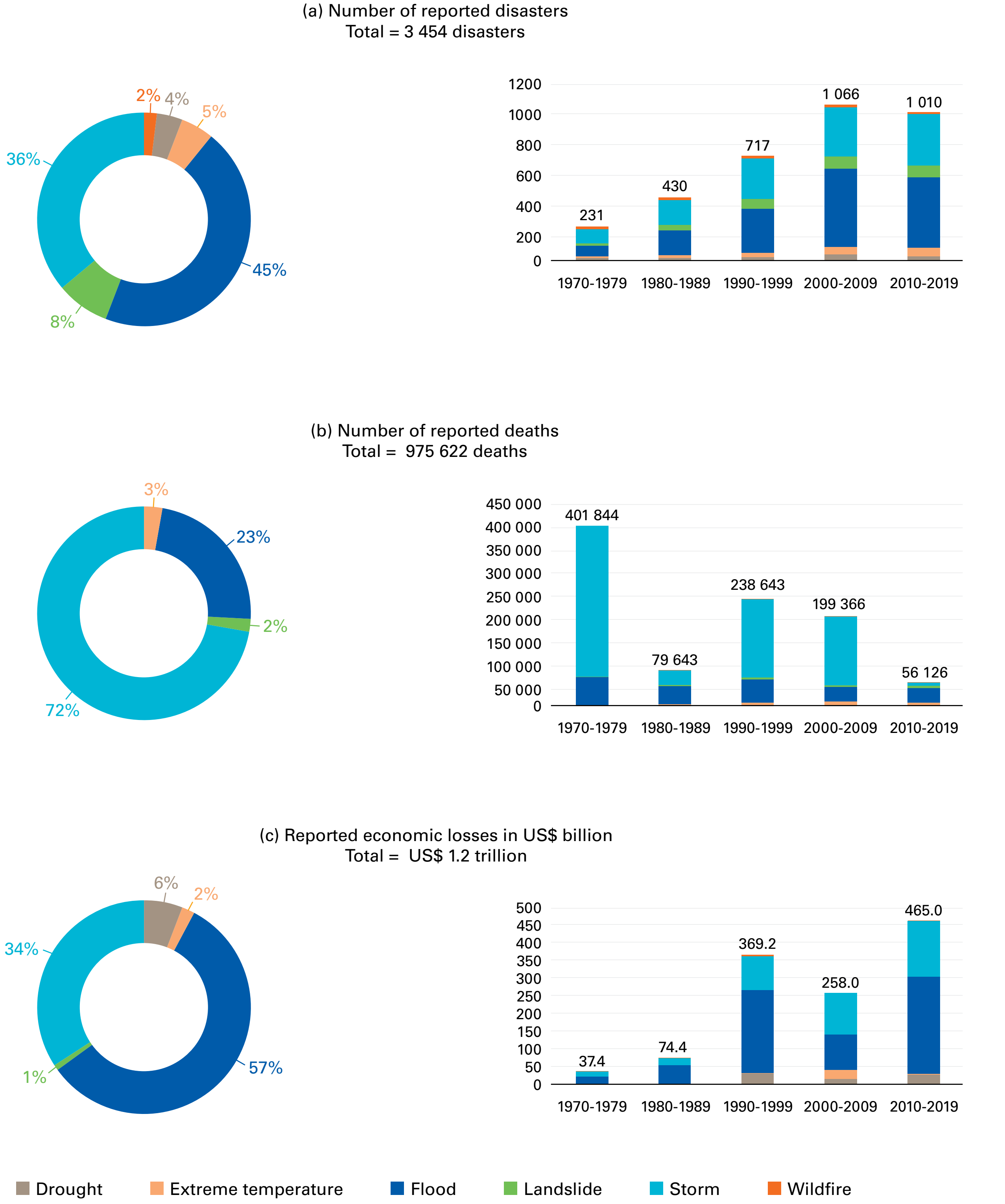


Figure 12. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard type and by decade in Asia

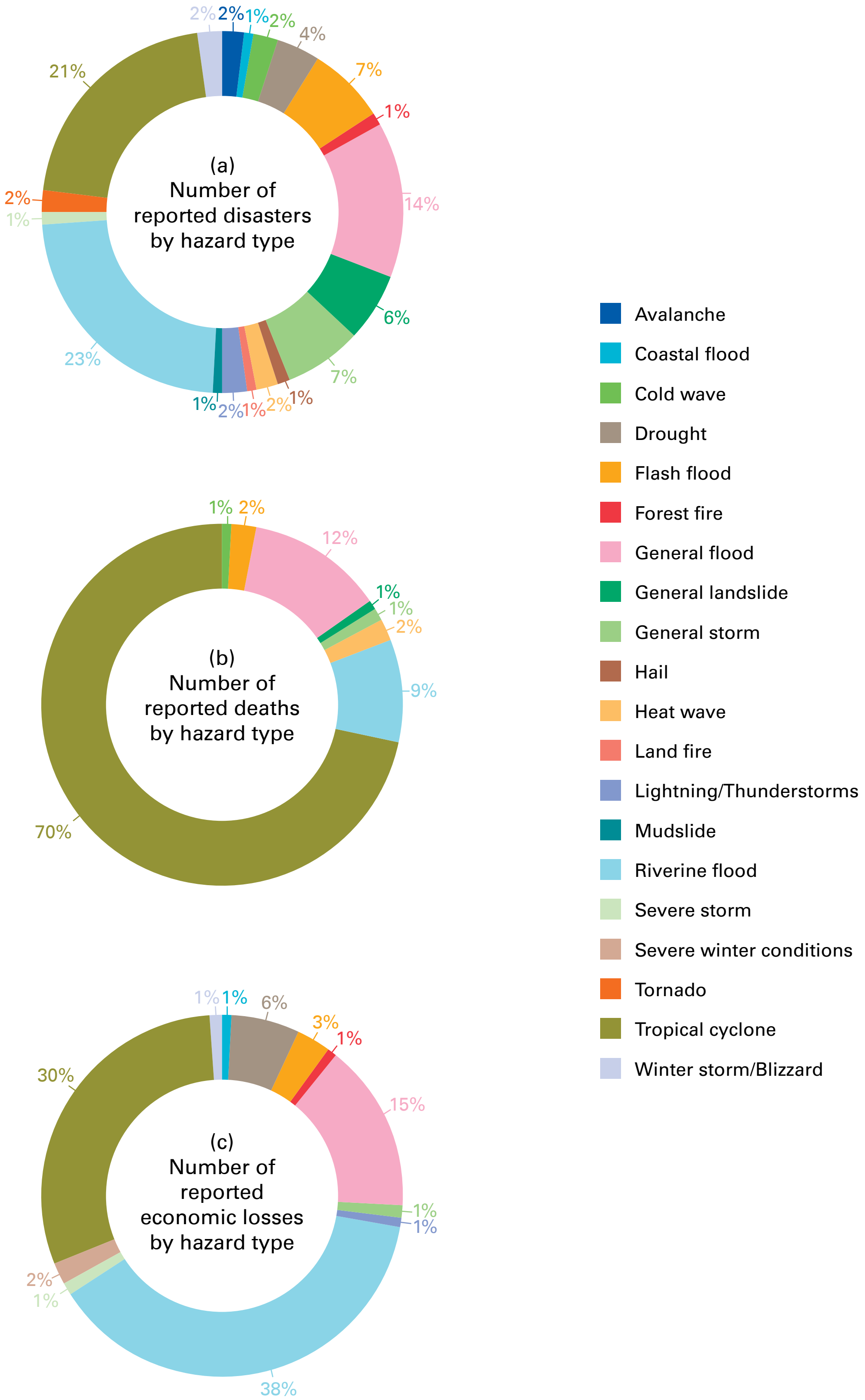


Figure 13. Distibution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard in Asia (1970–2019)

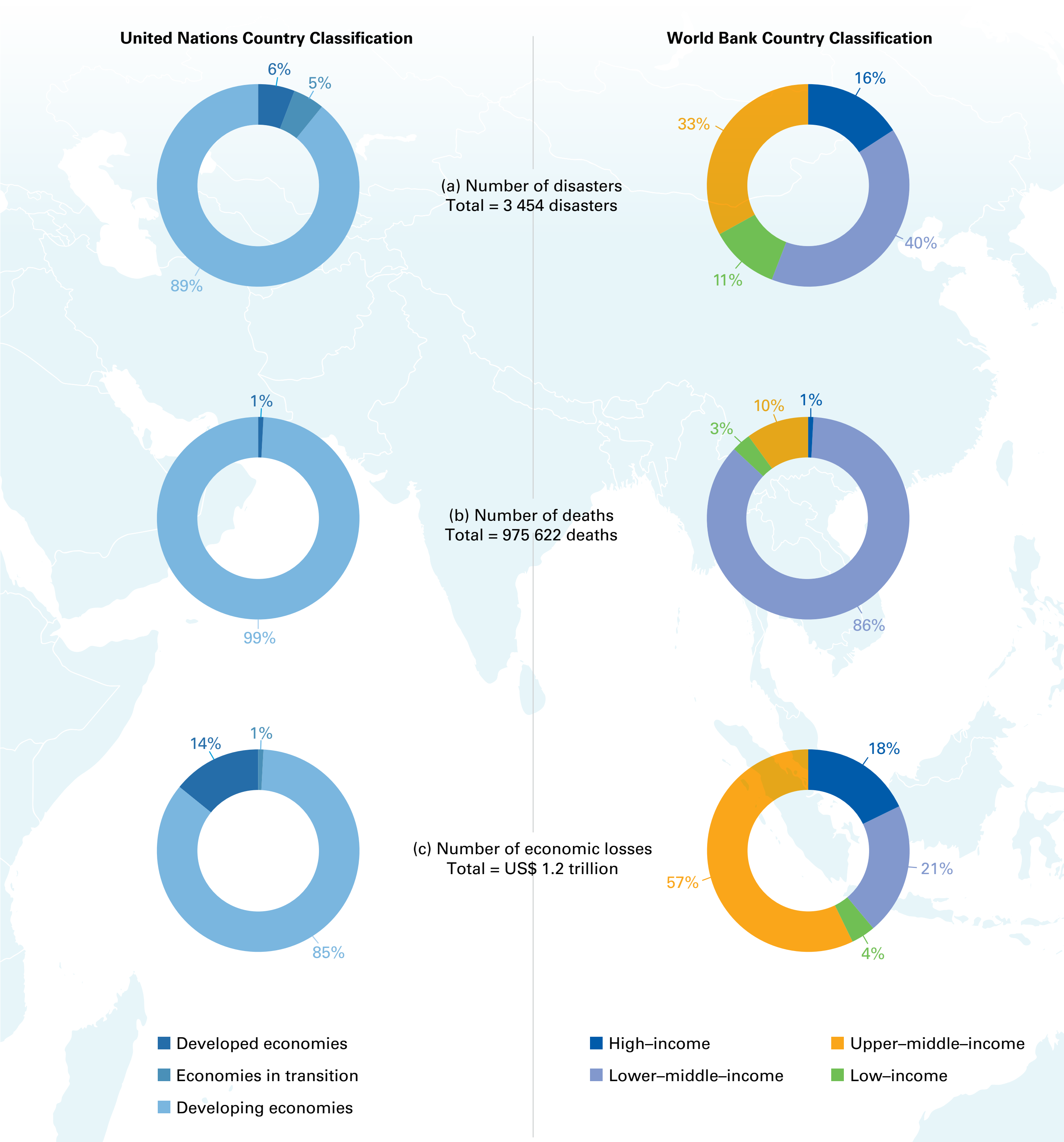


Figure 14. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by United Nations country classification in Asia (1970–2019). Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

Figure 15. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by World Bank country classification in Asia (1970–2019)

SOUTH AMERICA

South America recorded 867 disasters that resulted in 57 892 lives lost and US$ 100.9 billion economic losses from 1970 to 2019. Floods (59%) were the most prevalent cause of disaster, cumulating 77% of the death toll and 58% of the reported economic losses in the region.

Top 10 deaths and economic losses

The top 10 recorded disasters in the region accounted for 60% of total lives lost (34 854) and 38% of economic losses (US$ 39.2 billion). Flood represent 90% of events in the top 10 list of disasters by death toll and 41% of the top ten list by economic losses. (Table 4 (a, b). Overall, floods have led to the greatest number of disasters (59%), the greatest loss of life (77%) and the highest economic loss (58%) for the region over the 50-year period. The distributions of deaths and economic losses are indicated by country in Maps 5 and 6.

Disasters and impacts by decade

When viewed by decade, there is a general increase in the number of flood-related disasters, a notable increase in economic losses, but no discernible trend in reported deaths over the 50-year period (Figure 16). Flood-related disasters increased from 50% in the 1990s, to 60% in the 2000s and to 66% in 2010s.

Out of the 867 recorded disasters in South America, 90% reported less than 100 deaths and one third of these reported no deaths at all. It is noteworthy that three quarters of the recorded disaster (75%) had no economic impacts. The deadliest event in South America was the Venezuelan flood in 1999 that took 30 000 lives. This event skews the loss of life statistics for the region, as it accounts for 51% of total deaths reported in the last 50 years.

Economic losses amounted to US$ 3 billion on average per year over the last 10 years (2010–2019), double the amount of the previous decade (2000–2009). The costliest disaster recorded in South America in the last decade was a drought in Brazil in 2014 that cumulated to losses of over US$ 5 billion. Brazil accounts for 40% of economic losses reported in South America over the 50 years with total damages of US$ 41.7 billion.

Distribution of disasters and impacts by hazard

Figure 17 (a–c) shows the distribution in terms of total number, resulting deaths and economic losses as a function of hazard type. Riverine floods (33%), general floods (22%) and general landslides (10%) accrued the greatest number of disasters. Flash floods are shown to have caused the majority of deaths (54%), followed by riverine floods (14%) and general landslides (12%). In terms of economic losses, three hazards – droughts (28%), riverine floods (26%) and general floods (15%) – dominated the records.

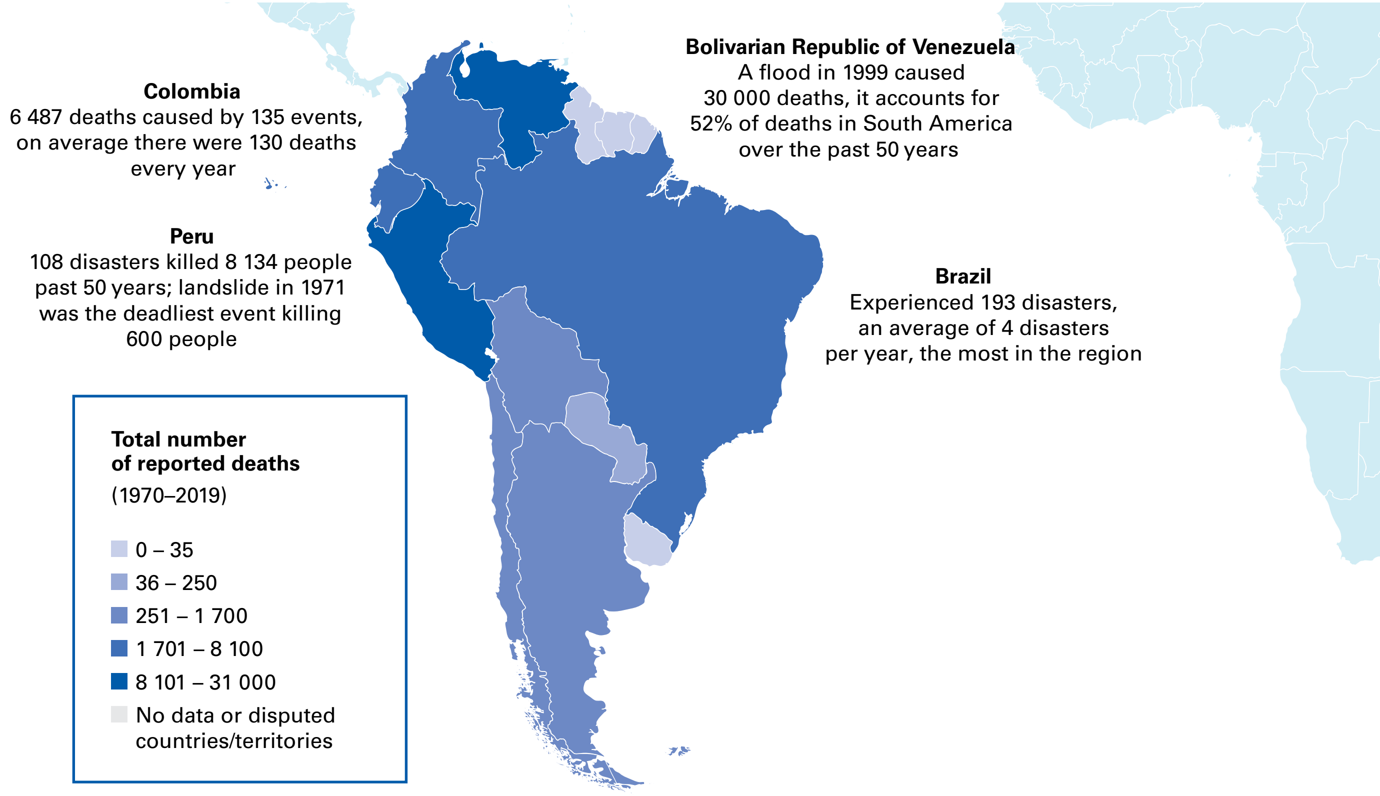
Disasters and impacts by United Nations and World Bank country classification

As is the case for African countries/territories, all South American countries are considered to be developing economies under the United Nations country classification scheme (Figure 18). The World Bank country classification, however, shows that 79% of the disasters and 86% of economic losses were reported in upper-middle-income countries while 95% of reported deaths occurred in lower-middle-income countries (Figure 19).

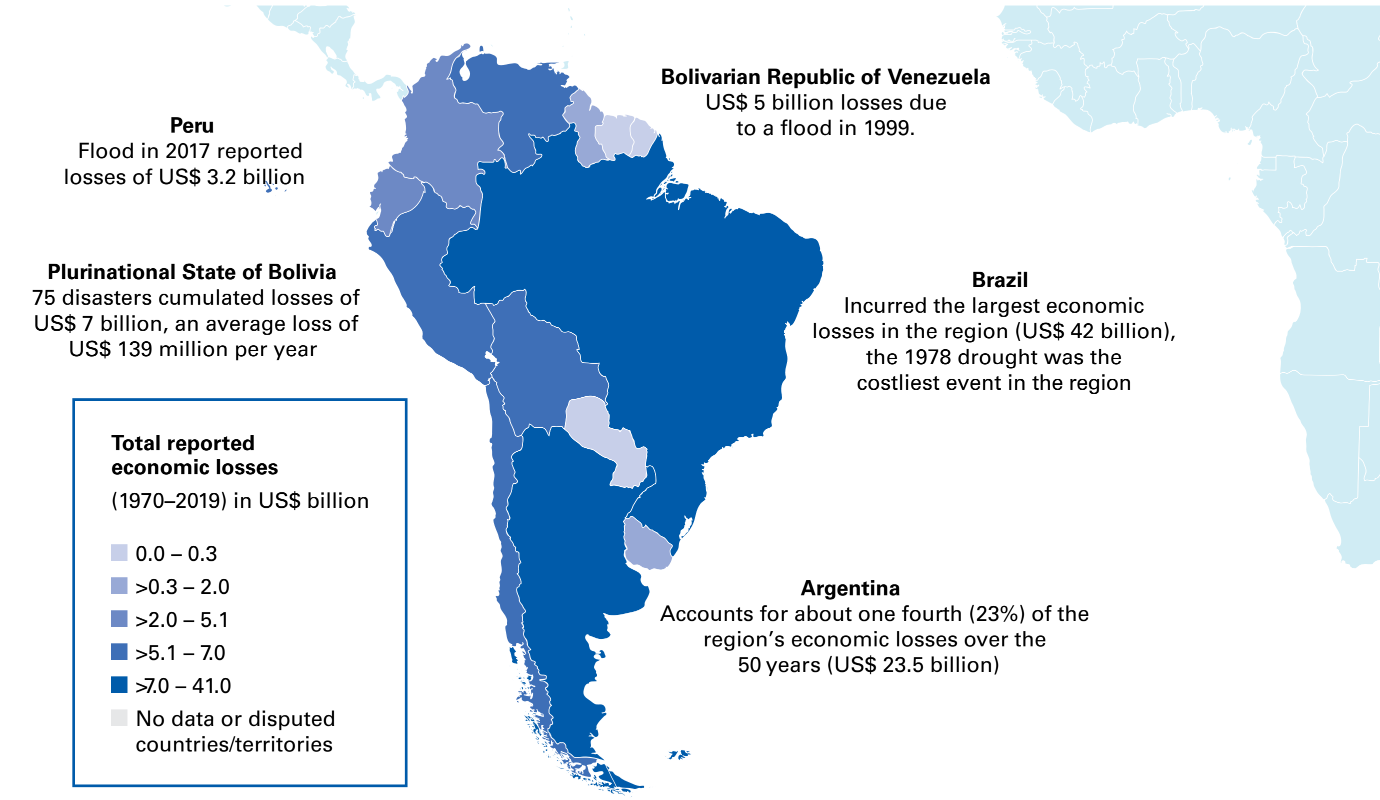
Table 4. Top 10 disasters in South America ranked according to reported (a) deaths and (b) economic losses (1970–2019)

(a)	Disaster type	Year	Country	Deaths
1	Flood	1999	Bolivarian Republic of Venezuela	30 000
2	Flood	2011	Brazil	900
3	Landslide	1987	Colombia	640
4	Landslide	1971	Peru	600
5	Storm	1997	Peru	518
6	Extreme temperature	2014	Peru	505
7	Landslide	1973	Peru	500
8	Flood	2010	Colombia	418
9	Extreme temperature	2010	Peru	409
10	Landslide	1983	Peru	364
(b)	**Disaster type**	**Year**	**Country**	**Economic losses (in US$ billion)**
1	Drought	1978	Brazil	9.02
2	Drought	2014	Brazil	5.28
3	Flood	1999	Bolivarian Republic of Venezuela	4.85
4	Drought	2018	Argentina	3.40
5	Flood	2017	Peru	3.16
6	Flood	1985	Argentina	3.09
7	Extreme temperature	1975	Brazil	2.84
8	Flood	1983	Argentina	2.56
9	Landslide	1983	Peru	2.54
10	Flood	1984	Brazil	2.46

View of a landslide that destroyed several houses in Manizales, Colombia, Wednesday, 19 April 2017. At least seven people were found dead after intense rains provoked several landslides in a mountainous, coffee-growing part of Colombia. (AP Photo/Maria Luisa Garcia)



Map 5. Reported disasters and their related deaths in South America (1970–2019)



Map 6. Reported disasters and their related economic losses in South America (1970–2019)

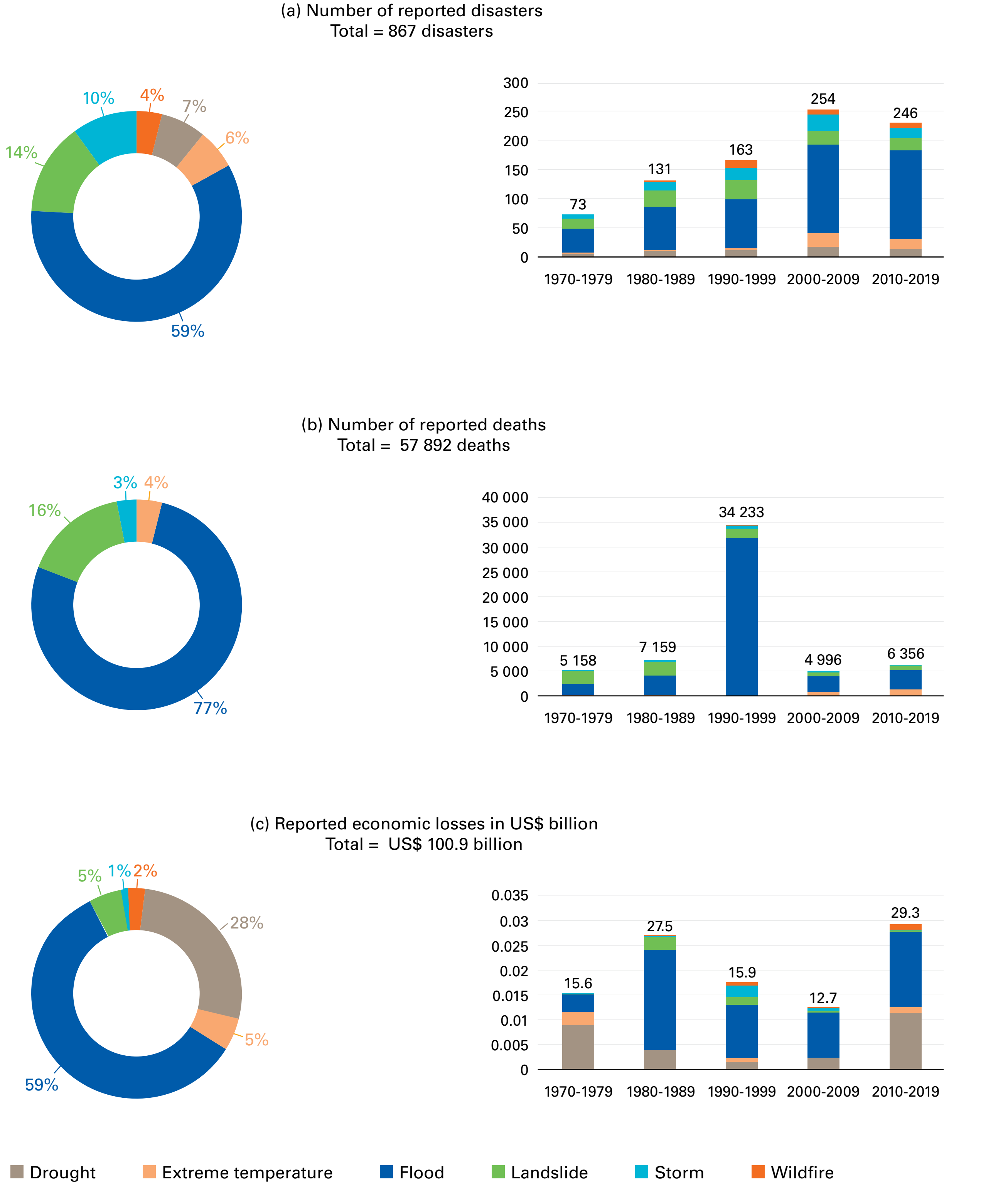


Figure 16. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard type and by decade in South America

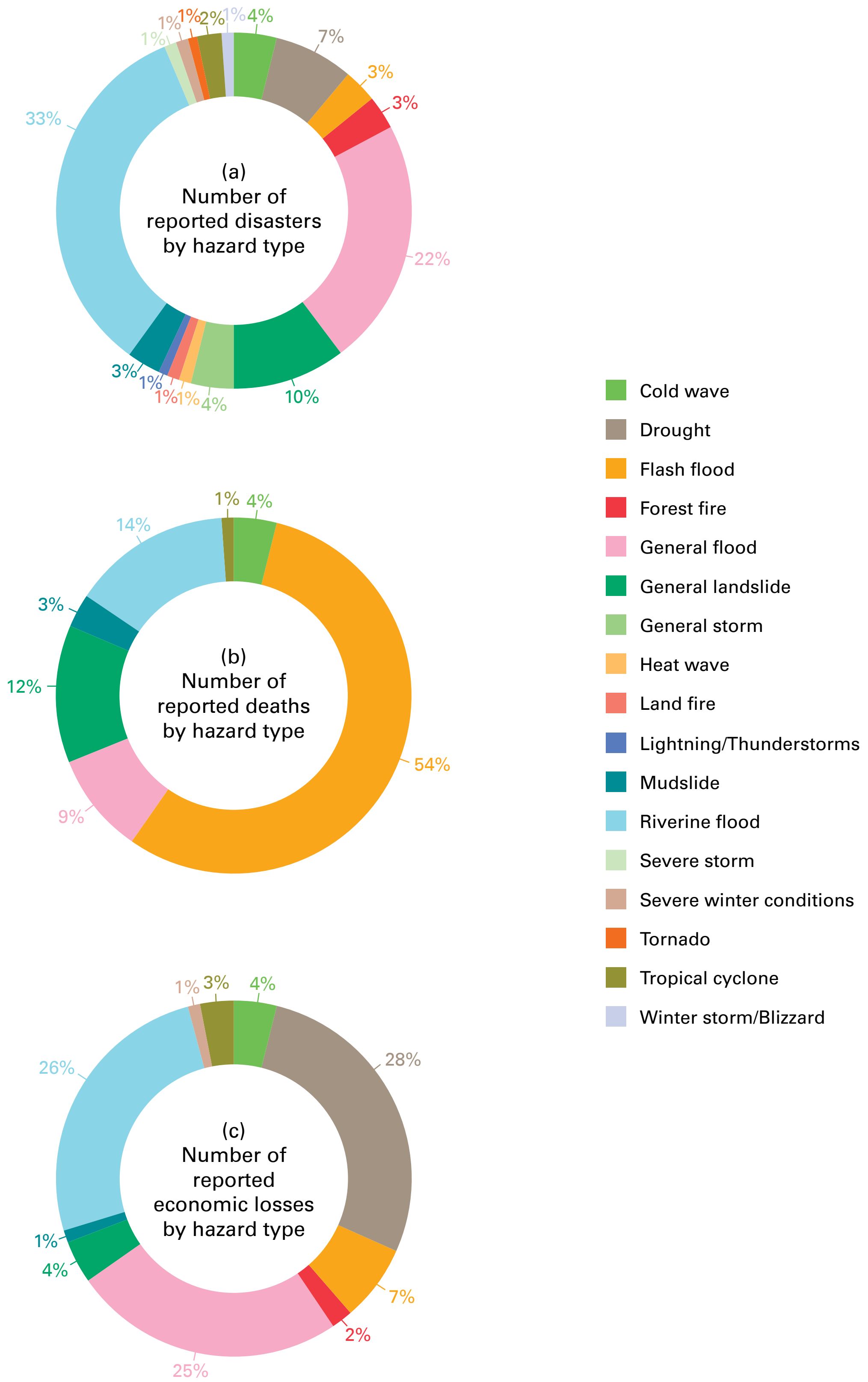


Figure 17. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard in South America (1970–2019)

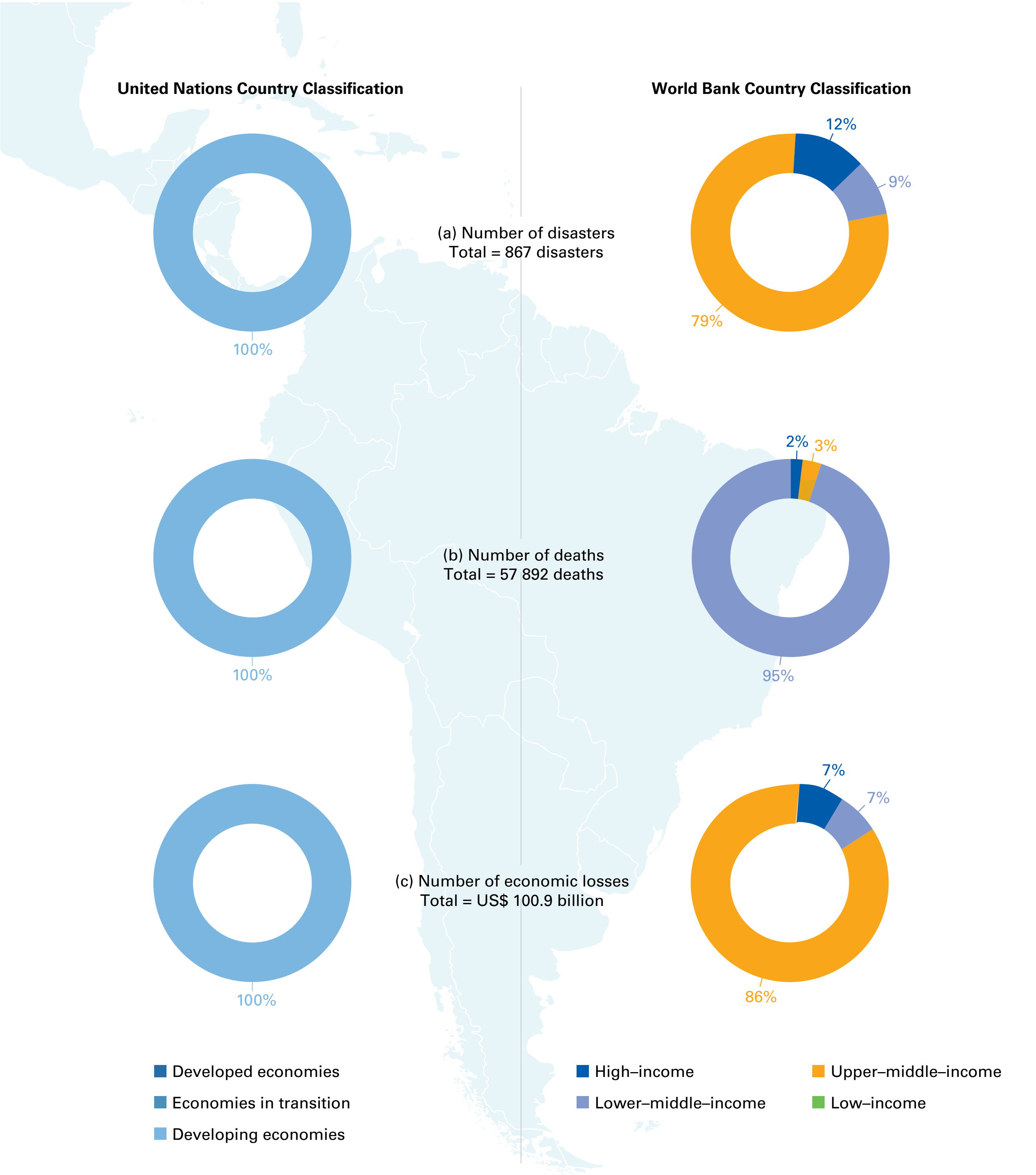


Figure 18. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by United Nations country classification in South America (1970–2019). Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

Figure 19. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by World Bank country classification in South America (1970–2019). Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

NORTH AMERICA, CENTRAL AMERICA AND THE CARIBBEAN

Economic losses related to weather, climate and water extremes have increased TENFOLD over the past 50 years.

In North America, Central America and the Caribbean, 1 977 recorded disasters, 74 839 deaths and economic losses of US$ 1.7 trillion. The region accounted for 18% of weather-, climate- and water-related disasters, 4% of associated deaths and 45% of associated economic losses worldwide over the past 50 years. Storms (54%) and floods (31%) were the most prevalent cause of recorded disasters. Storms were linked to the greatest loss of life (71%) and economic losses (78%) in the region. The distributions of deaths and economic losses are indicated by country in Maps 7 and 8.

The United States accounts for one third (38%) of global economic losses caused by weather, climate and water hazards.

Top 10 deaths and economic losses

The top 10 deadliest events accounted for 54% of the total reported lives lost (40 157 deaths) and the top 10 costliest events accounted for 36% of all losses (US$ 597.1 billion) in North America, Central America and the Caribbean (Table 5 (a, b)).

The top 10 disasters in terms of economic losses in the region all occurred in the United States. Eight out of the top 10 events were due to storms and seven occurred during the most recent decade 2010–2019; during this decade 90% of economic losses in the region were associated with storms in the United States.

Disasters and impacts by decade

There was a substantial increase in the number of disasters and economic losses by decade associated with weather-, climate- and water-related hazards in the region while deaths have generally decreased over the 50-year period (Figure 20).

The number of recorded disasters has increased over the 50 years, from a disaster occurring on average every 30 days in the 1970s to every seven days for the three decades between 1990 and 2019. The United States accounted for nearly half (43%) of weather-, climate- and water-related disasters in the region over the period.

In terms of human losses, the deadliest events recorded were in Honduras and Nicaragua, where Hurricane *Mitch* resulted in 17 932 deaths in 1998, and again in Honduras in 1974 where Hurricane *Fifi* resulted in approximately 8 000 deaths. However, in terms of economic losses, Hurricane *Katrina* in 2005, which contributed to US$ 163.6 billion in losses, stands out as the costliest disaster, followed by three hurricanes in 2017, *Harvey* (US$ 96.94 billion), *Maria* (US$ 69.39 billion) and *Irma* (US$ 58.16 billion).

Economic losses in the region increased tenfold over the 50-year period. It is noteworthy that the United States accounts for 83% (US$ 1.4 trillion) of economic losses reported in the region and 38% worldwide. The United States recorded 203 disasters that caused more than US$ 1 billion in economic losses each.

Distribution of disasters and impacts by hazard

Figure 21(a–c) shows the distribution in terms of total number, resulting deaths and economic losses as a function of hazard type. The analysis shows that three hazards were most prelavent: tropical cyclones (27%), riverine floods (17%) and general floods (10%). Tropical cyclones (60%) and riverine floods (14%) accounted for most of the lives lost. In terms of economic losses, tropical cyclones were also the prevalent hazard, accounting 58% of total damages in the region in all categories. Tropical cyclones were thus the most prevalent hazard.

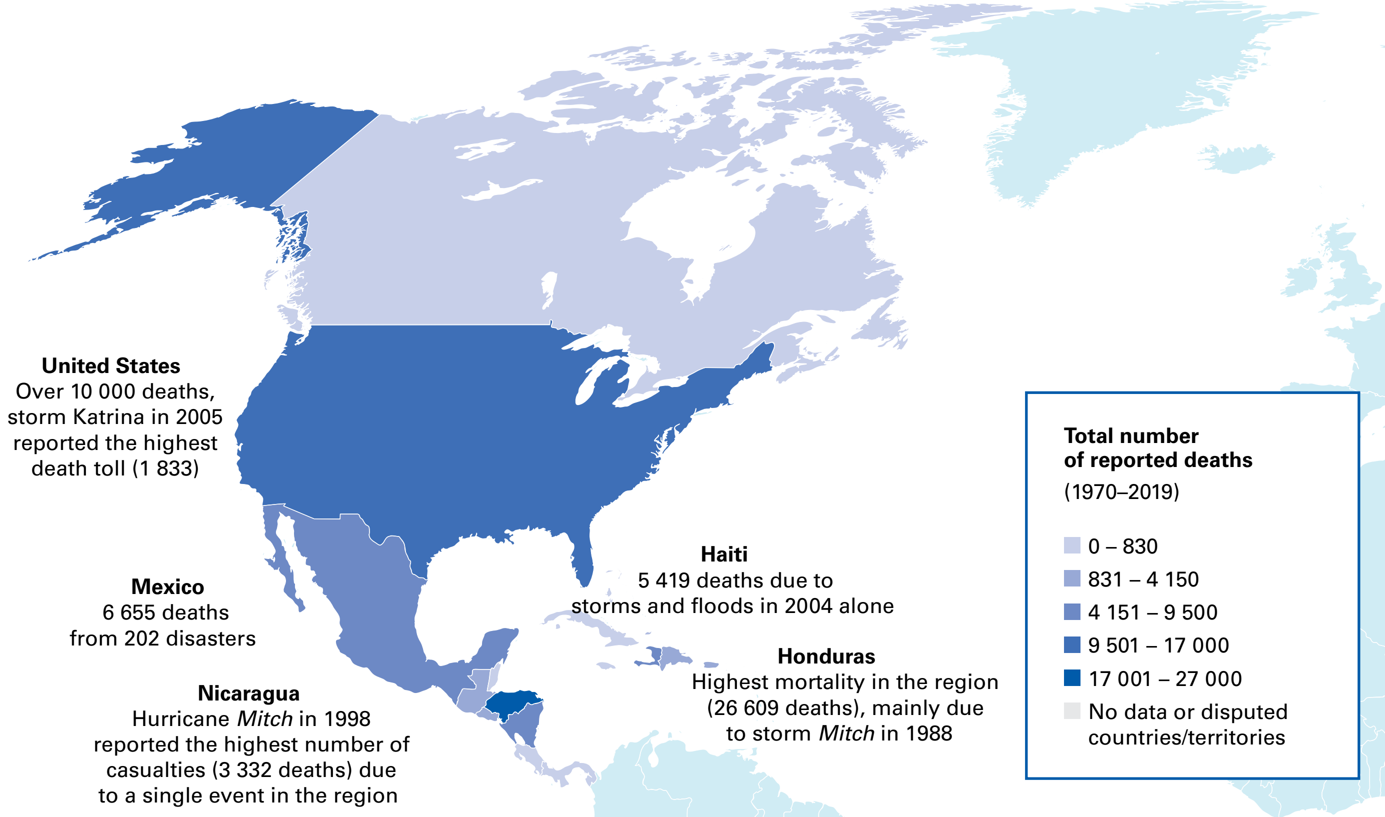
Distribution of disasters and their impacts by United Nations and World Bank country classification

Analysis of the EM-DAT record by the United Nations country classification shows half of disasters were reported in both developed and developing economies (49% each), while 76% of deaths occurred in countries with developing economies and 86% of economic losses were reported in countries with developed economies (Figure 22). Using the World Bank country classification, 87% of reported disasters occurred in high-income to upper-middle-income countries, 56% of reported deaths occurred in lower-middle-income and low-income countries, and 93% of reported economic losses occurred in high-income countries (Figure 23).

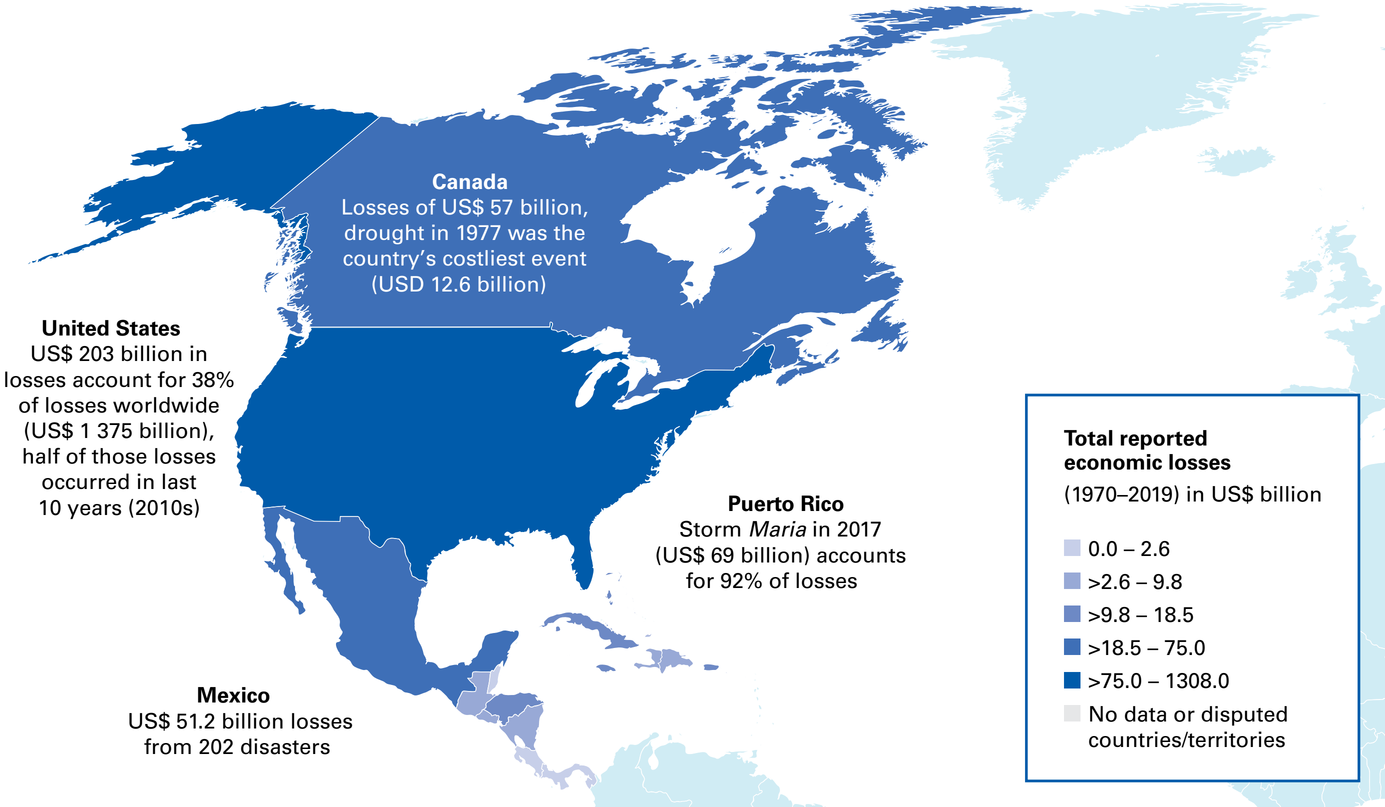
Table 5. Top 10 disasters in North America, Central America and the Caribbean ranked according to reported (a) deaths and (b) economic losses (1970–2019)

(a)	Disaster type	Year	Country	Deaths
1	Storm (*Mitch*)	1998	Honduras	14 600
2	Storm (*Fifi*)	1974	Honduras	8 000
3	Storm (*Mitch*)	1998	Nicaragua	3 332
4	Landslide	1973	Honduras	2 800
5	Storm (*Jeanne*)	2004	Haiti	2 754
6	Flood	2004	Haiti	2 665
7	Storm (*Katrina*)	2005	United States	1 833
8	Storm (*Stan*)	2005	Guatemala	1 513
9	Storm	1979	Dominican Republic	1 400
10	Extreme temperature	1980	United States	1 260
(b)	**Disaster type**	**Year**	**Country**	**Economic losses (in US$ billion)**
1	Storm (*Katrina*)	2005	United States	163.61
2	Storm (*Harvey*)	2017	United States	96.94
3	Storm (*Maria*)	2017	Puerto Rico	69.39
4	Storm (*Irma*)	2017	United States	58.16
5	Storm (*Sandy*)	2012	United States	54.47
6	Storm (*Andrew*)	1992	United States	48.27
7	Storm (*Ike*)	2008	United States	35.63
8	Wildfire	2019	United States	24.46
9	Storm (*Ivan*)	2004	United States	24.36
10	Drought	2012	United States	21.79

Aftermath of hurricane in Florida Keys leaves piles of trash and debris. (Jodi Jacobson/iStock)



Map 7. Reported disasters and related deaths in North America, Central America and the Caribbean (1970–2019)



Map 8. Reported disasters and related economic losses in North America, Central America and the Caribbean (1970–2019)

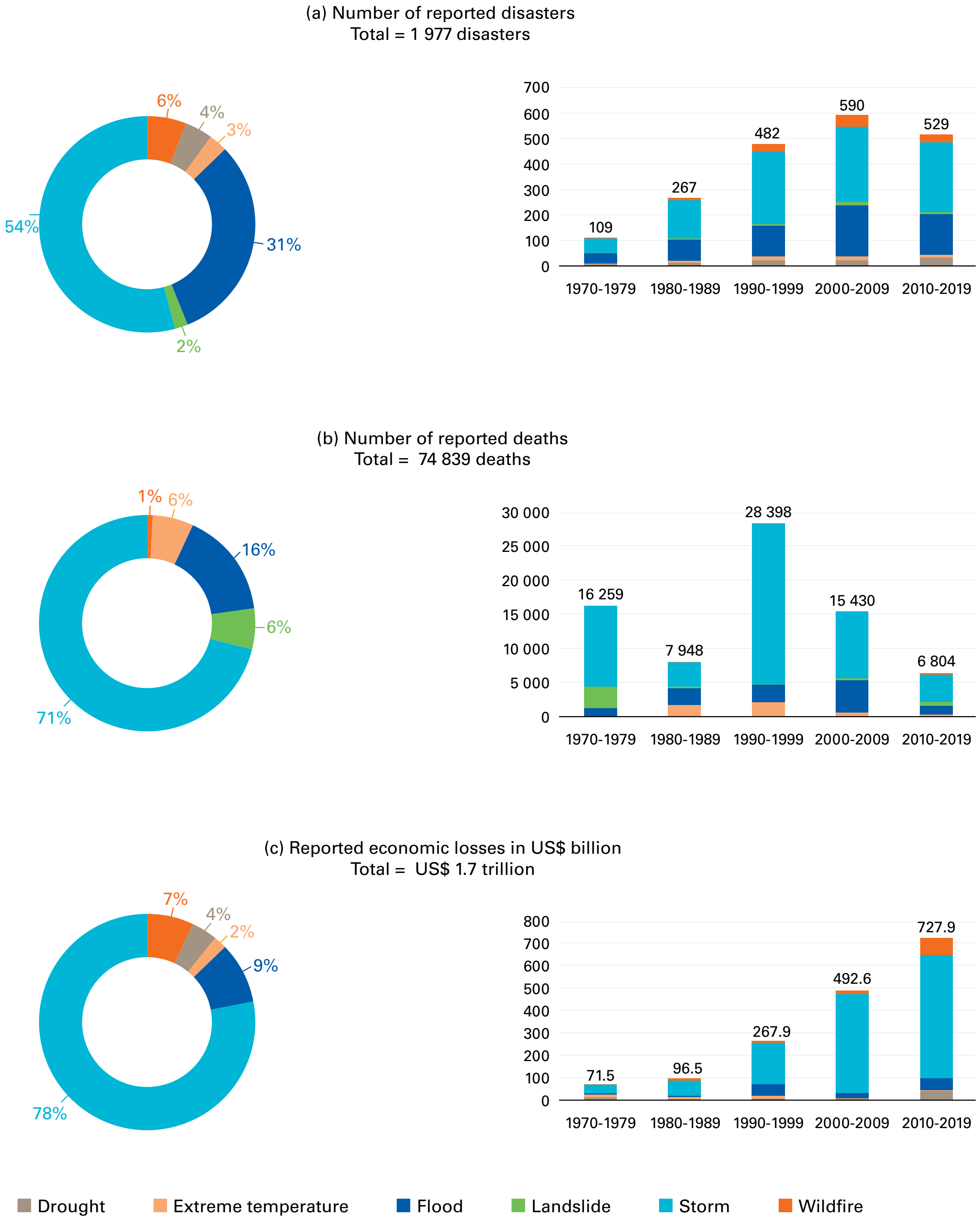


Figure 20. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard type and by decade in North America, Central America and the Caribbean

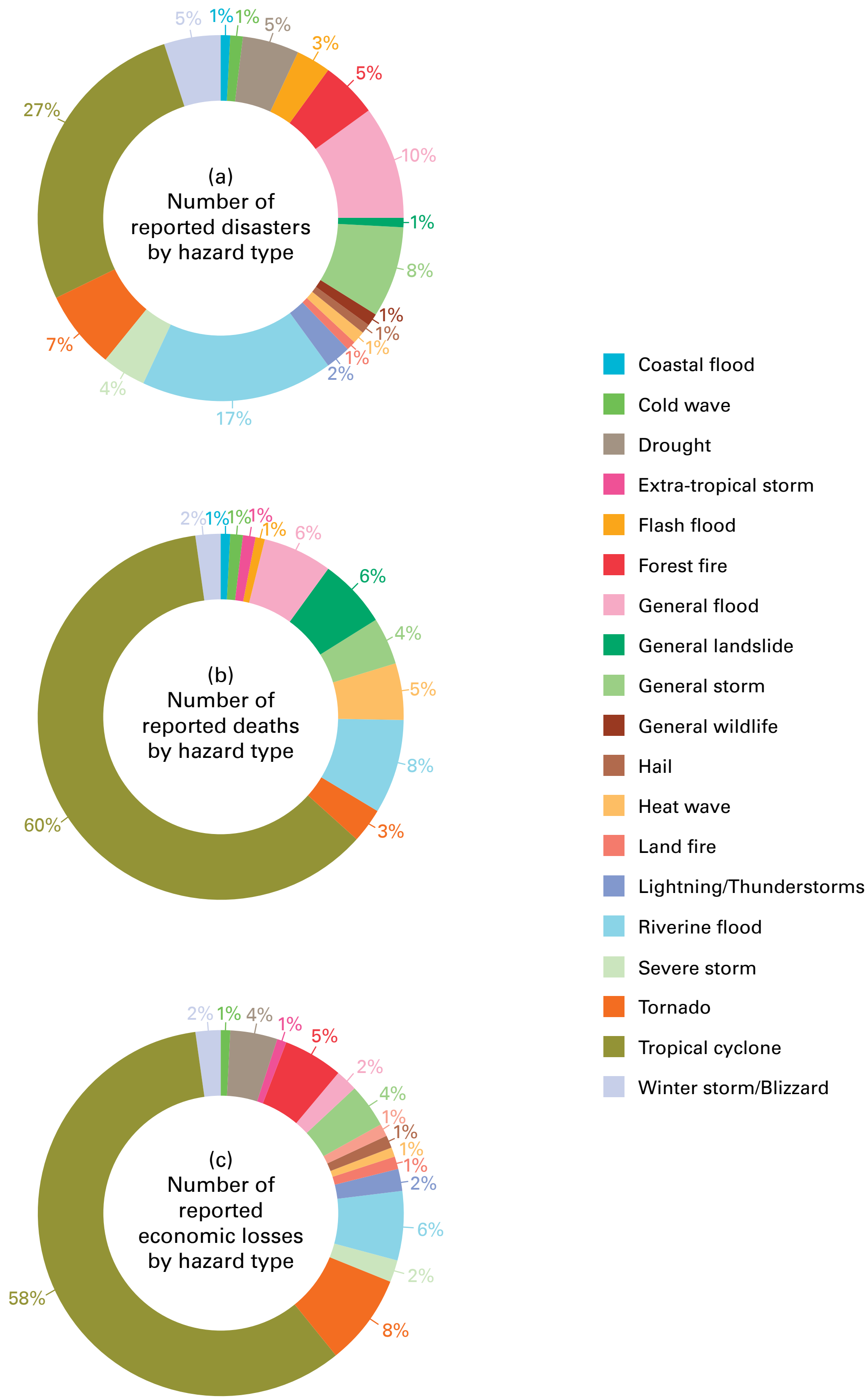


Figure 21. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard in North America, Central America and the Caribbean (1970–2019)

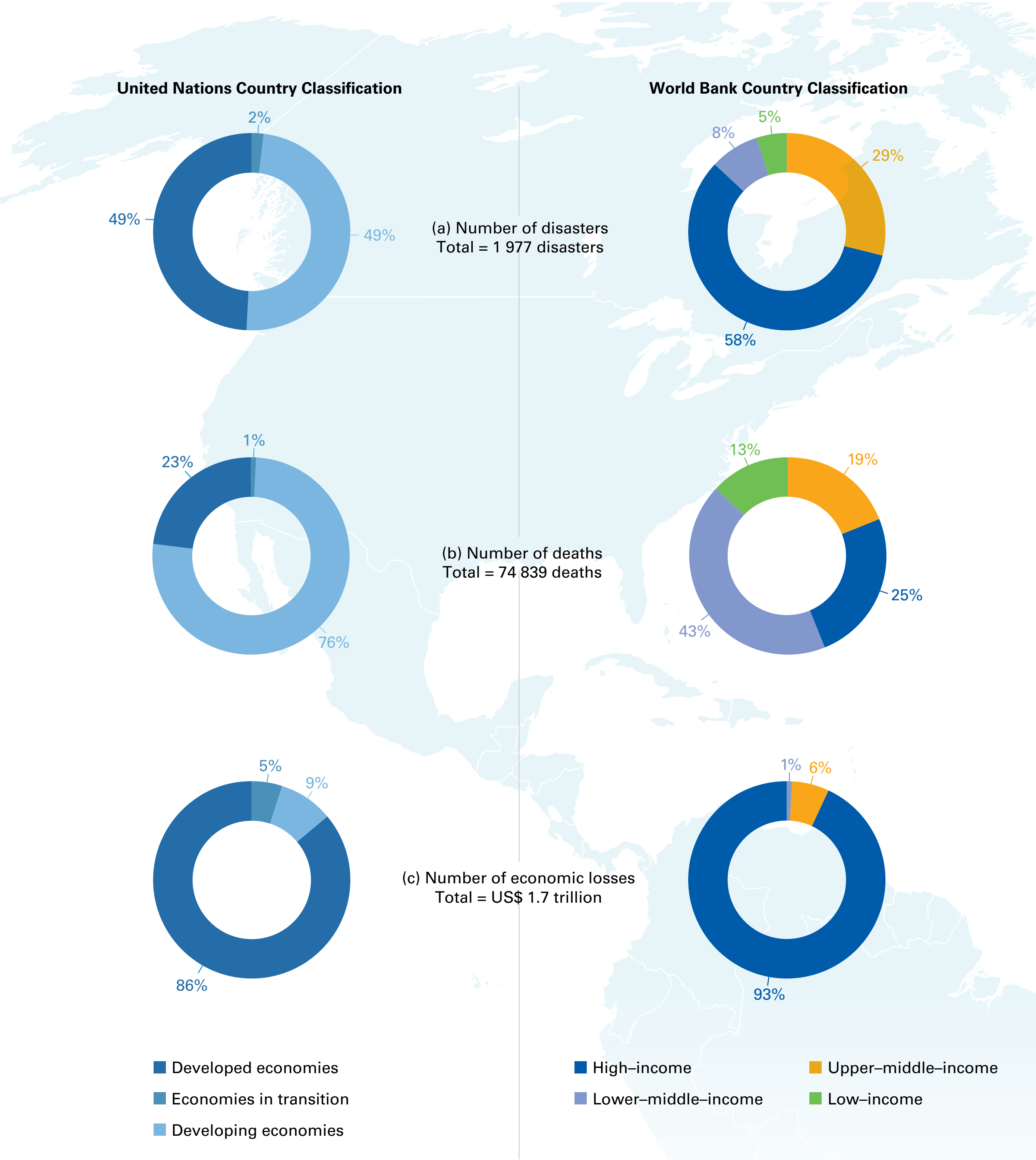
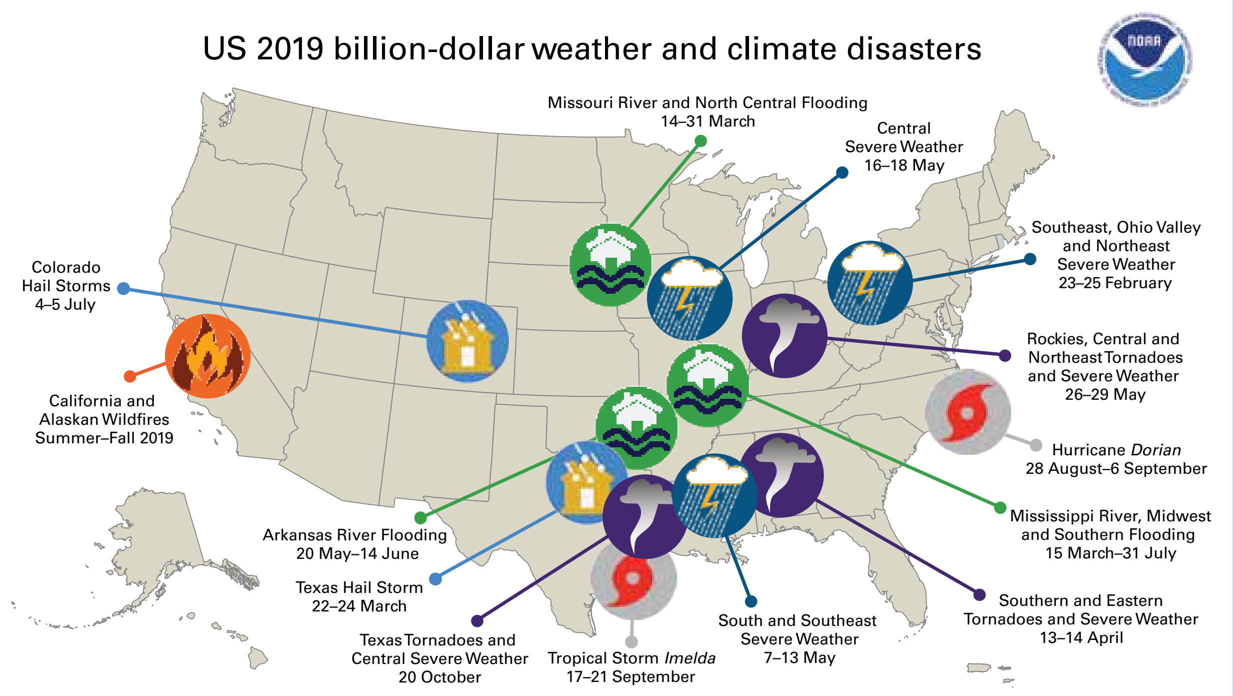


Figure 22. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by United Nations country classification in North America, Central America and the Caribbean (1970–2019)

Figure 23. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by World Bank country classification in North America, Central America and the Caribbean (1970–2019). Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

Box 2. Billion-dollar disasters in the United States

In 2019 there were 14 weather- and climate-related disaster events with losses exceeding US$1 billion each across the United States (National Oceanic and Atmospheric Administration (NOAA) NCEI, 2020). These events included three floods, eight severe storms, two tropical cyclones and a wildfire. Overall, these events resulted in the deaths of 44 people. 2019 marked the fifth consecutive year (2015–2019) in which 10 or more billion-dollar disasters had occurred in the United States – a record (Smith, 2020). The 1980–2019 annual average is 6.5 events (consumer price index (CPI) adjusted); the annual average for the most recent 5 years (2015–2019) is 13.8 events (CPI adjusted). The United States experienced more than twice the number of billion-dollar weather- and climate-related disasters during the 2010s (119) as compared with the 2000s (59) even after adjusting for inflation (as of January 2020).



This map denotes the approximate location for each of the 14 separate billion-dollar weather and climate disasters that impacted the United States during 2019.

Source: Information and illustration from NOAA NCEI, 2020.

Satellite picture of catastrophic Hurricane *Dorian* nearly stationary on Monday, 2 September 2019. The destructive Category 5 hurricane-with 200 mph wind gusts and a storm surge of 18–23 feet above normal tide levels devastated through Bahama Islands (NOAA).

SOUTH-WEST PACIFIC

Of all deaths caused by weather, climate and water hazards in the South-West Pacific, 75% were recorded in the Philippines, which averaged 1 000 deaths per year over the 50-year period.

The South-West Pacific region recorded 1 407 disasters, 65 391 deaths, and US$ 163.7 billion in economic losses between 1970 and 2019. Most of these disasters were associated with storms (45%) and floods (39%). Storms accounted for the greatest number of deaths (71%). Economic losses were evenly distributed among four hazard types: storms (46%), floods (24%), drought (17%) and wildfire (13%). The distributions of deaths and economic losses are indicated by country/territory in Maps 9 and 10.

Disasters resulting from weather, climate and water hazards in Australia accounted for 54% (US$ 88.2 billion) of economic losses in the entire South-West Pacific.

Top 10 deaths and economic losses

Storms were the most prevalent hazard, causing the greatest number of disasters (45%), highest number of deaths (71%) and largest economic losses (46%) in the South-West Pacific. The top 10 recorded disasters accounted for 39% of the deaths (25 394 deaths) and 42% of the economic losses (US$ 68.6 billion) in the region. The list of top 10 deadliest events is dominated by tropical cyclone in the Philippines (8 out of the 10) while seven out of the ten most costly events occurred in Australia (see Table 6 (a, b)).

Disasters and impacts by decade

The number of disasters reported in the South-West Pacific tripled over the 50-year period every 30 days on average. A disaster on average was reported in the 1970s, every 15 days in the 1980s and 1990s, every 10 days through the 2010s (Figure 24).

The number of deaths reported has increased slightly over the past 50 years. The deadliest event was Tropical Cyclone *Haiyan* in the Philippines in 2013, which claimed 7 354 lives. The Philippines accounts for 75% of all deaths (48 950) in the region (Figure 24).

Economic losses have fluctuated over the past 50 years, however, a substantial increase in the 2010s is linked to an increase in storms and floods.

Distribution of disasters and impacts by hazard

Tropical cyclones (36%), riverine floods (16%) and general floods (13%) were the most prevalently hazards associated with disasters. Tropical cyclones accounted for 69% of deaths in the region. In terms of economic losses, tropical cyclones cumulated 37% of damages, followed by riverine floods (17%), droughts (16%) and forest fires (11%) (Figure 25).

Distribution of disasters and their impacts by United Nations and World Bank country classification

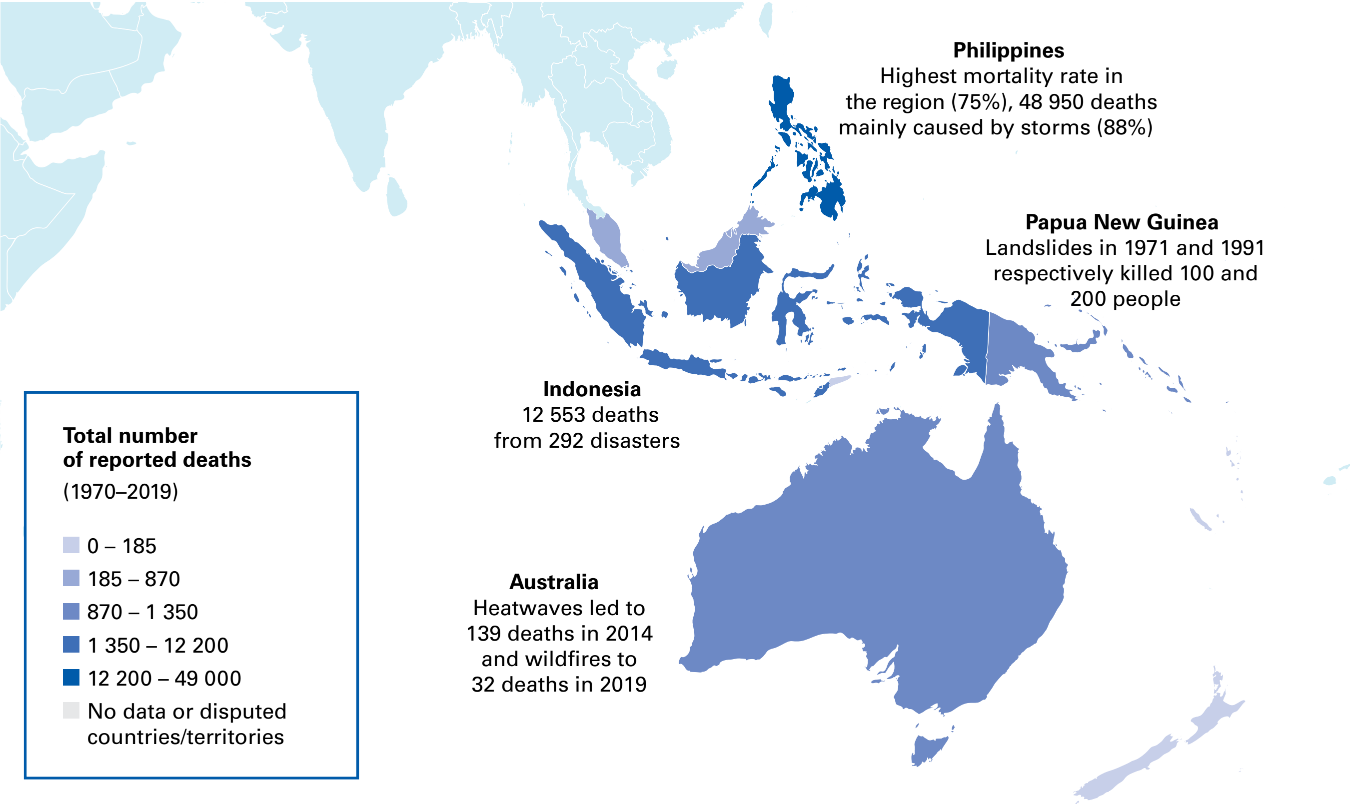
Using the United Nations country classification, 80% of the reported disasters and 98% of reported deaths occurred in countries with developing economies, while less than half (44%) of reported economic losses occurred in developing economies (Figure 26). Analysis based on the World Bank country classification scheme shows that while 88% of reported disasters occurred in high-income to upper-middle-income countries, 96% of the reported deaths and 39% of reported economic losses occurred in lower-middle-income countries (Figure 27).

Table 6. Top 10 disasters in the South-West Pacific ranked according to reported (a) deaths and (b) economic losses (1970–2019)

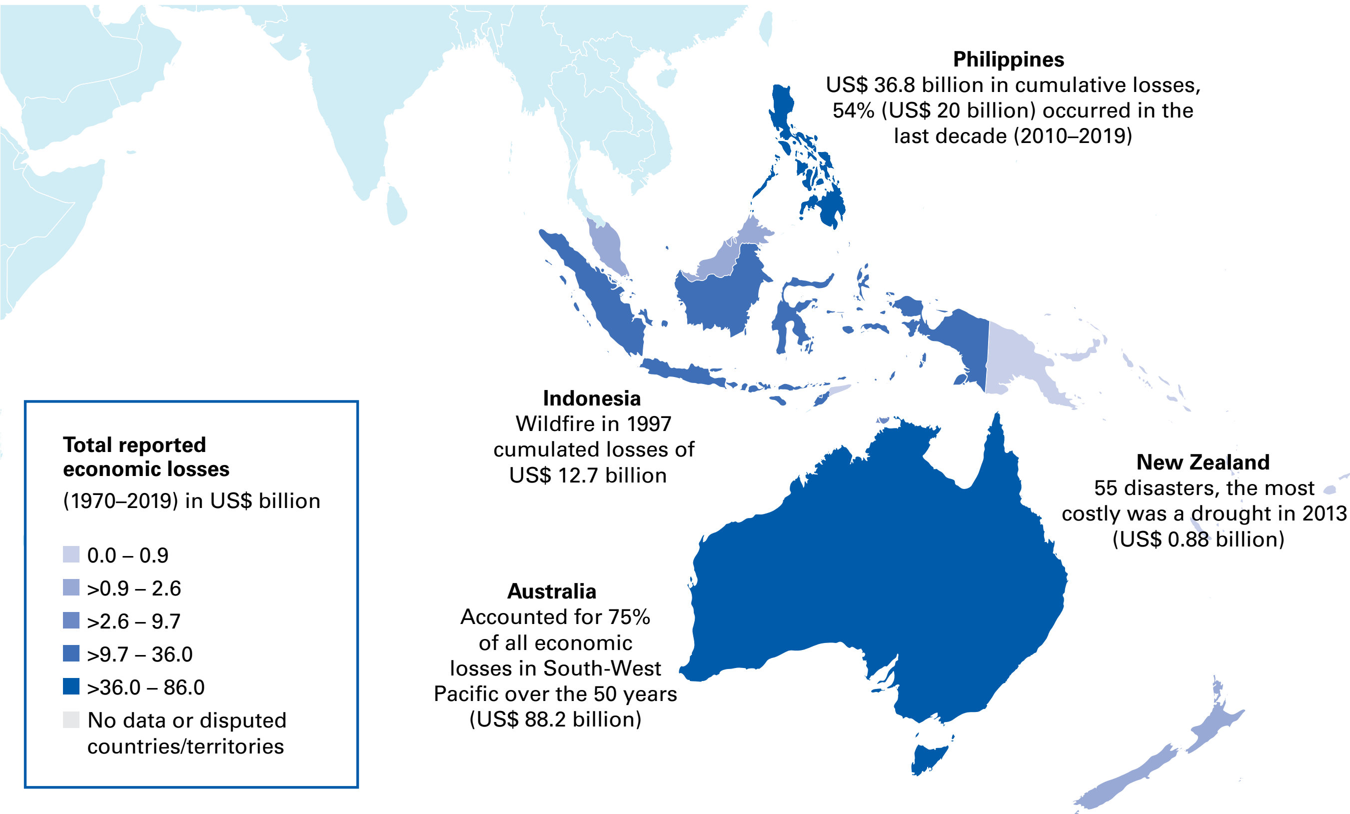
(a)	Disaster type	Year	Country	Deaths
1	Storm (*Haiyan*)	2013	Philippines	7 354
2	Storm (*Thelma*)	1991	Philippines	5 956
3	Storm (*Bopha*)	2012	Philippines	1 901
4	Storm	1973	Indonesia	1 650
5	Storm (*Winnie*)	2004	Philippines	1 619
6	Storm (*Joan & Kate*)	1970	Philippines	1 551
7	Storm (*Washi*)	2011	Philippines	1 439
8	Storm (*Ike*)	1984	Philippines	1 399
9	Storm (*Durian*)	2006	Philippines	1 399
10	Landslide	2006	Philippines	1 126
(b)	Disaster type	Year	Country	Economic losses (in US$ billion)
1	Drought	1981	Australia	16.85
2	Wildfire	1997	Indonesia	12.74
3	Storm (*Iniki*)	2013	Philippines	10.74
4	Flood	2010	Australia	8.56
5	Storm (*Tracy*)	1974	Australia	4.15
6	Storm (*Alby*)	1978	Australia	3.92
7	Flood	2013	Indonesia	3.22
8*	Drought	2002	Australia	2.84
8*	Storm	2011	Australia	2.84
10	Storm	2017	Australia	2.76

* Countries that have identical figures for deaths or economic losses are ranked jointly.

A sweeping shot of Barangay Anibong, taken in the Philippine city of Tacloban after Typhoon Haiyan struck in November 2013. (Tigeryan/iStock)



Map 9. Reported disasters and their related deaths in the South-West Pacific (1970–2019)



Map 10. Reported disasters and their related economic losses in the South-West Pacific (1970–2019)

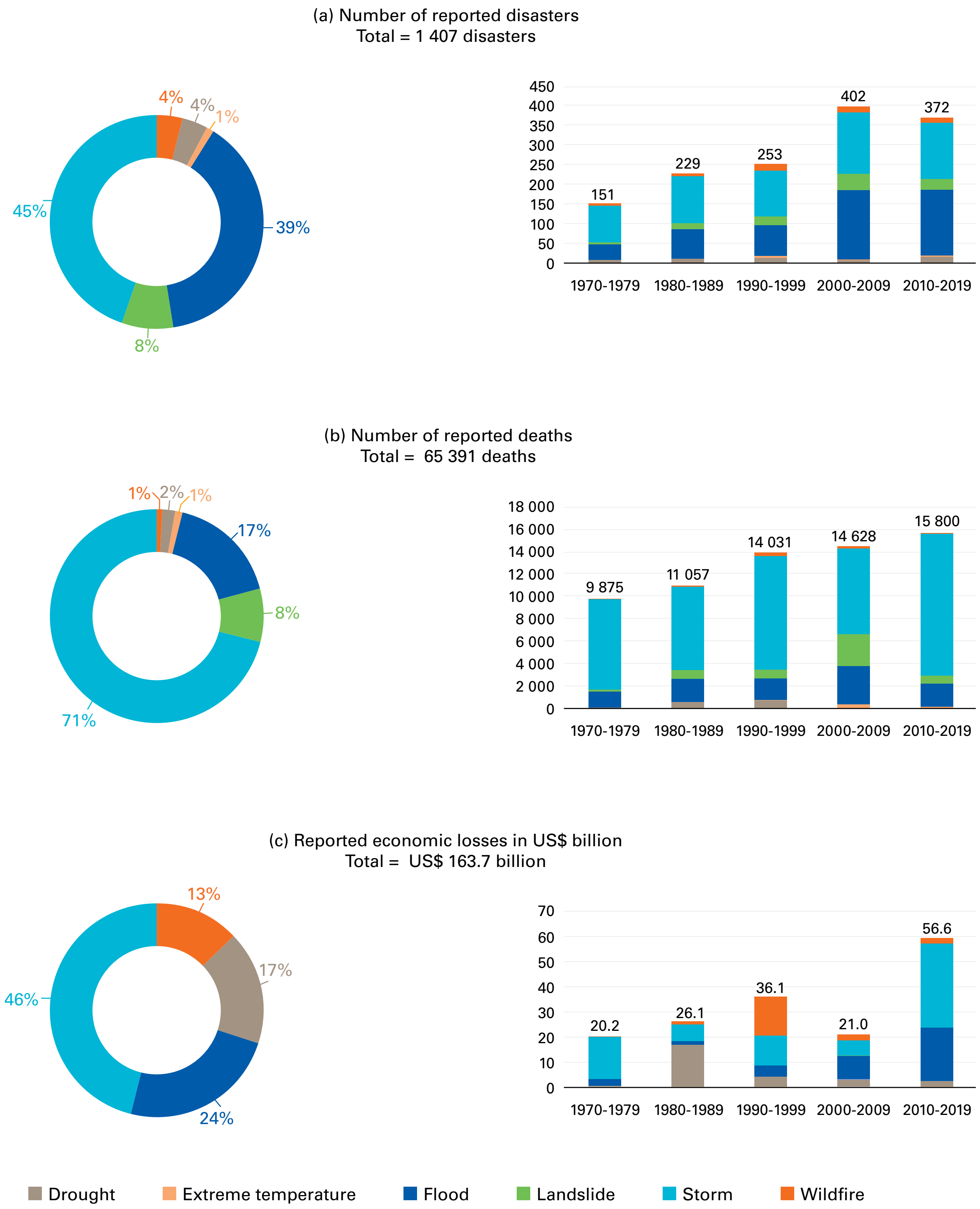


Figure 24. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard type and by decade in the South-West Pacific

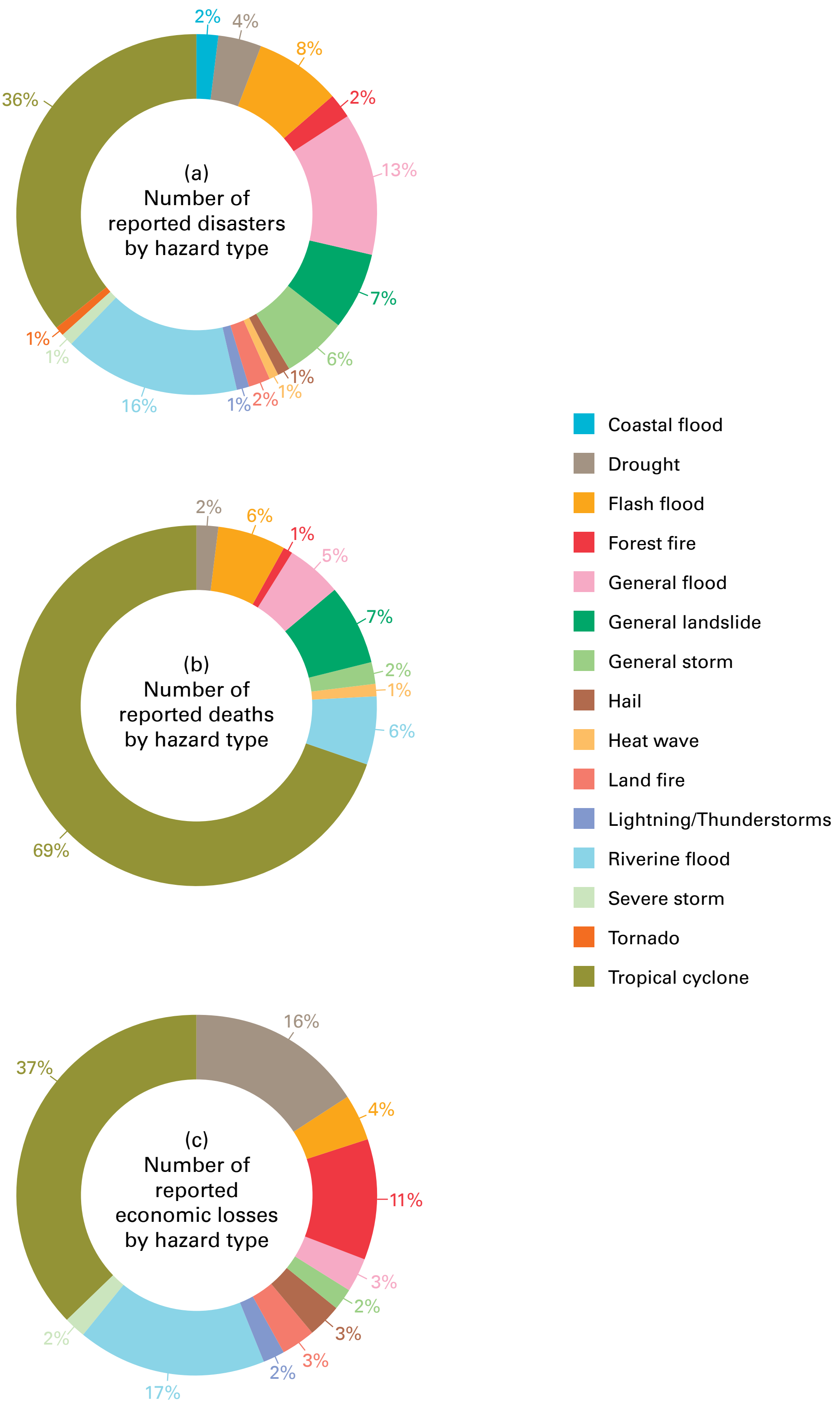
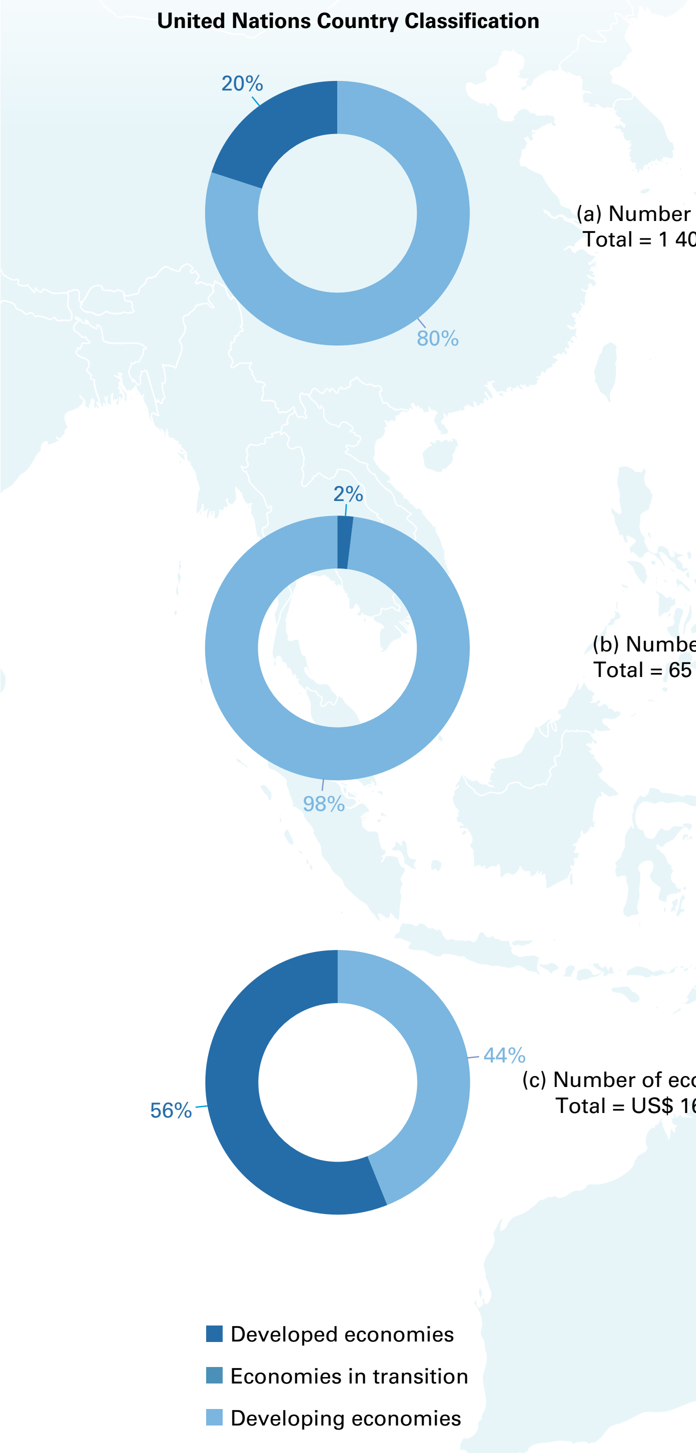


Figure 25. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard in the South-West Pacific (1970–2019)



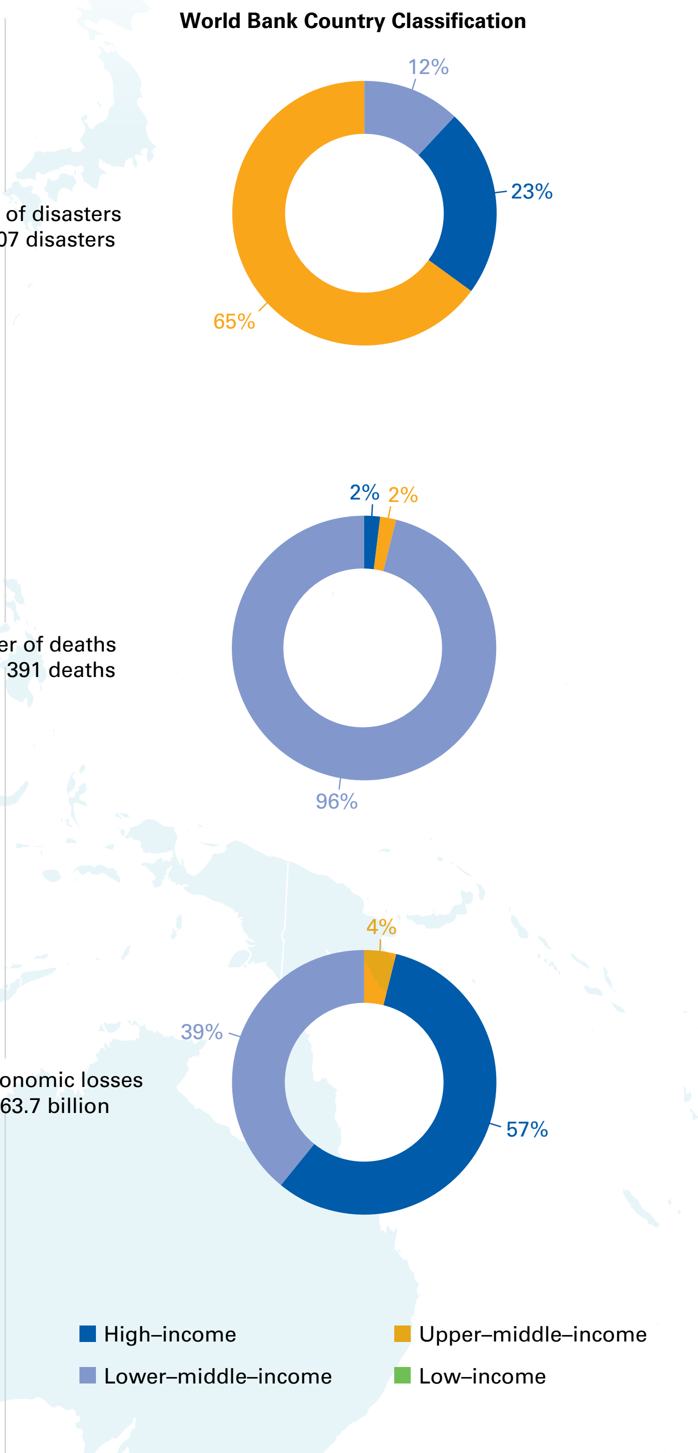


Figure 26. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by United Nations country classification in the South-West Pacific (1970–2019). Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

Figure 27. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by World Bank country classification in the South-West Pacific (1970–2019). Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

EUROPE

Over the 50-year period, two heatwave accounted for 80% of deaths resulting from weather-, climate- and water-related disasters in Europe.

In Europe, 1 672 recorded disasters cumulated 159 438 deaths and US$ 476.5 billion in economic damages from 1970–2019.

Although floods (38%) and storms (32%) were the most prevalent cause in the recorded disasters, extreme temperatures accounted for the highest number of deaths (93%), with 148 109 lives lost over the 50 years. Floods (36%) and storms (44%) incurred the most economic losses in the Europe. The distributions of deaths and economic losses are indicated by country in Maps 11 and 12.

The two extreme heatwaves of 2003 and 2010 accounted for the highest number of deaths (80%), with 127 946 lives lost in the two events. These two events skew the statistics on the number of deaths in Europe. The 2003 heatwave was responsible for half of the deaths in Europe (45%) with a total of 72 210 deaths within the 15 affected countries. The 2003 heatwave event accounted for over 90% of deaths reported in three countries over the 50 years: Germany (95%), Italy (94%) and Spain (90%) (Table 7 (a, b); Figure 28).

Top 10 deaths and economic losses

The 10 worst weaather-, climate- and water-related disasters accounted for 81% of total lives lost (129 333 deaths) and 23% of economic losses (US$ 111.52 billion) (Table 7 (a, b)). The top 10 deadliest event list is dominated by extreme temperatures and the top 10 costliest events by floods and storms. The 2010 heatwave that contributed to 55 736 deaths in Russia is the deadliest recorded event in Europe and within the Russian Federation, accounting for 94% of deaths related to weather, climate and water hazards. Floods and storms inflicted the largest economic losses during the period (US$ 377.5 billion). The 2002 flood in Germany accrued US$ 16.48 billion in losses and was the costliest event in Europe over the 50 years (Table 7 (b)).

The 2003 heatwave caused over 90% of deaths over the 50-year period in three countries: Germany (95%), Italy (94%) and Spain (90%).

Disasters and impacts by decade

When viewed by decade, the number of disasters and economic losses attributed to weather-, climate- and water-related disasters on average have increased (Figure 28). There was a substantial increase in deaths over the last two decades, primarily due to the heatwaves of 2003 and 2010. Economic losses due to disasters also increased, although the 2010s experienced reduced damages in comparison with the 1990s and 2000s.

Distribution of disasters and impacts by hazard

The distribution of disasters by related hazard shows that riverine floods (22%), general storms (14%) and general floods (10%) were most prevalent hazards in Europe. Heatwaves caused the greatest number of human losses (89%). Five hazards accounted for most of the economic losses: riverine floods (27%), general storms (15%), extratropical storms (14%), general floods (11%) and droughts (10%) (Figure 29).

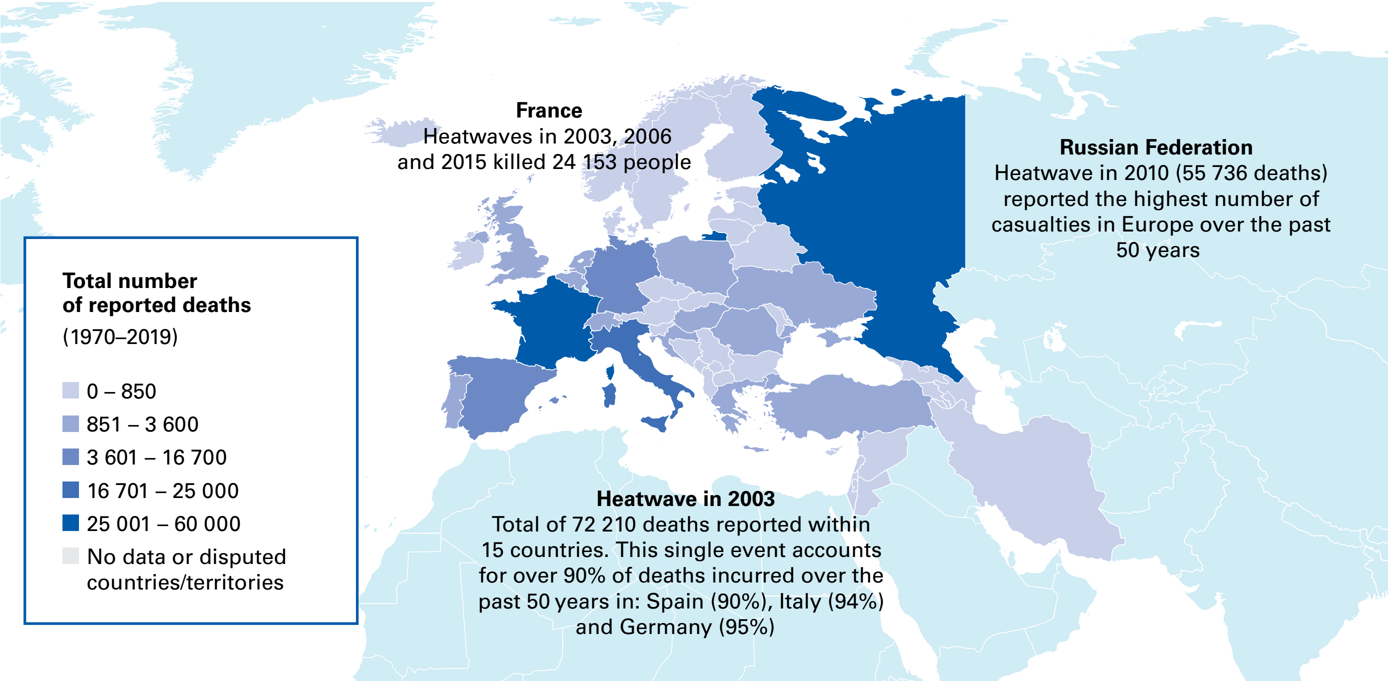
Disaster impacts by United Nations and World Bank country classification

Analysing the data according to United Nations and World Bank country classification schemes shows the majority of disasters, deaths and economic losses occurred in countries with developed economies and high-income countries (Figures 30 and 31). These statistics are skewed due to the two aforementioned heatwaves of 2003 and 2010.

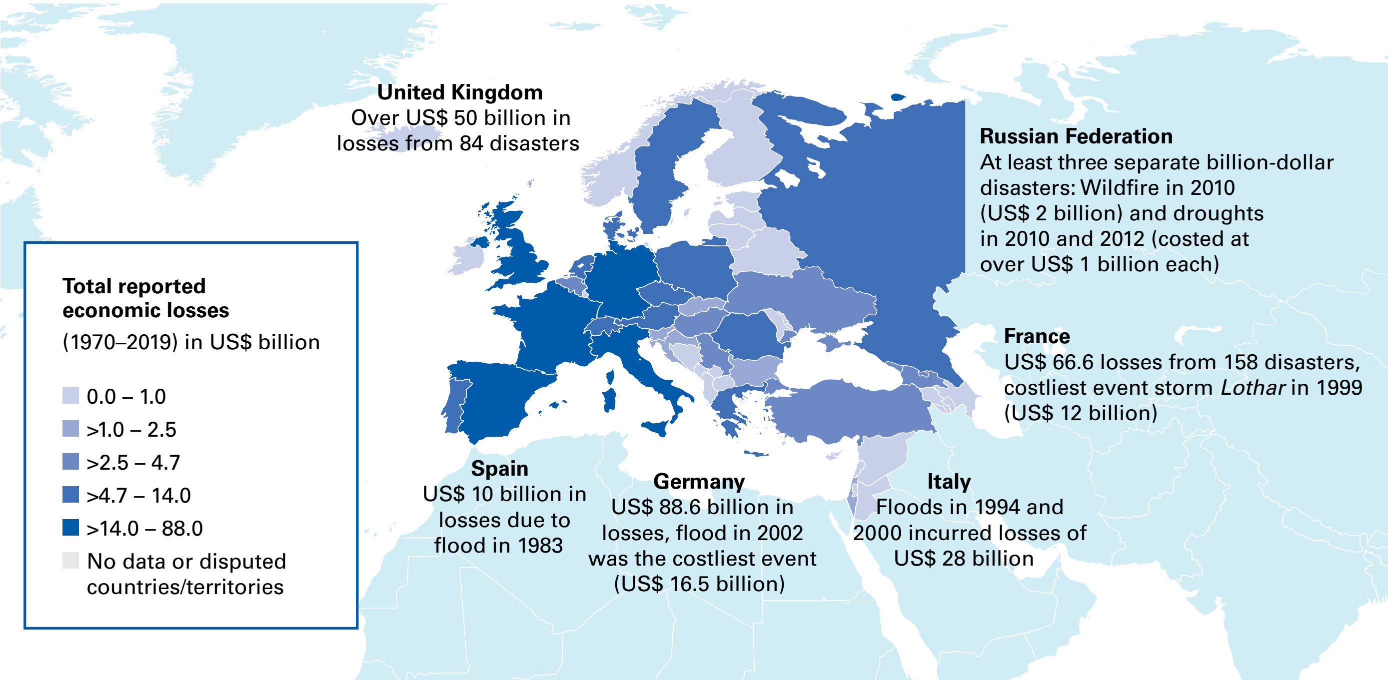
Table 7. Top 10 disasters in Europe ranked according to reported (a) deaths and (b) economic losses (1970–2019)

(a)	Disaster type	Year	Country	Deaths
1	Extreme temperature	2010	Russian Federation	55 736
2	Extreme temperature	2003	Italy	20 089
3	Extreme temperature	2003	France	19 490
4	Extreme temperature	2003	Spain	15 090
5	Extreme temperature	2003	Germany	9 355
6	Extreme temperature	2015	France	3 275
7	Extreme temperature	2003	Portugal	2 696
8	Extreme temperature	2006	France	1 388
9	Extreme temperature	2003	Belgium	1 175
10	Extreme temperature	2003	Switzerland	1 039
(b)	**Disaster type**	**Year**	**Country**	**Economic losses (in US$ billion)**
1	Flood	2002	Germany	16.48
2	Flood	1994	Italy	16.03
3	Flood	2013	Germany	13.86
4	Storm	1999	France	12.27
5	Flood	2000	Italy	11.87
6	Flood	1983	Spain	10.0
7	Drought	1990	Spain	8.81
8	Flood	2000	United Kingdom	8.75
9	Storm	2007	Germany	6.78
10	Storm	1990	United Kingdom	6.65

Flooding in Steyr, Austria, June 2009 (Gina Sanders/AdobeStock)



Map 11. Reported disasters and their related deaths in Europe (1970–2019)



Map 12. Reported disasters and their related economic losses in Europe (1970–2019)

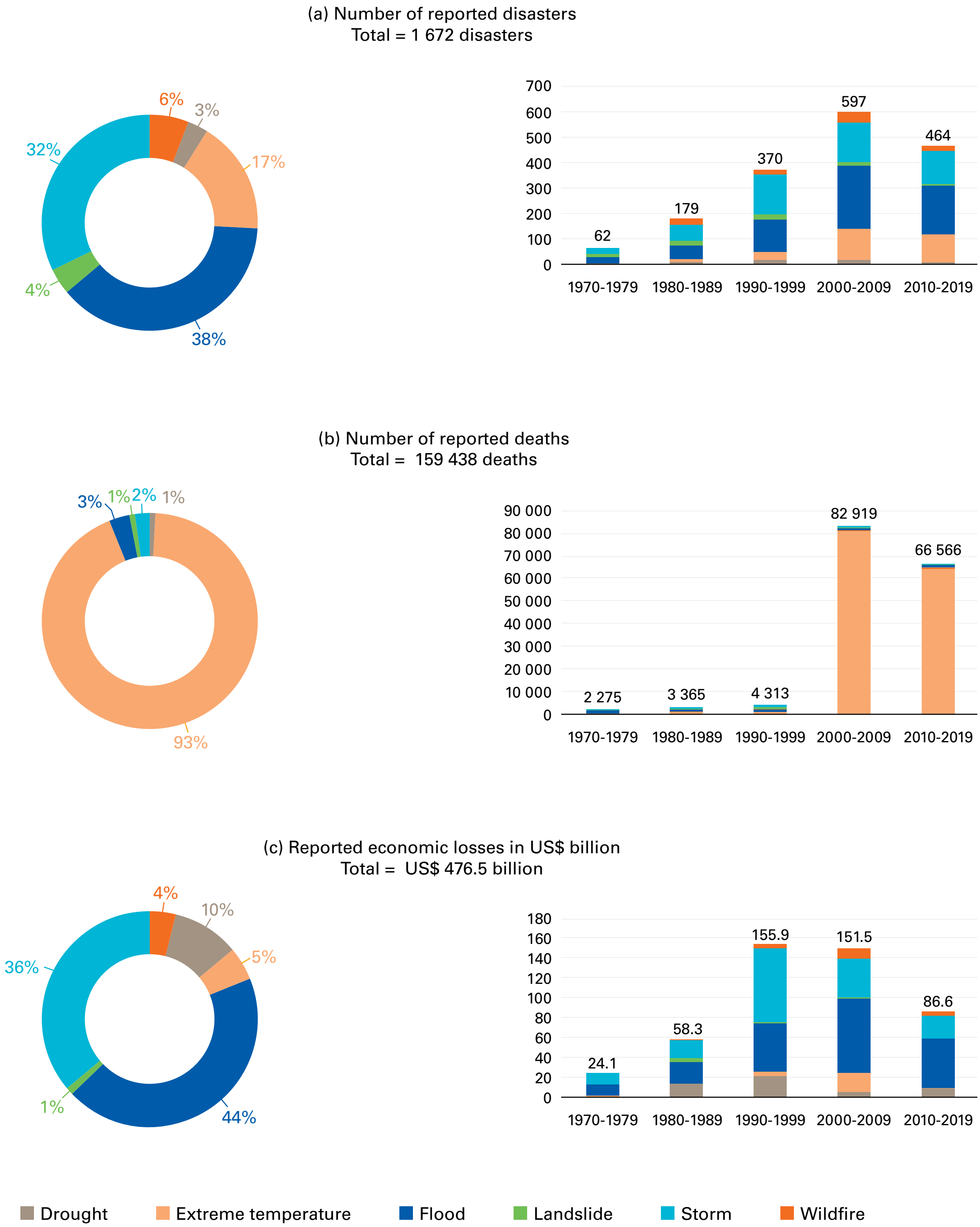


Figure 28. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard type and by decade in Europe

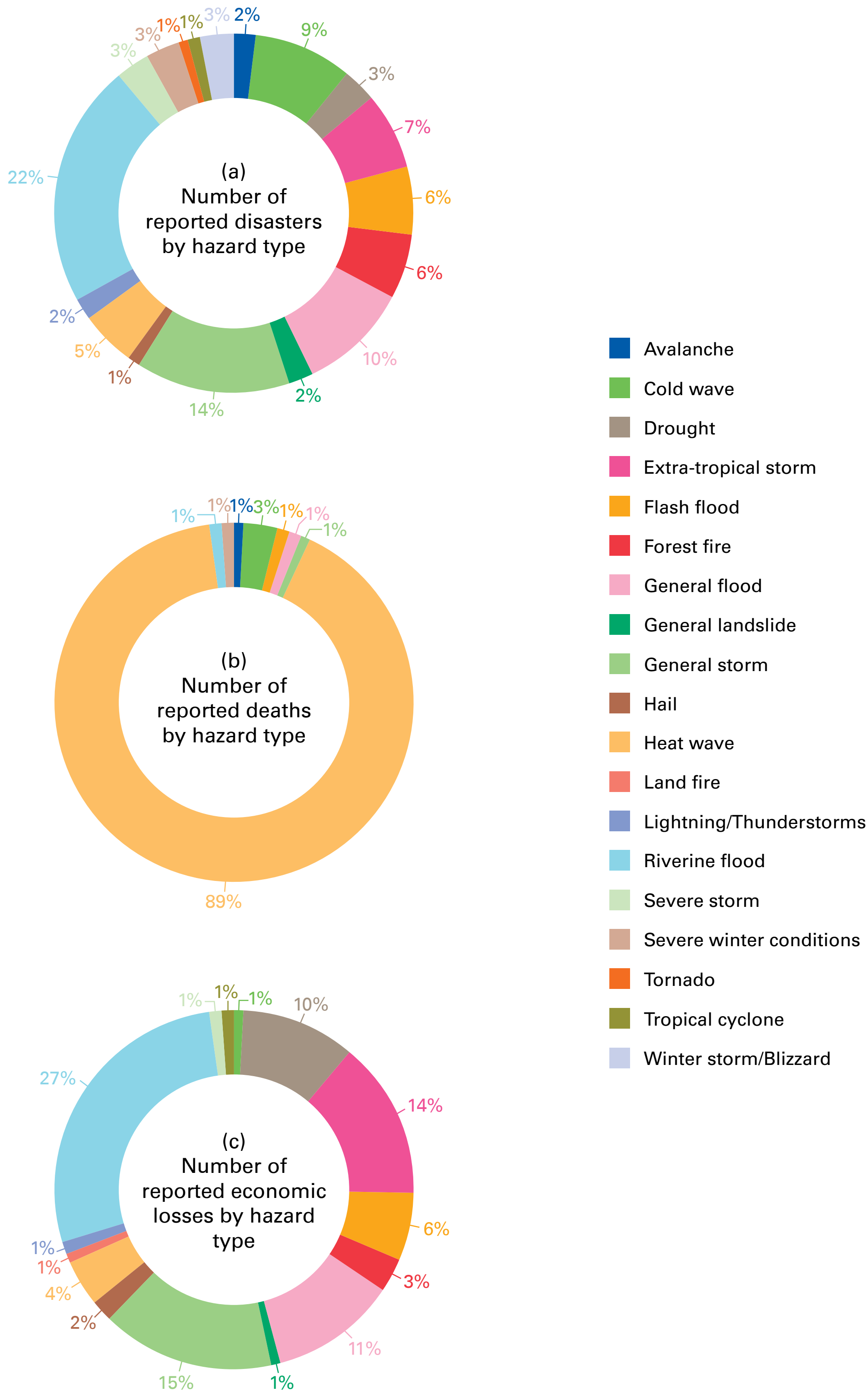
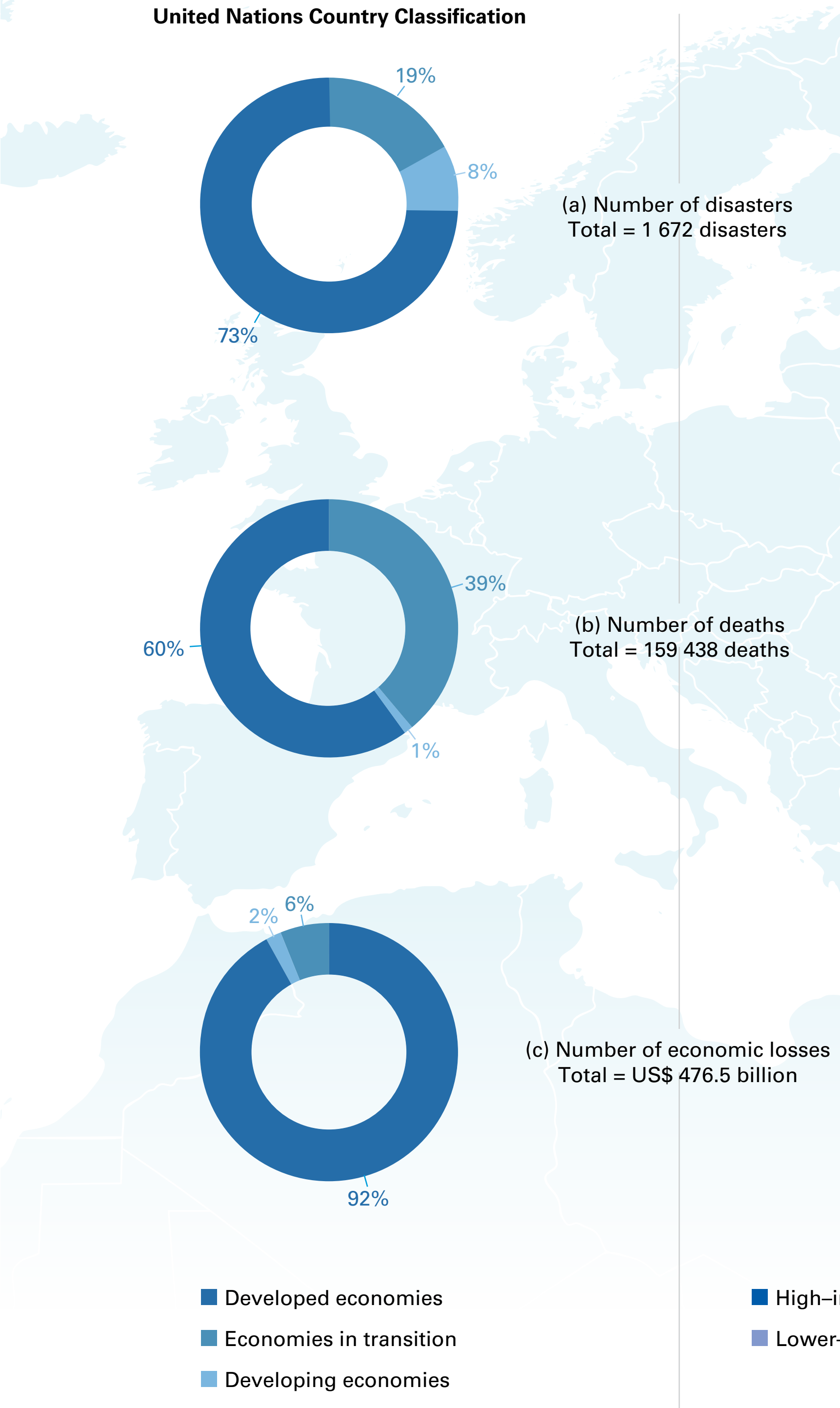


Figure 29. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by hazard in Europe (1970–2019)



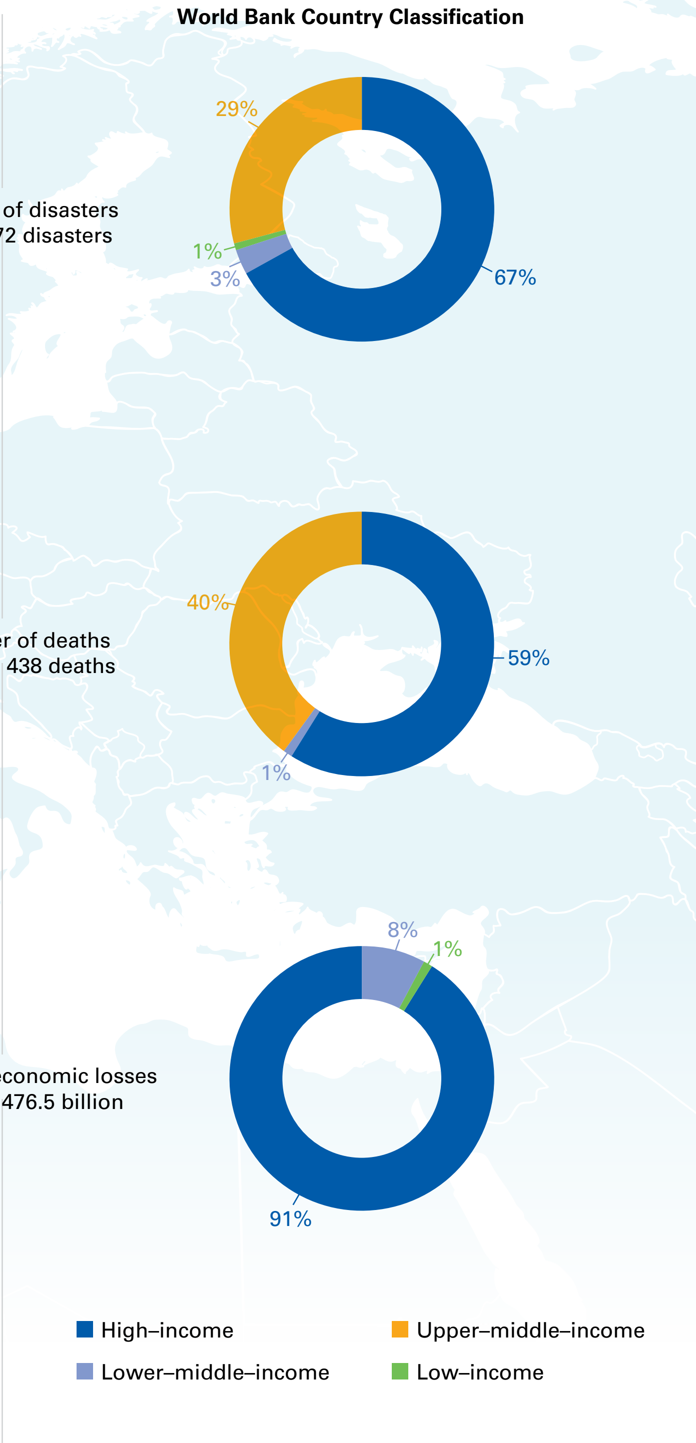


Figure 30. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by United Nations country classification in Europe (1970–2019)

Figure 31. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by World Bank country classification in Europe (1970–2019). Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

WMO region intercomparisons

Storms, floods and droughts were the most prevalent hazards recorded globally over the 50-year period. The distribution of deaths and economic losses from these hazards varies from region to region. For example, the main contributors to loss of life were droughts in Africa, storms in Asia, floods in Central America, North America and the Caribbean, storms in the South-West Pacific and in South America, and heatwaves (extreme temperature) in Europe. On the other hand, a large portion of economic losses were associated with floods in Africa, Asia, South America and Europe, along with storms in Central and North America and the Caribbean, and the South-West Pacific (Figure 32).[9]

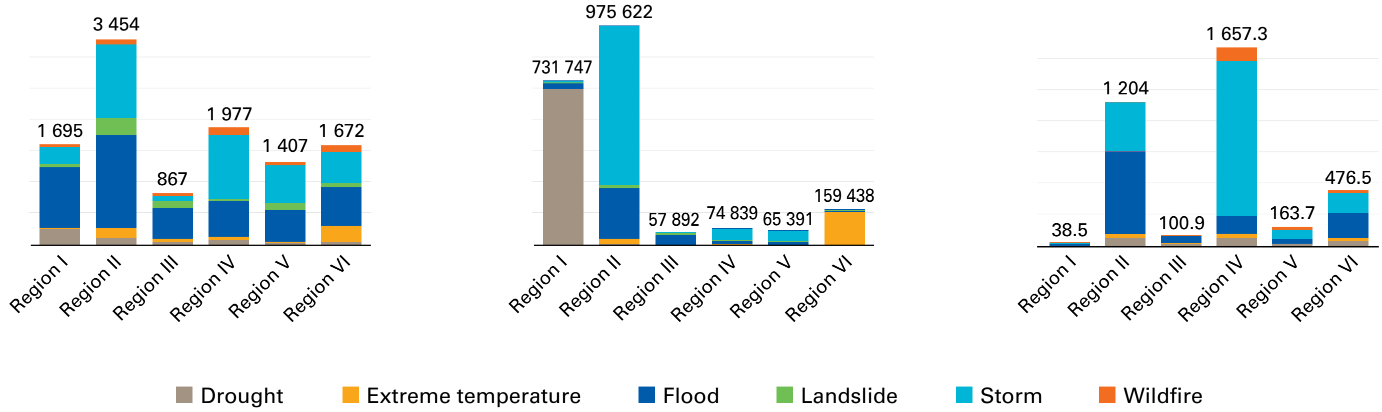


Figure 32. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses by WMO region (1970–2019)

9 A description and map of the WMO regions can be found in Annex III.

FOCUS ON TROPICAL CYCLONES

Tropical cyclones are one of the biggest threats to life and property even in the formative stages of their development. They generate a number of different hazards that can individually have significant impacts on life and property, such as storm surge, flooding, extreme winds, tornadoes and lightning. Combined, these hazards interact with one another and substantially increase the potential for loss of life and material damage.

Tropical cyclones led to a daily average of 43 deaths and US$ 78 million in losses from 1970–2019.

Over the 50-year period, 1 945 disasters were attributed to tropical cyclones, resulting in 779 324 deaths and US$ 1.4 trillion in economic losses. Tropical cyclones were responsible for 9% of all recorded disasters, including those related to technological hazards, and accounted for 17% of all reported deaths and 29% of all economic losses during the 50-year period.

Tropical cyclones represented 17% of weather-, climate- and water related disasters and were responsible for one third of both deaths (38%) and economic losses (38%) over the 50-year period.

The Philippines experienced the greatest number of tropical cyclone-related disasters (295 disasters, 15% of total), closely followed by China[10] (269 disasters, 14% of total) then Japan (101 disasters, 5% of total). Bangladesh which experienced only 3% of total tropical cyclones, reported 467 487 tropical cyclone-related deaths (60% of total), Myanmar 138 909 deaths (18% of total) and India 46 784 deaths (6% of total). Tropical cyclone-related disasters in these three countries combined represented 84% of total deaths globally (Table 8 (a)).

The United States (US$ 771.24 billion, 54% of total), Japan (US$ 136.03 billion, 10% of total) and China (US$ 134.32 billion, 9% of total) accounted for 73% of total economic losses from weather-, climate- and water-related disasters. Three of the top 10 disasters in terms of economic losses occurred in 2017: Hurricanes *Harvey* (US$ 96.9 billion), *Maria* (US$ 69.4 billion) and *Irma* (US$ 58.2 billion) (Table 8 (b)). Combined, these three hurricanes represented 35% of total economic losses of the top 10 disasters globally from 1970 to 2019.

Life of typhoon *Haiyan* survivors, 5 January 2014 (© h3k27/iStock)

10 Combined figures of China, including Hong Kong and Macao, China; and Taiwan, Province of China.

Table 8. Top 10 tropical cyclones by (a) number of deaths and (b) economic losses globally (1970–2019)

(a)	Disaster type	Year	Country	Deaths
1	Storm	1970	Bangladesh	300 000
2	Storm (*Gorky*)	1991	Bangladesh	138 866
3	Storm (*Nargis*)	2008	Myanmar	138 366
4	Storm	1985	Bangladesh	15 000
5	Storm (*Mitch*)	1998	Honduras	14 600
6	Storm	1977	India	14 204
7	Storm (05B)	1999	India	9 843
8	Storm	1971	India	9 658
9	Storm (*Fifi*)	1974	Honduras	8 000
10	Storm (*Haiyan*)	2013	Philippines	7 354
(b)	**Disaster type**	**Year**	**Country/territory**	**Losses in US$ billion**
1	Storm (*Katrina*)	2005	United States	163.61
2	Storm (*Harvey*)	2017	United States	96.94
3	Storm (*Maria*)	2017	Puerto Rico	69.39
4	Storm (*Irma*)	2017	United States	58.16
5	Storm (*Sandy*)	2012	United States	54.47
6	Storm (*Andrew*)	1992	United States	48.27
7	Storm (*Ike*)	2008	United States	35.63
8	Storm (*Ivan*)	2004	United States	24.36
9	Storm (*Charley*)	2004	United States	21.65
10	Storm (*Rita*)	2005	United States	20.94

It is difficult to establish trends within a database of extremes; however, by decade there were some general tendencies over the 50-year period. The number of disasters related to tropical cyclones over the period increased, while the number of deaths markedly decreased following a peak in the 1970s. Economic losses increased decade by decade over the period, with a substantial increase from 1990 to 2019 (Figure 33). The reduction in deaths is widely attributed to improved MHEWSs (IPCC, 2012).

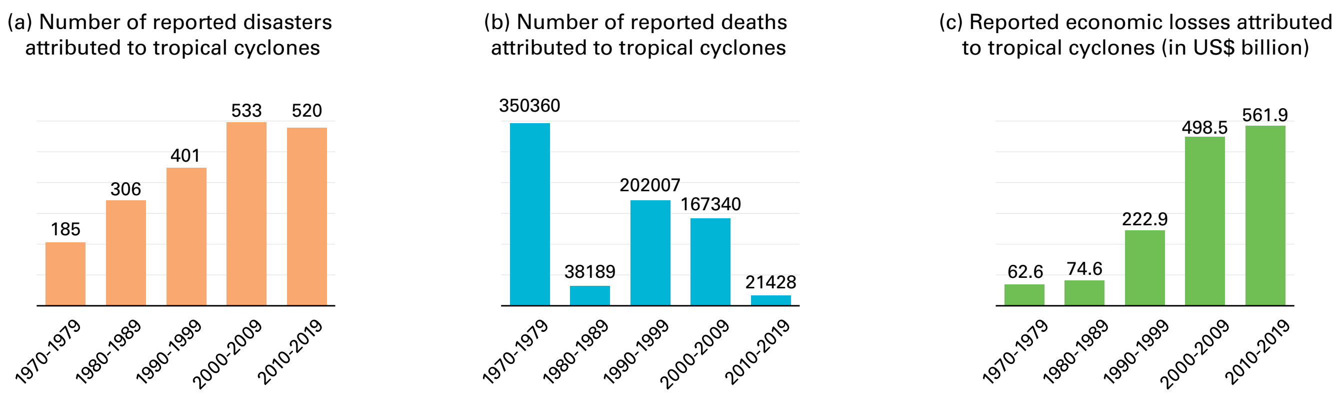


Figure 33. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses attributed to tropical cyclones by decade

Impacts by WMO region

Tropical cyclone-related disasters over the period analysed were reported mostly in Asia (WMO Region II), North America, Central America and the Caribbean (WMO Region IV) and the South-West Pacific (WMO Region V). However, statistics for Africa (WMO Region I) are also noteworthy (Figure 34, Table 9). Asia was significantly affected in terms of loss of life with 682 646 deaths. The majority of these deaths occurred in Bangladesh (467 487, 60% of total), Myanmar (138 909, 18% of total) and India (46 784, 6% of total). Most of the deaths in Bangladesh were linked to two tropical cyclone events, in 1970 and 1991, which reported a total death toll of 438 866 lives. These events led the government of Bangladesh and the regional and international community to strengthen the country's tropical cyclone early warning system. Subsequently, the significant reduction of deaths associated with tropical cyclones has been attributed to the improvement of such systems. In terms of economic losses, North America, Central America and the Caribbean and Asia were the most affected (Figure 34, Table 9).

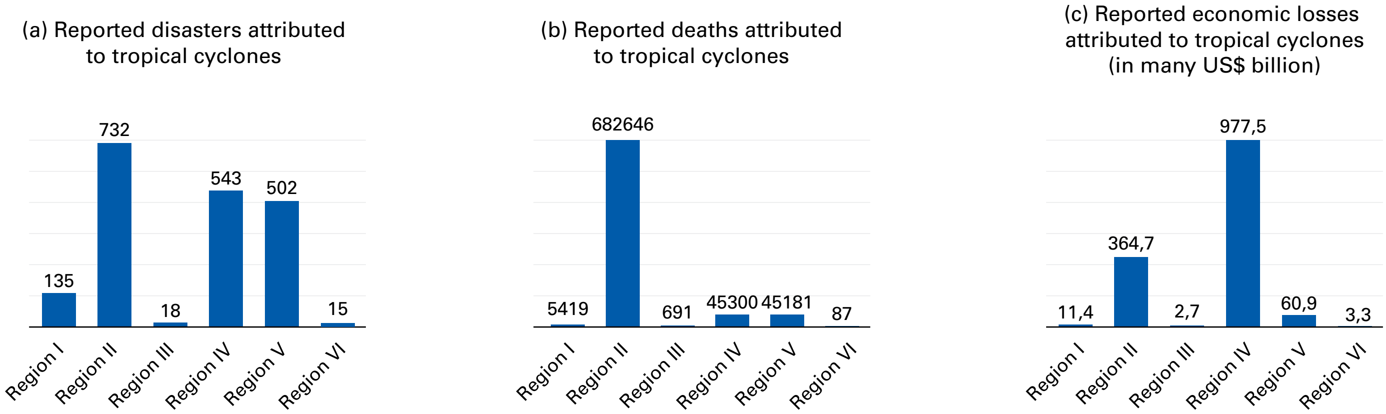


Figure 34. Distribution of (a)number of disasters, (b) number of deaths and (c) economic losses attributed to tropical cyclones by WMO region

Table 9. Distribution of number of disasters, number of deaths and economic losses attributed to tropical cyclones globally

	Number of disasters	Number of deaths	Economic losses in US$ billion
Region I (Africa)	135	5 419	11.40
Region II (Asia)	732	682 646	364.66
Region III (South America)	18	691	2.66
Region IV (North America, Central America and the Caribbean)	543	45 300	977.48
Region V (South-West Pacific)	502	45 181	60.91
Region VI (Europe)	15	87	3.30

Impacts of disasters resulting from tropical cyclones by United Nations and World Bank country classification

According to the United Nations country classification for the period 1970–2019, 86% of disasters associated with tropical cyclones occurred in developing economies and 13% in developed economies. In terms of deaths, 99% of deaths related to tropical cyclones occurred in developing economies whereas less than 1% of casualties occurred in developed economies. In contrast, 66% of economic losses attributed to tropical cyclones occurred in developed economies whereas 29% occurred in developing economies (Figure 35). The World Bank country classification shows similar results: 71% of disasters, 96% of deaths and 9% of economic losses occurred in low-income to upper-middle-income countries during the 50-year period. In contrast, upper-middle-income and high-income countries represented 9% of deaths and 91% of economic losses (Figure 36).

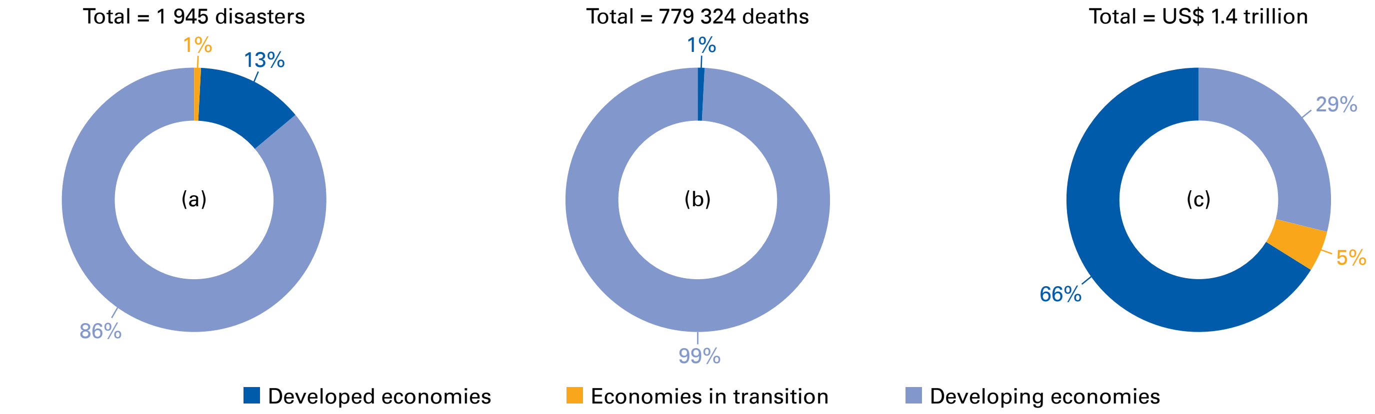


Figure 35. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses attributed to tropical cyclones by United Nations country classification. Categories not represented in the figures indicate that their percentage rounds to zero or is zero.

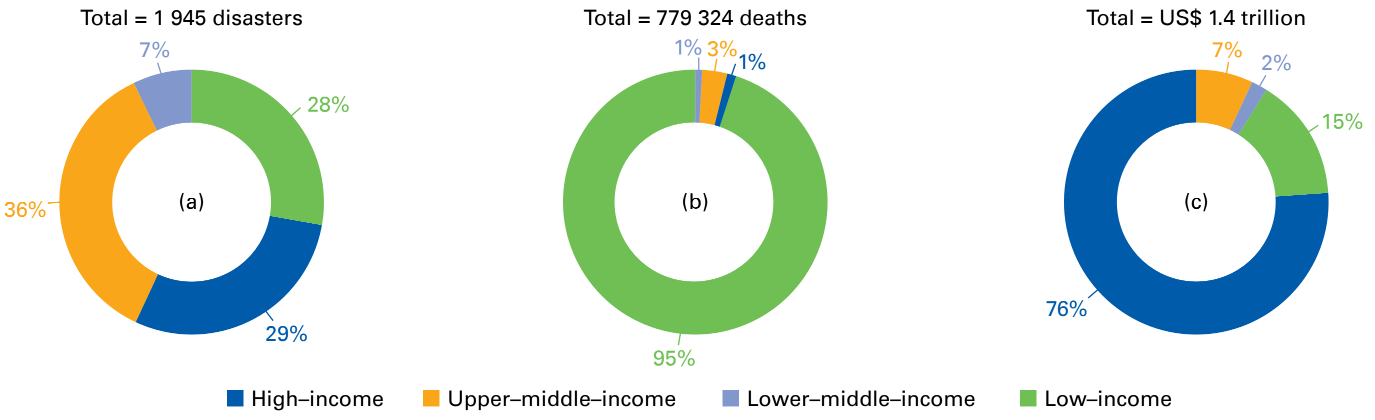


Figure 36. Distribution of (a) number of disasters, (b) number of deaths and (c) economic losses attributed to tropical cyclones by World Bank country classification

Impacts on small island developing States (SIDS)

Small island developing states (SIDS) and Island Territories recorded 465 tropical cyclone-related disasters that led to 10 253 deaths and US$ 150.07 billion in economic losses over the 50-year period.

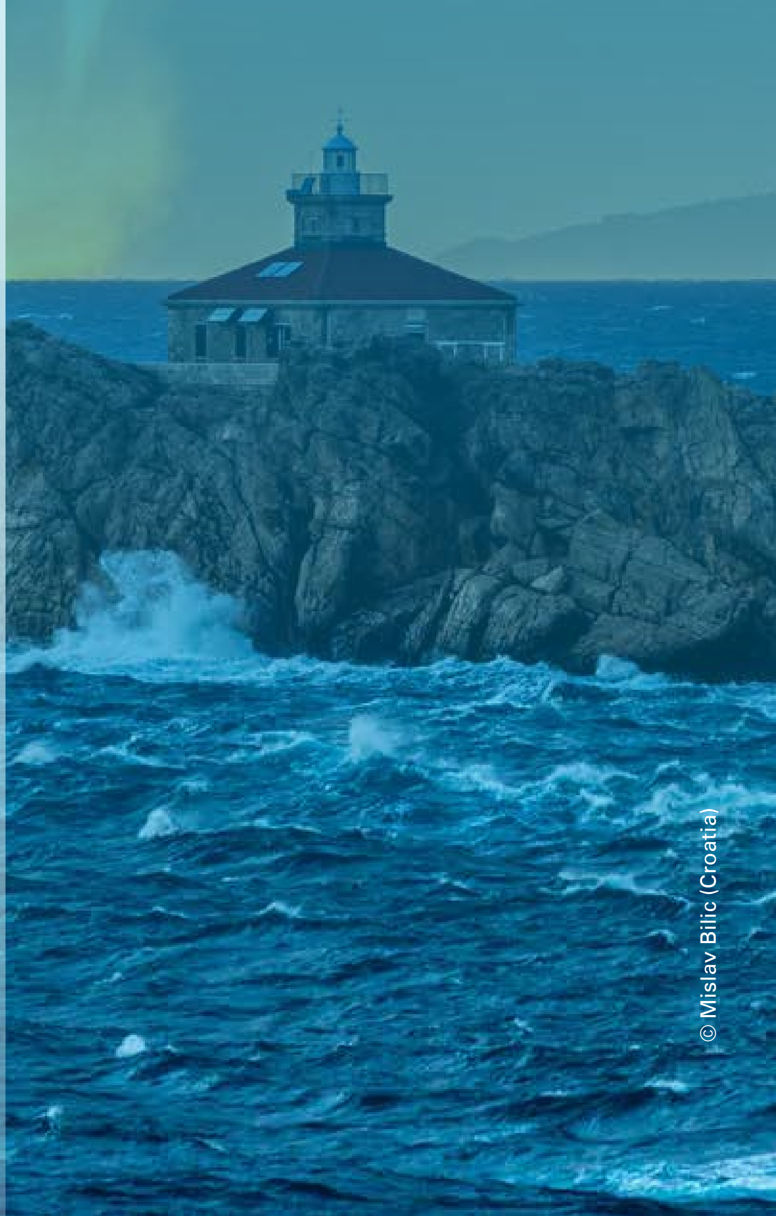
SIDS are particularly vulnerable to tropical cyclones owing to, one, their small size and correspondingly limited resources; two, their geographical location (in tropical latitudes and longitudes) in which such events are more frequent and topography (sea level elevation, 360° coastal perimeter, steep terrain on some islands); and, three, their physical isolation. Disaster risks for SIDS are exacerbated by climate change and sea level rise (Shultz et al., 2016). Examples of impacts on SIDS include Hurricanes *Maria* (2017) and *Dorian* (2019) that struck Caribbean islands with unprecedented consequences:

- Hurricane *Maria* was a category 4–5 events on the Saffir Simpson scale when it transited through the Lesser Antilles, Puerto Rico and the Bahamas. Dominica, which was still rebuilding after the impacts of Tropical Storm *Erika* in 2015 (estimated damage of near 100% of GDP), was one of the worst impacted islands. The island's assessed damages were over 200% of GDP (International Monetary Fund (IMF), 2019 (see Box 2)). The interruption of commerce and standard living conditions were also sustained for a long period for much of Puerto Rico. *Maria's* impacts brought devastation to Puerto Rico's transportation, agriculture, communications and energy infrastructure. For more information on the impacts of Hurricane *Maria*, see Box 3 (in right column) and Box 4 (on page 75.)

- Hurricane *Dorian* had severe impacts on a number of islands in its path – particularly in the northern Bahamas where it made landfall as a category 5 event on the Saffir-Simpson scale. For the Atlantic Basin, *Dorian* was a historically powerful and slow-moving hurricane with wind gusts reaching up to 320 km per h (200 miles per h) that stalled over the northern Bahamas for nearly 40 hours. Winds, rain, waves and storm surge devastated the area. At least 70 lives were lost and 282 people were reported missing after the hurricane (WMO, 2019).

Box 3. Impacts of Hurricane *Maria* on Dominica

Hurricane *Maria* is the strongest hurricane on record to have made landfall on Dominica (or strike within 111 km (60 nautical miles) of the island). The landfall pressures of the hurricane in Dominica and Puerto Rico were 922 and 920 millibars (mb), respectively, based on an extrapolation of the system's deepening and filling trends before making landfall in those islands. *Maria* contributed to catastrophic damage in Dominica, the majority of structures were seriously damaged or destroyed. Most trees and vegetation were downed or defoliated. According to media reports, the estimated damages reached at least US$ 1.31 billion. The agricultural sector was essentially eliminated. The once-lush tropical island was effectively reduced to an immense field of debris. In a Facebook post Dominica's Prime Minister, Roosevelt Skerrit, described the damage as "mind-boggling". The roofs of the majority of buildings and homes were either damaged or blown off. There was extensive damage to roads. Power, phone and Internet services were cut off, leaving the country almost incommunicado with the outside world.



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ROLE AND POTENTIAL OF DISASTER LOSS DATABASES

Disaster loss data and the Sendai Framework Monitor

A contribution from UNDRR

With the adoption in 2015 of the Sendai Framework, there has been a re-emphasis on disaster risk reduction over traditional disaster management. A key element of disaster risk reduction is pre-emptive planning based on an understanding and analysis of disaster risk. Through the Sendai Framework, member States noted that "It is urgent and critical to anticipate, plan for and reduce disaster risk in order to more effectively protect persons, communities …".[11]

According to the principles of the Sendai Framework, effective disaster risk reduction depends on local-level mapping of risks (hazards, exposure, vulnerabilities and capacities) and risk-informed strategies for both the prevention of disasters, and reduction of impacts when they do occur. In light of this, the first of four priorities for action of the Sendai Framework focuses on understanding disaster risk.

Detailed disaster loss data are essential for mapping the risks of natural and other hazards systematically. Data disaggregated by subnational units of sufficiently high resolution, by hazard, by demographic groups and by type of losses can enable stakeholders and policymakers to create a picture of who the most vulnerable are, and where, when and in what manner they are most vulnerable. Specifically, the Sendai Framework highlights the importance of compiling and sharing information on disaster losses and relevant data and statistics together with strengthening disaster risk modelling, assessment, mapping and monitoring.[12]

Disaster loss data are also deemed essential for the other priorities for action of the Sendai Framework. Specifically, under Priority 4, namely, enhancing disaster preparedness for effective response, the Framework noted that it will be important "To establish a mechanism of case registry and a database of disaster mortality in order to improve the prevention of morbidity and mortality".[13]

Consequently, the monitoring process of the Sendai Framework is closely tied to the collection of spatially disaggregated, event-based data on disaster-related losses. It is expected that high-quality event-based data will be aggregated to report on four of the seven targets of the Sendai Framework, which are focused on reducing (a) the number of people dead and missing; (b) the number of people affected; (c) direct economic losses; (d) damage to critical infrastructure and disruption of basic services.

The disaster loss database based on DesInventar – a tool for collecting disaster loss data made available by UNDRR and its partners – predates the Sendai Framework. To enable a clear connection between the data on the Sendai Framework monitoring system and national disaster loss databases, UNDRR updated the tool to align the data recording interface with the first four targets and associated indicators of the Sendai Framework, resulting in a new system called the DesInventar-Sendai. Most of the nationally owned databases built on this tool are located on a central server and can be accessed through www.desinventar.net. As of April 2020, there are 111 countries and territories that have DesInventar databases either centrally hosted by UNDRR or individually on their own stand-alone servers. Most of these databases are either owned or endorsed by national governments.

While there exists a degree of heterogeneity across countries in the quality and coverage of the data, the large number of data cards taken together provide a time series of disaster loss data that is event-based and spatially disaggregated. Moreover, subdividing the impacts of any hazard event into many small administrative unit events yields a much higher proportion of smaller loss totals than if all the losses in the event are aggregated. As of April 2020, the DesInventar-Sendai database contains some 727 000 approved data cards for the 111 countries and territories, for all years, with over 408 000 data cards for the period 2005–2019.

The depth of spatial disaggregation, together with the large number of event-based records provides information necessary for the creation of risk profiles of relatively small geographic areas. Unlike global disaster loss databases, the DesInventar-Sendai does not set a threshold on the size of the disaster to be recorded. It also reveals trends that might not show up in databases with national-level data alone. For instance, the UNDRR

11 Sendai Framework for Disaster Risk Reduction 2015–2030, para 5.
12 ibid. para 25(a).
13 ibid. para 33(n).

Global Assessment Report on Disaster Risk Reduction 2019 (GAR 2019) (UNDRR, 2019; page vii) noted that 68.5% of the direct economic losses due to disasters during 2005–2017 were attributed to extensive risk events, that is, the set of low-intensity, high-frequency events that are often localized in nature.[14] The high percentage of losses in the "extensive risk" events could be an artefact of DesInventar data structure in which municipalities are the observational unit. WMO is currently working on a cataloguing procedure that will help in the categorization of disaster events to a higher system of hazards through a WMO mechanism of scientific standardization. This will help local administrations working on national disaster loss databases such as DesInventar in tagging the disaster events in a hazard-centric manner.

As shown in GAR 2019, for 83 countries for which data are available over the period 2005–2015, the total number of dead and missing people as reported by national records through the Sendai Framework Monitor or the DesInventar mostly exceeds the number reported by a global disaster loss database such as EM-DAT, which records data for disasters that exceed a certain threshold (Figure 37).[15]

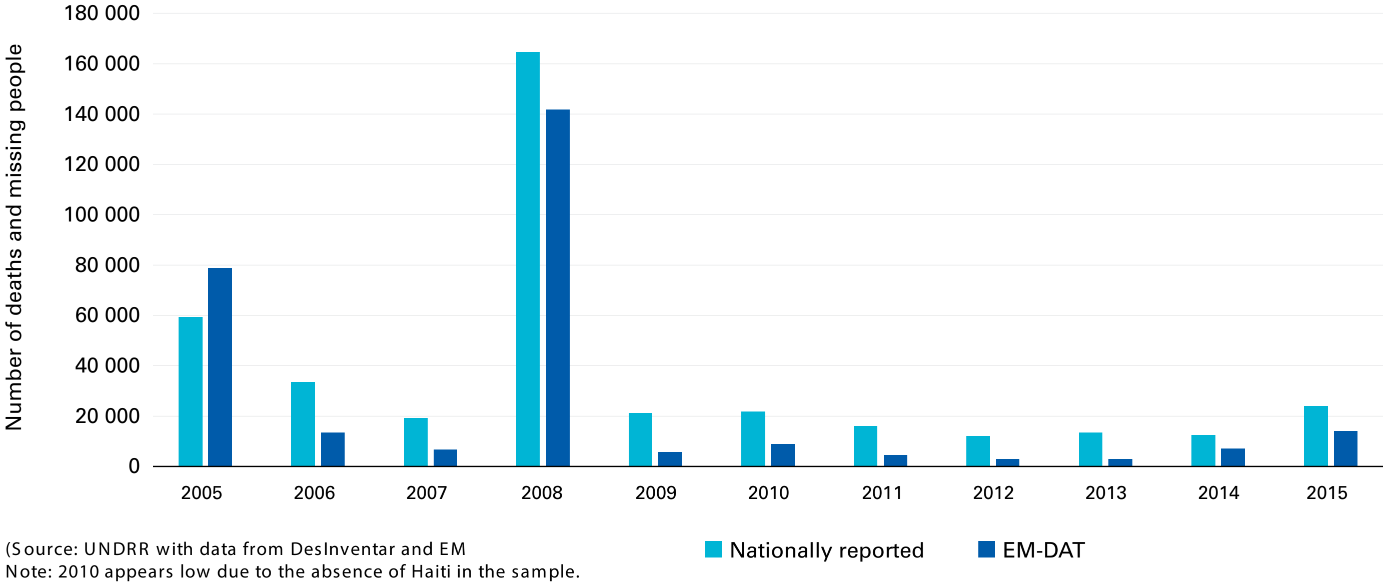

Figure 37. Mortality reported nationally in the Sendai Framework monitoring system and globally in EM-DAT for 83 countries and territories, 2005–2015

Source: UNDRR, 2019; page 222.

14 The threshold for intensive risk used in GAR 2011 was established at 25 deaths or 600 houses destroyed in any one local level loss report (GAR 2011, page 37).
15 EM-DAT defines its threshold as at least 10 people killed, or 100 affected, or a state of emergency declared and a call for international assistance made.

Analysis at the country level reveals greater nuance in the data. As an example four countries were compared for the period 2005–2019 – Colombia, Ecuador, Indonesia and the Niger. The countries were selected for their relatively good coverage in both DesInventar and EM-DAT databases, and for having experienced a wide range of both intensive and extensive risk events. Figure 38 shows the comparison in the number of dead and missing people as recorded in the nationally reported data and in EM-DAT for the countries. In Colombia, the nationally reported data show a significantly higher number of dead and missing people in all years apart from four, but the overall trend is somewhat similar. The data for Indonesia for the two sources closely follow each other. In Ecuador and the Niger, the nationally reported data show a significantly higher number of dead and missing people for all years, except for 2014 in the Niger, during the reporting period for which data are available. The spikes in all four countries reflect high-intensity events. In instances where intensive risk events dominate the data, EM-DAT and nationally reported data tend to converge.

Figure 38. Number of dead and missing people from disasters due to natural and other hazards in selected countries, 2005–2019

Source: CRED (2020)/Universié catholique de Louvain, Brussels/Guha-Sapir and Checchi (2018) and DesInventar-Sendai.

Challenges associated with disaster loss databases

Significant challenges have constrained the creation, expansion and use of disaster loss databases despite their widely-recognized value in providing highly granular, spatially disaggregated time series data for risk assessment, risk-informed investments and preparedness planning. Data entry and recording is highly labour intensive. Lack of adequately trained personnel has emerged as a key challenge in countries around the world. UNDRR has made hands-on training available to governments in Africa, the Americas and the Caribbean, Arab States, Asia-Pacific, Europe and Central Asia to bridge this capacity gap. However, many governments are financially constrained in employing dedicated staff for maintaining and updating disaster loss data. In many countries, the disaster-related data is not a part of official statistics and hence national statistical offices cannot provide the necessary quality control. Lack of information technology, including Internet connectivity, has constrained several developing countries from using web-based databases.

Availability of data has emerged as a challenge in several contexts. In some countries, different kinds of data may be available within different line ministries without a clear connection to disaster events. In the absence of a well-defined institutional set-up for a system such as DesInventar, silos among departments and lack of coordination between local and national levels could affect the quality of information and could even potentially create parallel datasets. Overcoming this challenge requires both appropriate tagging of data during the process of collection, and coordination across multiple ministries and government institutions to bring the data into a central disaster loss database.

Data quality is also affected by the context within which disaster data are collected – in the immediate aftermath of a disaster; during the course of search, rescue and relief operations; and in the backdrop of civil unrests or conflicts. The creation of baselines based on historical loss data has also proved challenging since data for losses have typically dwindled as one goes back in time. Even where disaster loss accounting is possible, data is not necessarily available for all Sendai Framework targets. For instance, human losses (targets A and B) are better accounted for than economic and infrastructure losses (targets C and D, respectively). Disaggregation of disaster loss data, for instance, by sex, income, age, and disabilities, has been challenging to ensure. Defining a common taxonomy for hazards has been a critical area of work since different countries have recorded losses from a variety of hazard events, and the recently released *Hazard Definition and Classification Review Technical Report* by UNDRR and ISC will provide a strong support to this process (UNDRR and International Science Council, 2020).

Widespread destruction caused by Hurricane Dorian is seen from the air, above Marsh Harbour, Great Abaco island, on 4 September 2019. (Gonzalo Gaudenzi/AP)

MORTALITY AND MORBIDITY – PERSPECTIVES FROM THE HEALTH SECTOR

A contribution from co-contributors WHO and Public Health England

Health impacts of emergencies and disasters

Hazardous events, including emergencies and disasters, exact a heavy toll on people's lives and health, social development, and the economy and environment of communities and countries. It is estimated that between 2005 and 2015, more than 1.5 billion people overall were affected by disasters, including over 700 000 lives lost, more than 1.4 million people injured, and approximately 23 million people made homeless due to natural and technological hazards (UNDRR, 2015). When outbreaks of disease (including epidemics and pandemics) and societal hazards are added, these figures grow substantially. People with higher levels of vulnerability and lower capacity to manage risks are disproportionately affected. Factors affecting vulnerability include poverty, gender, age, disability, poor health and poor nutritional status.

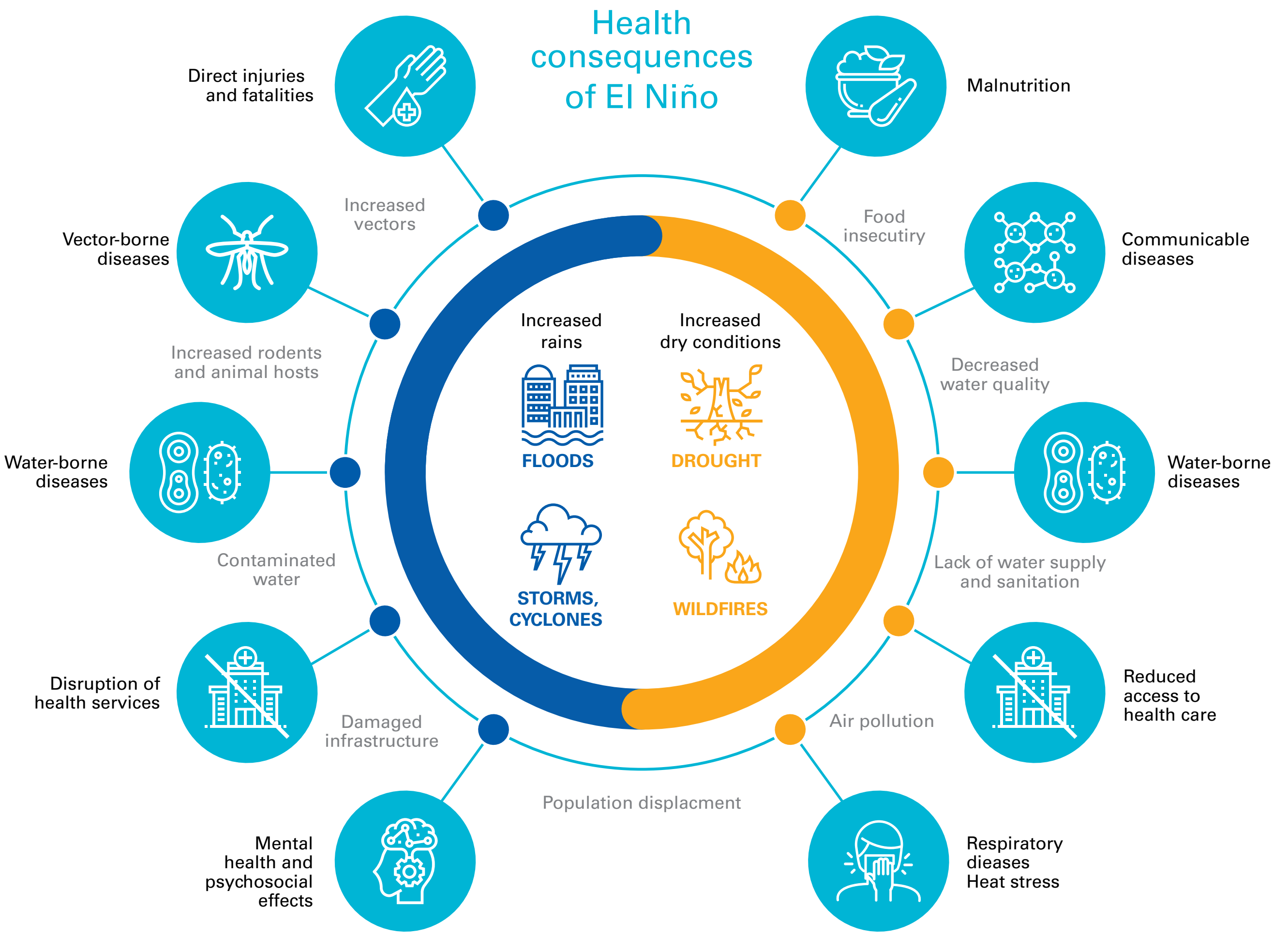

Figure 39. El Niño and health global overview

Source: WHO (2016).

Alongside loss of life due to the direct impacts of hazards, such as cyclones, floods and heatwaves, many other consequences provide indirect pathways to mortality, such as the disruption of healthcare services, the spread of communicable diseases and damage to critical infrastructure.[16] Furthermore, the time period between exposure of a person to a hazard leading to death can vary widely, which raises issues about attribution of death to an emergency or disaster. The disruption of care for chronic conditions, such as diabetes and cardiovascular diseases, and the onset of persistent stress can lead to a greater disease burden and deaths that may occur months or years after the event. Climate, including climate variability and change, is a major source of risk for hazardous events that affect public health. The direct and indirect effects on health of climate events are illustrated in Figure 39 using the example of the effects of the El Niño 2015/2016 that resulted in a wide range of health problems (WHO, 2016).

The number of reported weather, climate and water extreme events is increasing (IPCC 2012, 2014) and such events are expected to continue to become more frequent and severe in many parts of the world. At the same time, the past few decades have seen rapid growth in populations living in flood plains and cyclone-exposed coastal areas, particularly in cities in developing countries. Climate change has driven extreme high temperatures and has contributed to more frequent and extreme precipitation events and altered the intensity of tropical cyclones. Together, these trends will increase the risk of weather, climate and water hazards to human health (IPCC 2012, 2014; WHO and WMO, 2012). The following additional deaths are projected annually from the 2030s due to the impacts of climate change: 38 000 due to heat exposure in older people, 48 000 due to diarrhoea, 60 000 due to malaria, and 95 000 due to childhood undernutrition. Some infectious diseases are highly sensitive to temperature and rainfall, including cholera and the diarrhoeal diseases, as well as vector-borne diseases such as malaria, dengue and schistosomiasis.

Climate change threatens to reverse the progress that the global public health community has been making against many diseases and increase the challenges for the disaster risk management community to prevent, prepare for, respond to and aid recovery from natural, biological and social emergencies.

16 In addition, in the aftermath of many types of events, missing persons are not yet accounted as deaths.

Quantifying mortality and the challenges

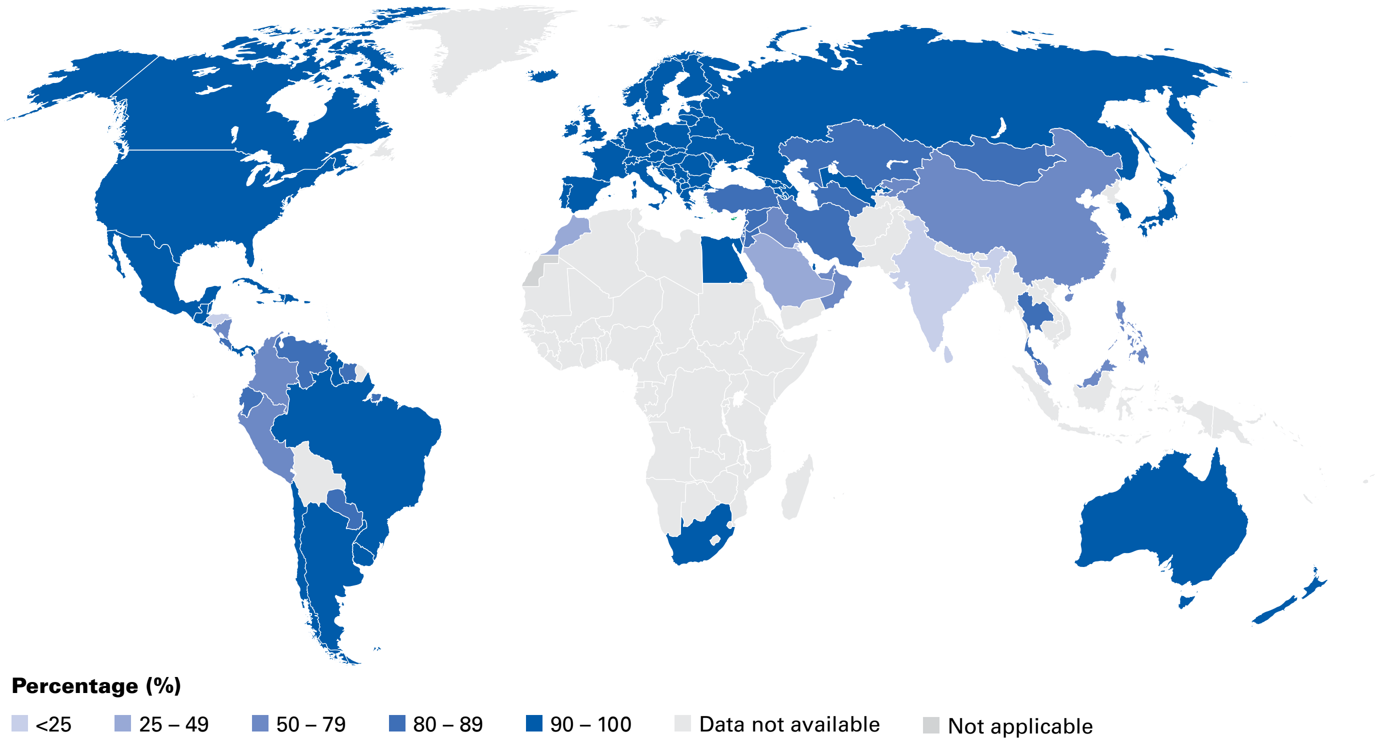

Figure 40. Civil registration coverage of cause of death (%), 2007–2016

Source: WHO, 2018.[17]

Progress has been achieved in reducing disaster risks and this has led to reduced mortalities, for example, as is the case for cyclone-related deaths in Bangladesh and India over the past decades. Despite this, high levels of vulnerability to hazardous events remain. The first global target of the Sendai Framework is to "Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100 000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015". To measure the success of policy and practice against meeting this target, mortality needs to be accurately quantified and interpreted.

As described previously, there are numerous challenges in defining disaster mortality, obtaining accurate available data, and estimating, interpreting, and reporting mortality data. Many countries do not have access to reliable disaster or emergency loss databases, nor to mortality data derived from national civil registration and vital statistics. The availability of information on births and deaths is inequitable around the world, with two thirds of annual deaths not registered (Figure 40).

In 2016, WHO demonstrated that the availability of data on cause of death varies significantly around the globe, with some countries recording cause of mortality in less than 25% of cases. Additionally, there is variation in attributing deaths to hazardous events, including the cause of death and how long after an event it occurs. Although all countries experience loss of life from emergencies and disasters, there is generally a higher risk of death in low- and middle-income countries, and these are the same countries that tend to lack vital registration data, further magnifying the data gap (Osuteye et al., 2017) (Figure 41).

17 See http://gamapserver.who.int/mapLibrary/Files/Maps/Global_CivilRegistrationDeaths_2007_2016.png.

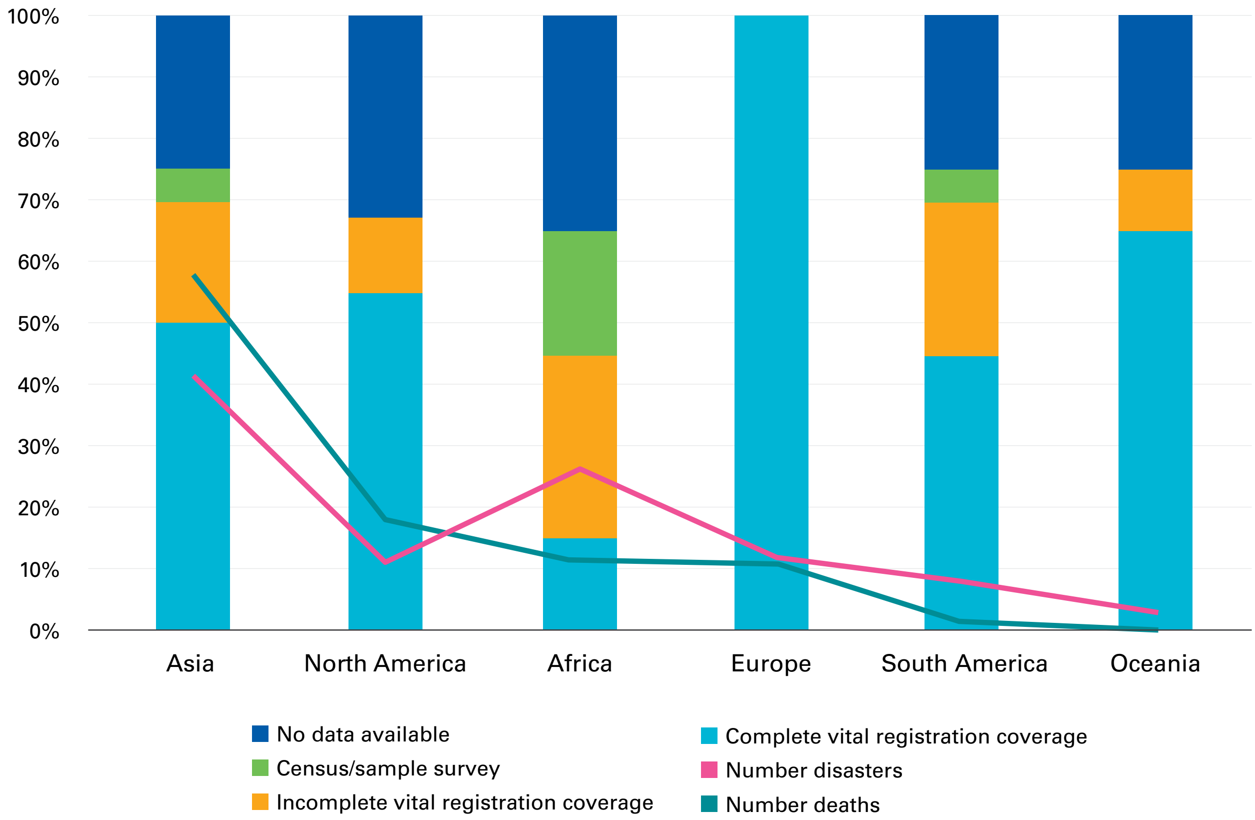

Figure 41. Proportion of countries by region where vital registration data are available and proportional disaster impact

Source: Green et al. (2019).

The need for the involvement of the health sector in monitoring disaster mortality

The imperative for good quality data is central to advocacy, design, implementation and evaluation of effective health emergency and disaster risk management policy and practice, and is recommended by the WHO Health Emergency and Disaster Risk Management Framework (WHO, 2019). While measuring the extent to which health is affected by hazardous events is a complex task, it is essential to assess, prioritize and reduce risks to health of future events and to build the resilience of communities and countries.

Credible death tolls are also important for community recovery after crises; they influence policy change and enhance political accountability (see Box 4). Health data, including mortality, are essential to monitor and evaluate the impacts of action taken by health and other sectors at all levels of society, identify good practice and improve future actions. Countries need to find a method of measuring mortality that works for the hazards they face and the resources that are available to them. This will demand leadership, training, action and coordination at all levels across all related sectors, including the health sector.

The Sendai Framework provides United Nations Member States with targets and indicators to enable monitoring and reporting of progress on action to reduce the risks and impacts of emergencies on the health and well-being, and on the economic, social and environmental development of countries. It emphasizes health in all policies and reinforces a focus on health with an outcome as a "substantial reduction of disaster risk and losses in lives, livelihoods and health".

Reporting against the Sendai Framework and the work implied overlaps with other global health initiatives, including the Sustainable Development Goals, the WHO Global Reference List of 100 Core Health Indicators and the WHO Thirteenth General Programme of Work Impact Framework.

It is vital that ministries of health are engaged with the Sendai Framework monitoring national focal points and work collaboratively with relevant partners to ensure comprehensive and accurate reporting of health-related data.

Box 4. Mortality estimates from Hurricane *Maria* in Puerto Rico

Puerto Rico was hit by Hurricane Maria, a category 4–5 hurricane, in September 2017, with widespread damage and heavy associated economic losses (see also Box 3 and section "Impacts on small island developing States"). There were notable damages to the hospital system and a power cut, which took weeks to restore. These factors are thought to have likely resulted in a high number of deaths. However, estimates of the number of deaths from Hurricane *Maria* have varied widely over time and by the method used, illustrating the wide range of approaches, differences and difficulties in providing timely, robust hazard mortality estimates.

An initial estimate of the number of deaths in Puerto Rico was given as 16 when the President of the United States visited two weeks after Hurricane *Maria* hit, with subsequent official government estimates revising the number to 64 at the end of 2017 (*Telemundo*, 2017). This official death count only considered deaths with a "hurricane-related" cause indicated on the death certificates. A study published in May 2018 (Kishore et al., 2018) estimated the number of excess deaths at 5 740 (with a 95% confidence interval of 1 506 to 9 889), nearly seventy times higher than the original estimates, with the majority of deaths resulting from the interruption of healthcare, electricity and water services. Following a critical review of this latter paper, a subsequent study (Santos-Lozada and Howard, 2018), gave a conservative estimate of 1 139 excess deaths (95% confidence interval from 1 006 to 1 272), with levels returning to the previous range by December of 2017, three months after the hurricane, highlighting the length of time over which the impact of a disaster can be comprehensively appreciated.

Given that the health sector holds critical data on mortality and other health-related Sendai Framework Monitor targets and indicators, WHO, with Public Health England, has developed a set of guidance notes – *WHO Technical Guidance Notes on Sendai Framework Reporting for Ministries of Health* – in consultation with Member States and partners.[18] These guidance notes will advise the health sector in its role in collecting and reporting data, including target A, which focuses on mortality reduction, and is also an indicator for the Sustainable Development Goals. The guidance notes are aligned with and complement the Technical Guidance for Monitoring and Reporting on Progress in Achieving the Global Targets of the Sendai Framework for Disaster Risk Reduction (UNDRR, 2017). The role of the health sector will likely include provision of data, verification of national disaster data and engagement with a range of sectors and stakeholders (such as the police force and the local government, among others). The guidance notes seek to help operationalize, simplify and standardize the collection and reporting of data through the application of common language and methods. They provide information on the key issues to consider when collecting health data, on what types of data should be collated, and on potential stakeholders to engage with.

Beyond the Sendai Framework targets that focus on direct impacts, the health sector has a role in addressing the full consequences of events on communities through consideration of indirect impacts over time. Health sector reporting will also enable ministries of health to measure annual effects and trends of the full impacts of emergencies and disasters on health; review progress in strengthening capacities and vulnerability reduction; and prioritize areas for further action.

To strengthen mortality data and reporting, countries will need to consider capacity development measures including health sector training on methods to improve monitoring and reporting on Sendai targets in the health sector; and contribute to the multisectoral disaster loss databases that are often managed by national disaster management agencies.

Civil registration and vital statistics are the backbone of effective national service delivery, with data also crucial to monitoring 12 of the 17 Sustainable Development Goals (Sustainable Development Solutions Network, 2019). In the medium and longer term, ministries of health could consider strengthening national and subnational capacities for civil registration and vital statistics, and developing national case registries for mortality and morbidity related to hazardous events, including emergencies and disasters.

The World Health Organization is committed to collaborating with ministries and partners to support countries in their efforts to strengthen their capacities for collecting and reporting data for the Sendai Framework targets and indicators, and the related indicators for the Sustainable Development Goals and other relevant frameworks. This is exemplified by the ongoing work on guidance, developed in the Technical Guidance Notes on Sendai Framework Reporting for Ministries of Health, in consultation with Member States and partners, for implementation by each United Nations Member State's focal point and/or coordinator for reporting to the Sendai Framework Monitor.

18 The guidance notes can be found at https://apps.who.int/iris/bitstream/handle/10665/336262/9789240003712-eng.pdf?sequence=1&isAllowed=y.

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ANNEXES

Annex I. About the Centre for Research on the Epidemiology of Disasters

The Centre for Research on the Epidemiology of Disasters has been active for more than 35 years in the fields of international disaster and conflict health studies, with research and training activities linking relief, rehabilitation and development. It was established in Brussels in 1973 at the School of Public Health of the Université catholique de Louvain as a non-profit institution with international status under Belgian law. In 1980, CRED became a WHO collaborating centre as part of the WHO Global Programme for Emergency Preparedness and Response. Since then, CRED has increased its international network substantially and collaborates closely with numerous United Nations agencies, intergovernmental and governmental institutions, non-governmental organizations, research institutes and universities.

Objective

The Centre promotes research and provides an evidence base to the international community on the burden of disease and related health issues due to disasters and conflicts in order to improve preparedness and responses to these humanitarian emergencies. CRED trains field managers, students, relief personnel and health professionals in the management of short- and long-term humanitarian emergencies.

Focus

The Centre's research focuses on all humanitarian and emergency situations with a major impact on human health. These include all types of natural and human-made disasters, such as earthquakes, floods and storms; longer-term disasters such as famines and droughts; and situations creating mass displacement of people such as civil strife and conflicts.

The Centre focuses on health aspects and the burden of disease arising from disasters and complex emergencies. CRED also promotes research on broader aspects of humanitarian crises, such as human rights and humanitarian law, socioeconomic and environmental issues, early warning systems, the special needs of women and children, and mental health care.

The Centre is actively involved in stimulating debate on the effectiveness of various humanitarian interventions. It encourages scientific and policy discussions on existing and potential interventions and their impacts on acute and chronic malnutrition, human survival, morbidity, infectious diseases and mental health.

The CRED team works in four main areas:

- Natural disasters and their impacts
- Civil strife and conflict epidemiology
- Database and information support
- Capacity-building and training.

Annex II. About global disaster loss and damage databases and the Centre for Research on the Epidemiology of Disasters Emergency Events Database

EM-DAT hazard classification

Table 10. Hazard classification as defined in EM-DAT

Disaster group	Disaster subgroup	Disaster main type	Disaster subtype	Disaster sub-subtype
Natural	Meteorological	Extreme temperature	Cold wave	
			Heatwave	
			Severe winter conditions	Snow/ice
				Frost/freeze
		Fog		
		Storm	Convective storm	Derecho
				Hail
				Lightning/thunderstorm
				Rain
				Sand/dust storm
				Severe storm
				Storm/surge
				Tornado
				Wind
				Windstorm/blizzard
			Extratropical storm	
			Tropical storm	
	Climatological	Drought		
		Glacial lake outburst		
		Wildfire	Forest fire	
			Land fire: Brush, bush, pasture	
	Hydrological	Flood	Coastal flood	
			Flash flood	
			Ice jam flood	
			Riverine flood	
		Landslide	Avalanche (Snow, debris, mudflow, rockfall)	
		Wave action	Rogue wave	
			Seiche	

EM-DAT information

The EM-DAT database depends on a number of sources of information, as highlighted in Table 11.

Table 11. List of the main sources commonly used by CRED to gather the necessary information for the disasters likely to be included in EM-DAT

Sources	Examples
United Nations	Office for the Coordination of Humanitarian Affairs, Integrated Regional Information Networks, World Health Organization, Food and Agriculture Organization
National figures	Official country figures (for example, Philippines – National Disaster Risk Reduction and Management Council)
United States technical agencies	Office of United States Foreign Disaster Assistance, National Oceanic and Atmospheric Administration, United States Geological Survey, Federal Emergency Management Agency
NGOs	International Federation of Red Cross and Red Crescent Societies and/or National Red Cross Societies
Intergovernmental organizations	World Bank, European Union
Reinsurance companies	MunichRe, SwissRe
Insurance magazine	*Lloyd's Casualty Week*
Research centres	Universities/academic institutions (for example, University of South Carolina/Hazard and Vulnerability Research Institute/Sheldus Database), Asian Disaster Preparedness Centre, Dartmouth Flood Observatory and any scientific paper or working document
Press/media	Agence France-Presse, Reuters
Other databases	Examples include: United States Geological Survey (earthquake), Dartmouth Flood Observatory (flood), WHO (epidemics) and Smithsonian Institution Volcanism Program (volcanic eruption)

The institutions detailed in Table 11 that collect damage and loss data concerning natural hazards also provide reports and publications about the analyses of disasters that have been occurring worldwide, providing information about their magnitude, socioeconomic impacts and geographic distribution. Some of the main publications used as source material are listed in Table 12.

Table 12. List of the main publications focusing on major natural or man-made disasters and their related socioeconomic impacts

Institution	Publication name	Frequency	Keywords
CRED	Annual Disaster Statistical Review: The numbers and trends	Yearly	Victims – economic losses – natural disasters
WMO	*State of the Global Climate*	Yearly	Climate variables – climate anomalies
Swiss Re	Sigma Reports on "Natural catastrophes and man-made disasters"	Yearly	Natural disasters – economic losses – victims
Munich Re	*TOPICS Geo*	Yearly	Natural disasters – economic losses – victims
UNDRR	*Global Assessment Report*	Biannual	Economic risk – disaster risk reduction

EM-DAT event template

The EM-DAT database provides a number of data fields related to disasters (as indicated in Table 13).

Table 13. EM-DAT definitions included in the database describing both the social and the economic impacts of disasters

Field	Definition
Killed (deaths)	Persons confirmed as dead and persons missing and presumed dead
Injured	People suffering from physical injuries, trauma or an illness requiring medical treatment as a direct result of a disaster
Homeless	People needing immediate assistance for shelter
Affected	People requiring immediate assistance during a period of emergency, including displaced or evacuated people
Total affected	Sum of injured, homeless and affected
Total estimated damages	A value of all damages and economic losses directly or indirectly related to the disaster
Reconstruction cost	Costs of replacing lost assets
Insured losses	Economic damages covered by the insurance industry

Each disaster event is recorded in the EM-DAT database with the variables shown in Table 14.

Table 14. Disaster event variables in the EM-DAT database

Variable	Details
Disaster information	• Disaster number (DISNO – a unique ID of 8 digits: 4 digits for the year and 4 digits for the disaster number, for example, 19950324) • Disaster group/type/subtype/sub-subtype • Name • Entry criteria – for a disaster to be entered into the database at least one of the following criteria must be fulfilled: – 10 or more people reported killed – 100 or more people reported affected – Declaration of a state of emergency – Call for international assistance
Temporal information	• Year (Note: A drought that lasted for two or several years is recorded with its beginning year following EM-DAT's guidance) • Start and end dates • Local time
Geographical information	• Country/continent/region • Location • Latitude/longitude
Characteristics	• Origin • Associated disasters • Magnitude/scale

Variable	Details
International appeal	• OFDA response • Request for international assistance • Declaration of state of emergency • Aid contribution
Economic impact	• Estimated damages (direct/indirect; by sector) • Insured losses • Reconstruction cost
Human impact	• Total deaths (= deaths + missing) • Injured • Homeless • Affected • Total affected (= injured + homeless + affected)
Sector impact	• Impact on infrastructure: houses, bridges, hospitals, crops, roads damaged/destroyed • Sectors affected: industry, sanitation, communication

Country name changes

A number of country names have changed over the years for various political reasons (Table 15). The EM-DAT country name is given in the first column, What WMO region the country belongs to in the second column. The last column gives a brief explanation of the political changes.

Table 15. List of country name changes since the establishment of the EM-DAT data.

Country/territory name as listed in EM-DAT	Geographic RA	Information
Czechoslovakia	6	Split into Czech Republic (presently Czechia) and Slovakia (SVK) in January 1993
Eritrea	1	Separated from Ethiopia and Eritrea in 1993
German Democratic Republic	6	Germany (DEU) since 1990
Germany, Federal Republic of	6	Germany (DEU) since 1990
Serbia Montenegro	6	Split into Serbia (SRB) and Montenegro (MNE) in 2006
Soviet Union	2	Split into 15 countries in 1991
Timor-Leste		Separated from Indonesia in 2002
Yemen Arab Republic	2	Yemen (YEM) since 1990
People's Democratic Republic of Yemen	2	Yemen (YEM) since 1990
South Sudan	1	Separated from Sudan in 2011
Yugoslavia	6	Split into five countries in 1991/92 (Slovenia, Croatia, Bosnia and Herzegovina, Serbia Montenegro and North Macedonia)

All data records for Yugoslavia, Serbia Montenegro and Czechoslovakia were included in the global statistics and global maps. For the regional map of Europe however, data from these former countries could not be shown and were therefore excluded (Table 16), unless one of these data records could be specifically attributed to another existing country from the metadata.

Table 16. Disaster statistics from three former countries that were excluded from the map of Europe

Country	Statistics		
	Number of disasters	Number of deaths	Economic losses (in US$ billion)
Czechoslovakia	9	24	0.036
Serbia Montenegro	13	20	0.0
Yugoslavia	8	130	3.97

Annex III. List of WMO regions and corresponding countries and territories as listed in EM-DAT

The countries and territories that were included in the EM-DAT database are matched to each of the six WMO regions according to their geographical location (Table 17). The mainland of all countries is contained within one single WMO region, with the exception of the Russian Federation (formerly referred to as the Union of Soviet Socialist Republics) and Kazakhstan (formerly part of the Union of Soviet Socialist Republics), which stretches across both WMO Region II (Asia) and WMO Region VI (Europe) (See Figure 42). The entries in the EM-DAT database for the Russian Federation and Kazakhstan were therefore carefully considered according to location (based on the information available in EM-DAT) to ensure that the reported events and their associated socioeconomic losses are properly attributed to the corresponding WMO region. Overseas territories (for example, La Reunion) and federal states (for example, Hawaii), respectively, are included in the WMO region in which they are located, with an indication of which country they are associated with.

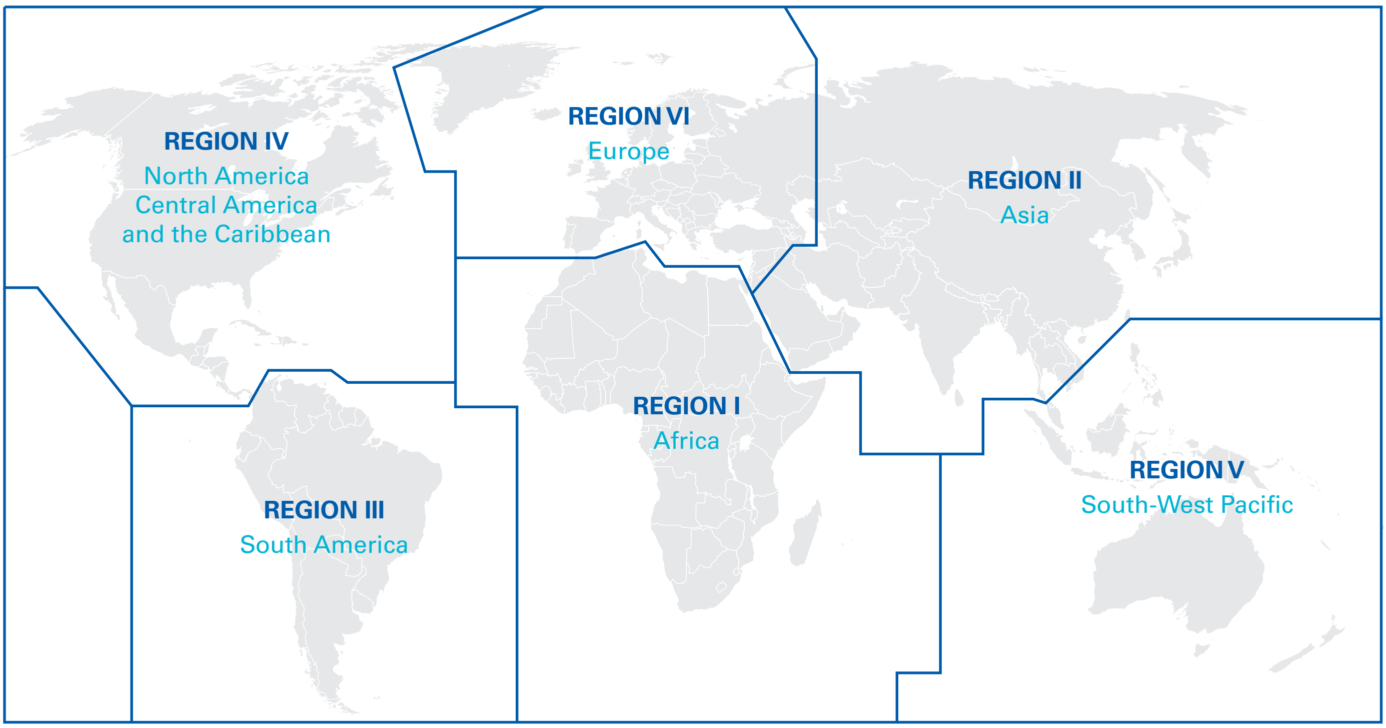

Figure 42. Map of WMO regional associations

Table 17. Number of disasters reported per country/territory by WMO region for the period of 1970–2019

Note: The names of WMO Member States and Territories are according to WMO standard. Non-member states and territories are according to the United Nations standard as listed in EM-DAT data.

Region I (Africa)			
State/territory	No. of disasters	State/territory	No. of disasters
Algeria	56	Madeira (Portugal)	3
Angola	50	Malawi	51
Benin	24	Mali	34
Botswana	17	Mauritania	30
Burkina Faso	30	Mauritius	19
Burundi	42	Morocco	42
Cameroon	24	Mozambique	79
Canary Islands (Spain)	7	Namibia	23
Cabo Verde	8	Niger	40
Central African Republic	31	Nigeria	64
Chad	29	Reunion (France)	11
Comoros	11	Rwanda	31
Congo	11	Saint Helena (United Kingdom))	1
Côte d'Ivoire	14	Sao Tome and Principe	1
Democratic Republic of the Congo	49	Senegal	30
Djibouti	20	Seychelles	4
Egypt	23	Sierra Leone	16
Eritrea	6	Somalia	62
Ethiopia	74	South Africa	90
Gabon	5	South Sudan	15
Gambia	19	Sudan	53
Ghana	27	Swaziland	14
Guinea	18	Togo	15
Guinea-Bissau	12	Tunisia	17
Kenya	76	Uganda	47
Lesotho	19	United Republic of Tanzania	64
Liberia	10	Zambia	25
Libya	3	Zimbabwe	27
Madagascar	72		

Region II (Asia)			
State/territory	No. of disasters	State/territory	No. of disasters
Afghanistan	138	Nepal	96
Bangladesh	277	Oman	14
Bhutan	6	Pakistan	159
Cambodia	32	Qatar	1
China	721	Republic of Korea	97
Democratic People’s Republic of Korea	42	Russian Federaton (WMO Regional Association II)	76
Hong Kong (China)	107	Saudi Arabia	24
India	550	Sri Lanka	93
Iran, Islamic Republic of	93	Taiwan (Province of China)	79
Iraq	12	Tajikistan	51
Japan	208	Thailand	134
Kazakhstan	19	Turkmenistan	1
Kuwait	2	United Arab Emirates	1
Kyrgyzstan	18	Uzbekistan	3
Lao People’s Democratic Republic	39	Viet Nam	217
Macao (China)	6	Yemen (prior to 1990: Yemen Arab Republic)	4
Maldives	3	Yemen (prior to 1990: People’s Democratic Republic of Yemen)	7
Mongolia	27	Yemen	41
Myanmar	56		

Region III (South America)			
State/territory	No. of disasters	State/territory	No. of disasters
Argentina	103	Guyana	11
Bolivia, Plurinational State of	75	Paraguay	45
Brazil	193	Peru	108
Chile	73	Suriname	2
Colombia	135	Uruguay	31
Ecuador	48	Venezuela, Bolivarian Republic of	41
French Guiana (France)	2		

Region IV (North America, Central America and the Caribbean)			
State/territory	No. of disasters	State/territory	No. of disasters
Anguilla[19] (United Kingdom)	6	Honduras	69
Antigua and Barbuda	10	Jamaica	34
Bahamas	20	Martinique (France)	12
Barbados	10	Mexico	202
Belize	18	Monstserrat (United Kingdom)	3
Bermuda (United Kingdom)	5	Netherlands Antilles	2
British Virgin Islands (United Kingdom)	8	Nicaragua	53
Canada	110	Panama	46
Cayman Islands (United Kingdom)	7	Puerto Rico (United States)	30
Costa Rica	45	Saint Barth	1
Cuba	68	Saint Kitts and Nevis	8
Curaçao and Sint Maarten	1	Saint Lucia	15
Dominica	12	Saint Martin (French)	1
Dominican Republic	63	Saint Vincent and The Grenadines	16
El Salvador	41	Trinidad and Tobago	10
Grenada	6	Turks and Caicos Islands (United Kingdom)	7
Guadeloupe (France)	10	United States of America	848
Guatemala	69	United States Virgin Islands (United States)	8
Haiti	103		

Region V (South-West Pacific)			
State/territory	No. of disasters	State/territory	No. of disasters
American Samoa (United States)	4	Niue	2
Australia	226	Northern Mariana Islands	4
Brunei Darussalam	1	Palau	2
Cook Islands	7	Papua New Guinea	38
Fiji	49	Philippines	514
French Polynesia (France)	7	Samoa	11
Guam (United States)	8	Solomon Islands	22
Indonesia	292	Timor-Leste	8
Kiribati	5	Tokelau (New Zealand)	3
Malaysia	65	Tonga	17
Marshall Islands	6	Tuvalu	7
Micronesia, Federated States of	10	Hawaii (United States)	5
New Caledonia (France)	9	Vanuatu	28
New Zealand	55	Wallis and Futuna Islands (France)	2

19 Group membership of the British Caribbean Territories (Anguilla, Montserrat, Turks and Caicos Islands, British Virgin Islands, Cayman Islands).

Region VI (Europe)			
State/territory	No. of disasters	State/territory	No. of disasters
Albania	25	Jordan	12
Armenia	9	Latvia	8
Austria	48	Lebanon	11
Azerbaijan	10	Lithuania	14
Azores (Portugal)	2	Luxembourg	12
Belarus	12	Montenegro	11
Belgium	55	Netherlands	35
Bosnia and Herzegovina	24	North Macedonia	21
Bulgaria	41	Norway	10
Croatia	27	Poland	53
Cyprus	9	Portugal	43
Czechia	26	Republic of Moldova	15
Czechoslovakia	9	Romania	83
Denmark	16	Russian Federation (WMO Regional Association VI)	88
Estonia	4	Serbia	37
Finland	3	Slovakia	21
France	158	Slovenia	7
Georgia	20	Spain	89
Germany (prior to 1990: German Democratic Republic)	3	State of Palestine	7
Germany (prior to 1990: German Federal Republic)	12	Sweden	12
Germany	75	Switzerland	53
Greece	56	Syrian Arab Republic	10
Hungary	32	Turkey	71
Iceland	5	Ukraine	33
Ireland	22	United Kingdom of Great Britain and Northern Ireland	84
Israel	16	Union of the Soviet Socialist Republics (until 1991)	6
Italy	99	Yugoslavia	8

Annex IV. Country classification by the United Nations and the World Bank

The figures and diagrams presented in this publication representing the number of disasters, deaths and economic losses due to weather, climate and water extremes are based principally on two systems of economic categorization, those developed by the United Nations and the World Bank. These two systems are not all-inclusive, and some smaller island countries and territories are omitted. These are listed in Table 19. For this Atlas, the classification of these countries/territories has been based on a supplementary economic classification developed by the United Nations Conference on Trade and Development (UNCTAD).

The classifications developed by the United Nations and the World Bank are universally employed to compare the economies of the 193 countries that they cover. Exploitation of the differences in approaches of the two systems is useful to reflect on and evaluate the disasters attributed to weather, climate and water extremes within the context of monitoring the achievement of the Sendai Framework and the Sustainable Development Goals.

The World Bank country classification by income group contains four categories (figures are for 2015 for the fiscal year 2017):

- Low income (lower than **US$ 1 181**)
- Lower-middle income (**US$ 1 026–US$ 4 035**)
- Upper-middle income (**US$ 4 036–US$ 12 475**)
- High income (**US$ 1 2476** or more)

Income is measured using gross national income (GNI) per capita. While it is understood that GNI per capita does not completely summarize a country's/territory's level of development or measure its welfare, it has proved to be a useful and easily available indicator that is closely correlated with other, non-monetary measures of the quality of life, such as life expectancy at birth, mortality rates of children, and rates of enrolment in schools. However, there are some limitations associated with the use of GNI that users should be aware of. For instance, GNI may be underestimated in lower-income economies that have more informal, subsistence activities. Nor does GNI reflect inequalities in income distribution. This World Bank's classification can be found at http://databank.worldbank.org/data/download/site-content/OGHIST.xls.

United Nations country classification by the Department of Economic and Social Affairs (DESA):

- Developed economies
- Economies in transition
- Developing economies

This classification is based on information obtained from the Statistics Division and the Population Division of DESA, as well as from the five United Nations regional commissions, UNCTAD, the United Nations World Tourism Organization, IMF, the World Bank, the Organisation for Economic Co-operation and Development, and national and private sources. The country classification has been prepared as part of the World Economic Situation and Prospects; it classifies countries of the world into one of three broad categories to reflect basic economic country conditions. This United Nations classification can be found at https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/WESP2019_BOOK-ANNEX-en.pdf.

Classification of Small Island Developing States and those countries/territories that are not covered by the World Bank List can be found at https://unctadstat.unctad.org/EN/Classifications/DimCountries_EconomicsGroupings_Hierarchy.pdf.

United Nations and World Bank economic classifications of the number of countries and territories in each WMO region can be found in Table 18. For these countries, we have used the UNCTAD classification and included them in the developing country list.

Table 18. United Nations and World Bank economic classifications of countries and territories by WMO Region

	United Nations economic classification of countries and territories by WMO Region		*World Bank economic classification of countries and territories by WMO region*	
Global	Developed economies	42	High-income	77
	Developing economies	160	Lower-middle-income	48
	Economies in transition	19	Low-income	33
			Upper-middle-income	63
Region I	Developed economies	1	High-income	4
	Developing economies	56	Lower-middle-income	21
			Low-income	24
			Upper-middle-income	8
Region II	Developed economies	1	High-income	10
	Developing economies	30	Lower-middle-income	11
	Economies in transition	6	Low-income	7
			Upper-middle-income	9
Region III	Developing economies	13	High-income	2
			Lower-middle-income	2
			Upper-middle-income	9
Region IV	Developed economies	3	High-income	17
	Developing economies	30	Lower-middle-income	3
	Economies in transition	1	Low-income	1
			Upper-middle-income	13
Region V	Developed economies	3	High-income	11
	Developing economies	25	Lower-middle-income	8
			Upper-middle-income	9
Region VI	Developed economies	34	High-income	33
	Developing economies	6	Lower-middle-income	3
	Economies in transition	12	Low-income	1
			Upper-middle-income	15

Table 19. States not included in the United Nations and World Bank classifications, and for which the UNCTAD classifications were used

American Samoa	Curaçao	Montserrat	Saint Vincent and the Grenadines
Anguilla	Dominica	Nauru	Seychelles
Antigua and Barbuda	Federated States of Micronesia	Niue	Sint Maarten
Aruba	French Polynesia	New Caledonia	Tonga
Bermuda	Grenada	Northern Mariana Islands	Turks and Caicos Islands
British Virgin Islands	Guam	Palau	Tuvalu
Cayman Islands	Marshall Islands	Saint Kitts and Nevis	United States Virgin Islands
Cook Islands	Martinique	Saint Lucia	

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