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Introduction

Recent natural and human-induced events have highlighted the fragility and vulnerability of the built environment to disasters. People's homes and work places, transport networks, water supply and sanitation systems, energy generation and distribution networks are all critical to the way we live our lives but they can also be vulnerable to a broad range of risks and threats. These physical systems, which represent a major proportion of the long-term developmental investment for most countries, have traditionally been designed, built and maintained by the myriad professions involved with the construction industry. Therefore, it is argued that a wide range of built environment practitioners can play a proactive role in ensuring that the built environment is designed and developed in a way that alleviates or eradicates the current and future risks that natural hazards and human-induced threats pose.

> "*While hazards, such as earthquakes, cyclones and tsunamis are natural in origin; the way that disaster risk has become embedded in the contemporary urban landscape is largely anthropogenic. Decades of mass urbanisation accompanied by poor urban planning, non-existent or poorly regulated building codes and little or no proactive adaptation to the impacts of climate change have increased humanity's exposure to these hazards*". (Bosher 2014: 240)

Clearly there are many deeply ingrained root causes that can lead to some people being poor/marginalised or particularly prone to the impacts of natural hazards; these root causes are especially focused upon in publications such as '*At Risk*' by Wisner *et al.* (2004) and thus are not discussed in as much depth in this book. '*Disaster Risk Reduction for the Built Environment: An introduction*' examines multi-hazard and multi-threat adaptation issues mainly from a built environment perspective whilst also considering the non-structural elements of multi-hazard/threat adaptation.

The aim of this book is to highlight the numerous positive roles that practitioners such as civil and structural engineers, urban planners and designers, architects and facilities managers (to name just a few) can undertake to ensure that disaster risk is attended to in on-going and future construction projects. The book does not aim to set out prescriptive ('context blind') solutions to complex problems because such solutions can invariably generate new problems. It is intended that this book can raise awareness, and in doing so inspire a broad range of people (professional or lay) to consider Disaster Risk Reduction (DRR) in their work or everyday activities. We will achieve this by providing a broad range of examples, case studies and thinking points that will help to facilitate consideration of differing contexts.

Disaster Risk Reduction for the Built Environment, First Edition. Lee Bosher and Ksenia Chmutina.

Figure 1.1 Locals dealing with the aftermath of the 2015 Nepalese earthquake (*Source:* US Embassy Kathmandu on Flickr).

1.1 So what is a Disaster?

Disaster is a serious disruption of the functioning of a society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using its own resources.

Alexander (2002) outlines some of the characteristics of disasters, including ‘substantial’ destruction and/or ‘mass’ casualties, without putting values on the scale of the disaster as “*small monetary losses can lead to major suffering and hardship or, conversely, large losses can be fairly sustainable…*”, depending on the chain of circumstances.

Wisner *et al.* (2004) state “*A disaster occurs when a significant number of vulnerable people experience a hazard and suffer severe damage and/or disruption of their livelihood system in such a way that recovery is unlikely without external aid. By ‘recovery’ we mean the psychological and physical recovery of victims, the replacement of physical resources and the social relations required to use them.*”

Key points arising from these definitions are the requirement for external aid resulting from a combination of an event and people’s abilities (or inabilities) to cope with the event. The disaster event is what leads to the emergency response to meet the needs of the affected population.

1.2 What are the Hazards and Threats?

A ‘**hazard**’ can be defined as a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

A ‘threat’ can be defined as a person or thing that is regarded as dangerous or likely to inflict pain or misery.

For the purposes of this book, the definitions that will be used to distinguish between the two main causes of disasters are the simpler descriptors of:

Hazard: is primarily a 'natural' source of potential danger
Threat: is primarily a 'human-induced' source of potential danger

Disasters are usually classified into natural and human induced (sometimes also called 'manmade'). 'Natural disasters' is a common term used, particularly by the media, as it relates to disasters that appear to have been caused by hazards of natural origin such as extreme weather, geophysical phenomena or epidemics. However, it is important to recognise that these so called 'natural disasters' are rarely very natural, because there tends to be many important human induced factors that have converted the natural hazard into a disaster (i.e., low-quality buildings, poor locational planning), see Thinking Point *1.1* and later chapters for further discussions on this matter.

Natural hazards are typically split into two categories, namely, 1) geo-hazards, and 2) hydro-meteorological hazards. Table 1.1 provides a list of the key geophysical-hazards and hydro-meteorological hazards that occur globally. The magnitude of natural hazards tends to be determined by key factors such as meteorology (which is influenced by the changing seasons), topography, hydrology, geology, biodiversity (of flora and fauna) and tidal variations (caused by lunar and meteorological influences, coastal topography and influenced by the type and locality of coastal developments). These processes are typically benign and provide the basis for people to exist in harmony with their natural environment. However, infrequently (and some would suggest more frequently) natural hazards impact upon the built environment, causing damage, deaths, disruption and financial losses.

1.3 Climate Change and Disasters

There is now a broad scientific consensus (including from the Intergovernmental Panel on Climate Change, IPCC) that the global climate is changing in ways that are likely to have a profound impact on human society and the natural environment over the coming decades (IPCC, 2014). Experts have suggested that the impact of global climate change (which is arguably both natural and anthropogenic in nature) has increased the frequency and intensity of disasters, and will further increase the frequency and intensity of such events in the future (IPCC, 2014). The impact of these events can be psychological, sociological and political but are typically reported in economic terms.

Thinking Point 1.1

So How Natural are 'Natural Disasters'?

So why is a 'natural disaster' not really a 'natural disaster'? Can you think of any examples when it would be clearly appropriate to call a disaster a 'natural disaster'? The human influences upon the causes of disasters are too often overlooked because sometimes these influences can be discrete and driven by very different socio-economic factors. For example, in many high-income countries, people like to live near rivers (and are prepared to pay for the benefit in many cases) for the aesthetic and recreational benefits that rivers can offer. Therefore, a flood event that occurs in the non-tidal stretch of the River Thames, for example, inundating people's homes, businesses and lifelines will typically be referred to as a 'natural disaster' but the flood hazard manifests itself as a disaster, because, in this case, society has chosen to build homes, infrastructure and businesses in an area vulnerable to floods.

Table 1.1 Typology of Hazards and Threats.[1]

Natural hazards **A Hazard is primarily a 'natural' source of potential danger**		***Human-induced threats*** **A 'Threat' is primarily a 'human-induced' source of potential danger**	
Geophysical Hazards	Earthquakes	***Malicious***	War
	Volcanic eruptions		Terrorism
	Tsunamis (*inc. Seiches*)		Arson
	Landslides		Civil unrest
	Subsidence		Vandalism
Hydro-Meteorological Hazards	Floods	***Non-malicious***	Ineffective planning
	Coastal erosion		Poor quality construction
	Hurricanes/cyclones/typhoons		Rapid urbanisation
	Tornadoes		Pollution
	Extreme temperatures		Epidemics
	Storm surges		Industrial 'accidents'
	Drought		Corruption
	Fires		

Sea-level rise could provide an increasing challenge to developments located in coastal areas. Inevitably, such changes will have, and are already beginning to have, major consequences for the built environment, particularly critical infrastructures. The potential interrelationships between climate change, anthropogenic systems and natural systems, and their subsequent influences on natural hazards and human-induced threats are illustrated in Figure 1.2.

Changes in many extreme weather and climate-related events have been observed since the mid-twentieth century. Global climate change is understood to be the result of human activities since the Industrial Revolution — such as the burning of fossil fuels and land use change (e.g., deforestation) — resulting in a significant increase in greenhouse gases such as carbon dioxide (CO_2) (Figure 1.3).

While greenhouse gases are a natural part of the Earth's atmosphere and serve to maintain temperatures to support life, excessive emission of these gases is causing more heat to be trapped in the atmosphere, leading to rising temperatures. Projected changes in the climate include temperature increases on land and at sea, leading to melting of glaciers and ice caps, sea-level rise, and changing/irregular rainfall patterns. These changes affect almost every aspect of human life and the ecosystems on which it depends. Climate change will result in increases in the frequency and intensity of extreme weather events, as well as significant impacts from more gradual changes. The nature, extent and duration of climate change impacts will vary across different regions.

[1] Please note: An in-depth analysis of each of these hazards/threats is beyond the scope of this book. Some key hazards/threats will be discussed in sufficient depth in forthcoming chapters. For more detailed information about different types of hazards and some key threats you may wish to refer to the book 'Environmental Hazards' by Keith Smith (2013).

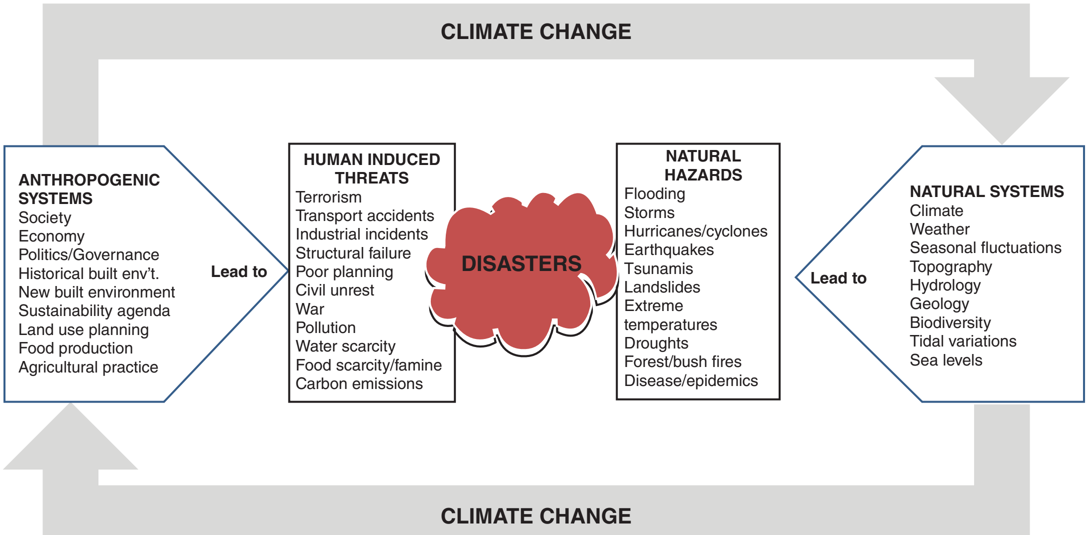

Figure 1.2 Potential interrelationships between climate change and hazards/threats (*Source:* Adapted from Bosher, 2007.).

According to the fifth IPCC assessment report, the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale, with the frequency of heat waves on the increase in large parts of Europe, Asia and Australia. There are now more land regions where the number of heavy precipitation events has increased than where it has decreased: this implies greater risks of flooding.

Climate change may not be significantly responsible for the recent skyrocketing cost of disasters, but it is very likely that the portended changes in the climate will impact future catastrophes. Climate models provide a glimpse of the future, and while they do not agree on all of the details, most models predict a few general trends. First, according to the IPCC, an increase of greenhouse gases in the atmosphere will probably boost temperatures over most land surfaces, although the exact change will vary regionally. More uncertain – but possible – outcomes of an increase in global temperatures include increased risk of drought and increased intensity of storms, including tropical cyclones with higher wind speeds, a wetter Asian monsoon, and, possibly, more intense mid-latitude storms. The combined result of increased temperatures over land, decreased equator-versus-pole temperature differences, and increased humidity could be increasingly intense cycles of droughts and floods, as more of a region's precipitation falls in a single large storm rather than a series of smaller precipitation events. A warmer, wetter atmosphere could also affect hurricanes, but changes to tropical storms are harder to predict and track. Even if tropical storms don't change significantly, other environmental changes brought on by global warming could make the storms more deadly. Melting glaciers and ice caps will likely cause sea levels to rise, which would make flooding more severe when storms affect coastlines (Figure 1.4).

Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions (known as climate change mitigation), which, together with adaptation can limit climate change risks. Thus, the UN's 'Global Assessment Report on Disaster Risk Reduction' (UNISDR, 2015a) notes that the benefits of strong and early action far outweigh the economic costs of inaction. The implications

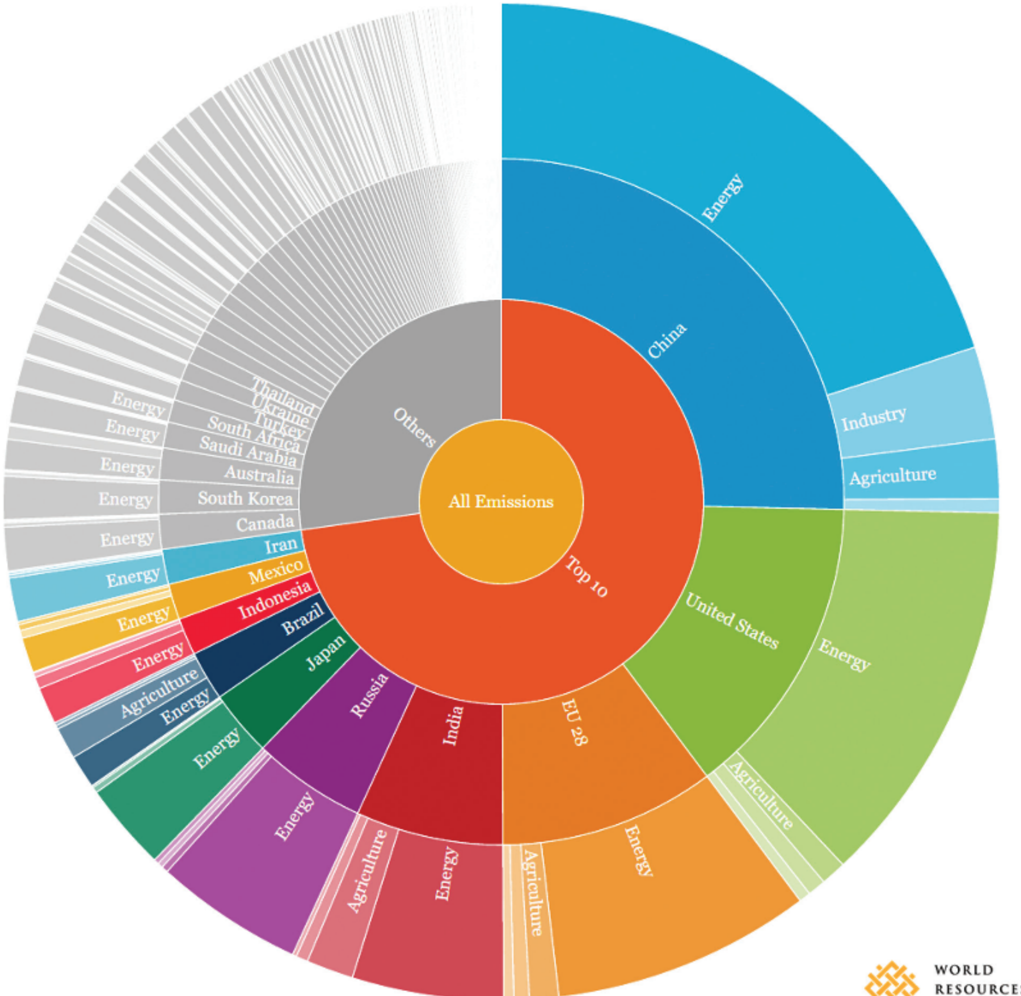

Figure 1.3 Global GHG emissions by country and by sector (*Source:* Reproduced with permission of Friedrich).

of any 'strong and early action' will pose important questions for the planning, design, construction, and maintenance of the built environment and the protection of critical infrastructures.

Consequently, when designing buildings, infrastructure and communities, it is important to plan for future climatic conditions throughout the design life of the development, and not just for the current climate (this issue will be discussed further in Chapter 9). This should be seen as a commercial opportunity for practitioners involved with the built environment. Well-designed buildings, appropriately protected from the hazards associated with climate change, will be easier to sell or let and could also command higher prices. Opportunities are therefore available for organisations to position themselves as market leaders in the concept of 'future-proofing' buildings, thereby presenting a means of attracting new customers and potentially gaining a competitive edge.

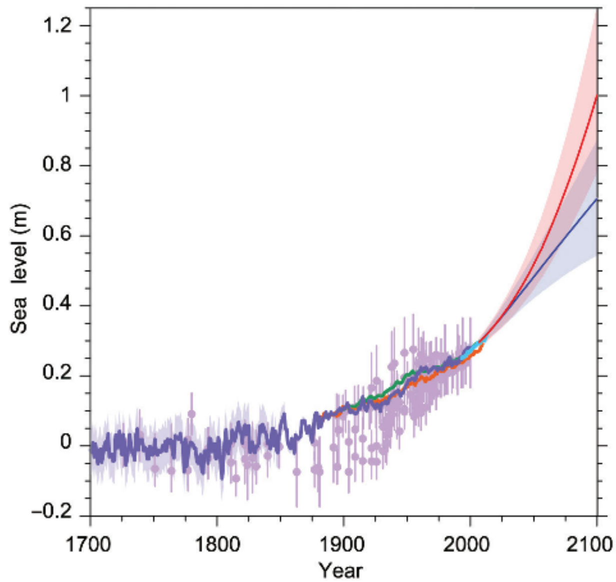

Figure 1.4 IPCC Sea level rise projections: Compilation of paleo sea level data, tide gauge data, altimeter data, and central estimates and likely ranges for projections of global mean sea level rise for RCP2.6 (blue) and RCP8.5 (red) scenarios (Section 13.5.1), all relative to pre-industrial values (2013) (*Source:* Church 2013. Reproduced with permission of Cambridge University Press).

1.4 Impacts of Disasters Globally

Over the past 40 years there has been a significant increase in the number of people affected by disasters globally. According to the Red Cross, an average of 354 disasters occurred throughout the world each year from 1991 to 1999. Between 2000 and 2004, this figure more than doubled to an average of 728 disasters per year (cited in Penuel & Statler, 2011: 233). And each year, the amount of people being affected by disasters has gradually been increasing (Figure 1.5).

Between 2000 and 2013, on average 226 million people per year (that is approximately 3% of the world's population) were affected by all types of disasters. During the same period, nearly 2 million people were killed, an average of 148,894 people each year (EM-DAT, 2014). Based on recent figures obtained from the EM-DAT disaster database (Table 1.2), over the last five years there has been a general decrease in the amount of disaster events occurring and a trend towards lower total deaths each year. 2010 experienced the most disaster events ever recorded (670) and thus witnessed a high amount of deaths (336,743), largely linked to the impacts of the Haitian Earthquake (for more details, see Case Study 5.2).

The least amount of disaster events occurring over the same period happened in 2015 (251), and as a consequence the annual economic damages were the lowest (US$14bn) over that 5-year period. The most costly year (in economic terms) was 2011, with US$364bn of damages, mainly linked to the impacts of the Japan (Tōhoku) earthquake and tsunami, Hurricane Irene (USA) and floods in Thailand, the Philippines and Pakistan. The average figures per year over this five-year period of, 530 disaster events, 140 million people affected, 78 thousand killed and US$151bn in damages are testament to the massive negative impacts that disasters have across the world.

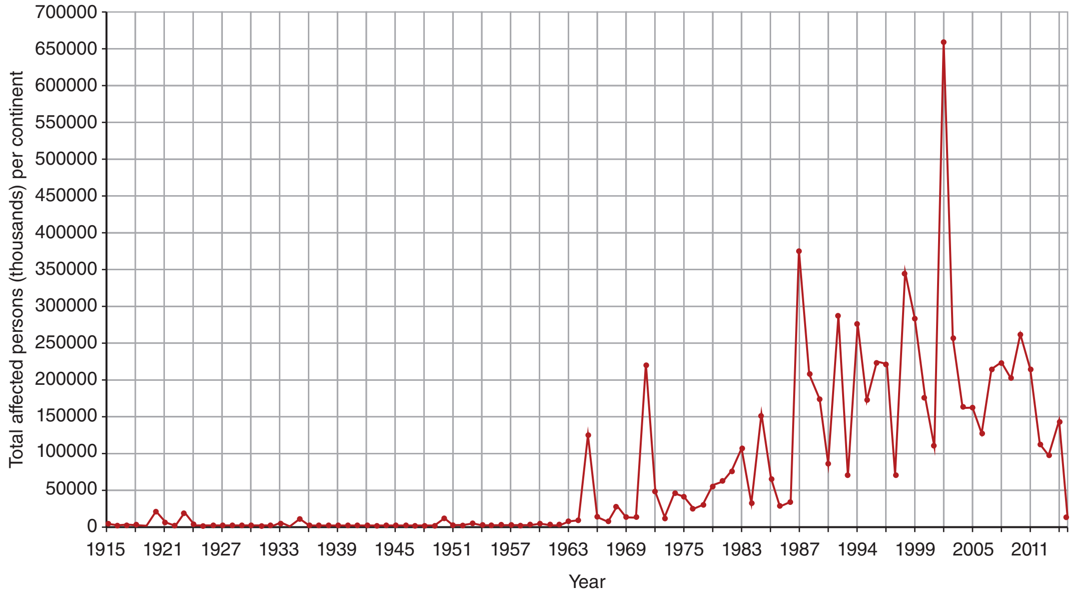

Figure 1.5 Total number of people reported affected by disasters, globally between 1915–2015 (*Source:* The OFDA/CRED EM-DAT International Disaster Database).

Table 1.2 Global Disaster Events and Impacts Between 2010 and 2015.

Year	Amount of disaster events	Total deaths	Total people affected	Total damages (US$)
2010	670	336,743	260.5m	153 bn
2011	605	40,769	213m	364 bn
2012	560	17,578	113m	156 bn
2013	546	28,922	97m	120 bn
2014	549	25,790	142m	98 bn
2015	251	19,321	11.5m	14 bn
Ave:	***530***	***78,187***	***140m***	***151 bn***

Source: The OFDA/CRED EM-DAT International Disaster Database

Disasters wreak havoc on nations irrespective of a country's wealth or resources, but invariably it is the least-developed nations that suffer the most (Bosher, 2008; UNISDR, 2015a). Amongst the top 10 countries[2] in terms of disaster mortality in 2012, six countries were classified as low-income or lower-middle income economies and four as high-income or upper-middle income economies. These countries accounted for 68% of global reported disaster mortality in 2012 (Guha-Sapir, Hoyois & Below, 2013).

[2] The countries listed in the report, based on total deaths in 2012, were 1) Philippines, 2) China P.R., 3) Pakistan, 4) India, 5) Russia, 6) Afghanistan, 7) Nigeria, 8) Peru, 9) Iran, and 10) USA.

1.5 Trends in the Occurrence of Disasters

When investigating disasters, it is interesting to assess whether there are any patterns or trends in the occurrence of disasters. Looking back over the last decade, the main pattern is one of major disasters dominating the death rates. Notable disasters (with approximate death tolls) include:

- 2004, earthquake and tsunami, Indian Ocean, 280,000 deaths
- 2010, earthquake, Haiti, 160,000 deaths
- 2008, cyclone Nargis, Myanmar, 138,366 deaths
- 2005, Kashmir earthquake, Pakistan/India, 100,000 deaths
- 2008, Sichuan earthquake, China, 87,587
- 2003, heat wave, across Europe, > 70,000 deaths
- 2003, Bam earthquake, Iran, 26,271 deaths
- 2011, earthquake and tsunami, Japan, 15,889 deaths
- 2015, earthquake in Nepal, >9,000 deaths
- 2013, typhoon Haiyan, Philippines, China, Vietnam, 6,340 deaths

However, over a longer period, a different picture emerges. The following graphs (Figures 1.6–1.9), based on recent data obtained from the EM-DAT database, show a dramatic increase in the number of disasters over the last century. Some of the initial messages are:

- The amount of disasters occurring each year is on the increase.
- The number of people killed by disasters has thankfully decreased, but the number of people being affected is generally on the increase.
- The number of people killed and affected by 'technological' disasters has increased.

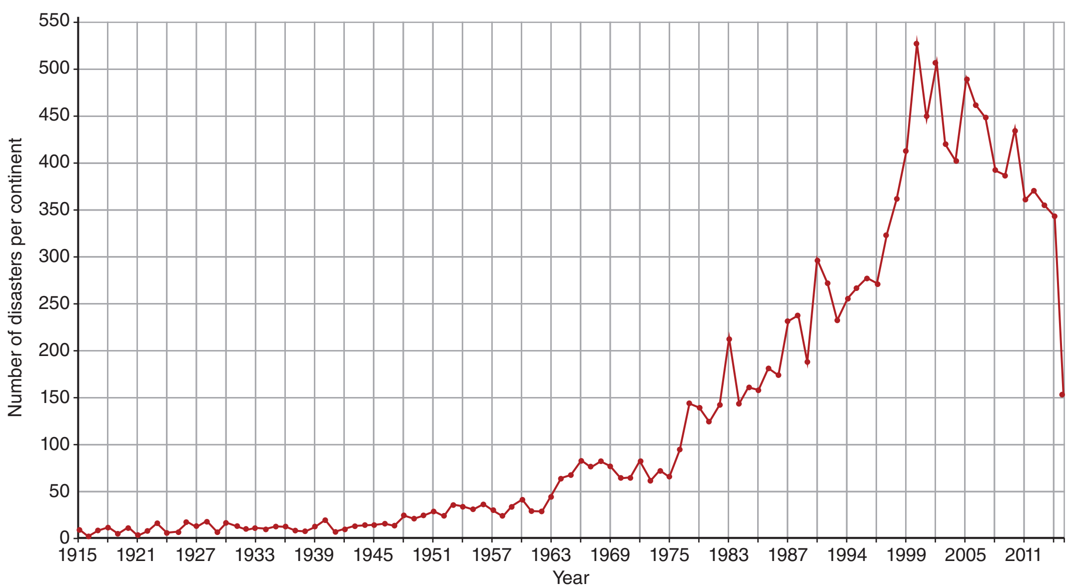

Figure 1.6 Total number of disasters associated with natural hazards 1915–2015 (*Source:* The OFDA/CRED EM-DAT International Disaster Database).

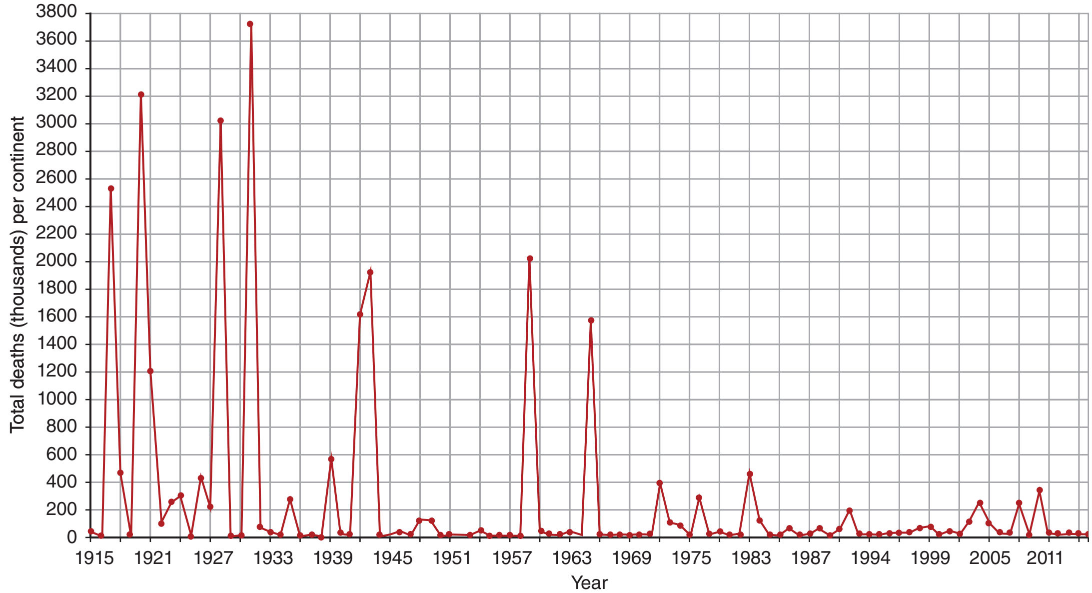

Figure 1.7 Total number of people killed by disasters associated with natural hazards 1915–2015 (*Source:* The OFDA/CRED EM-DAT International Disaster Database).

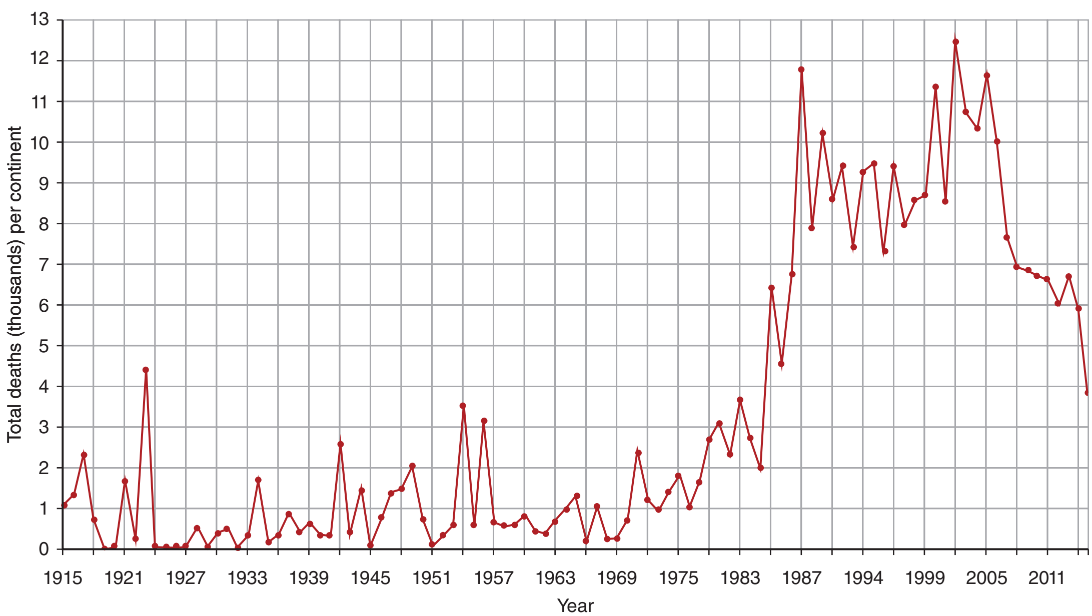

Figure 1.8 Total number of people killed by technological disasters 1915–2015 (*Source:* The OFDA/CRED EM-DAT International Disaster Database).

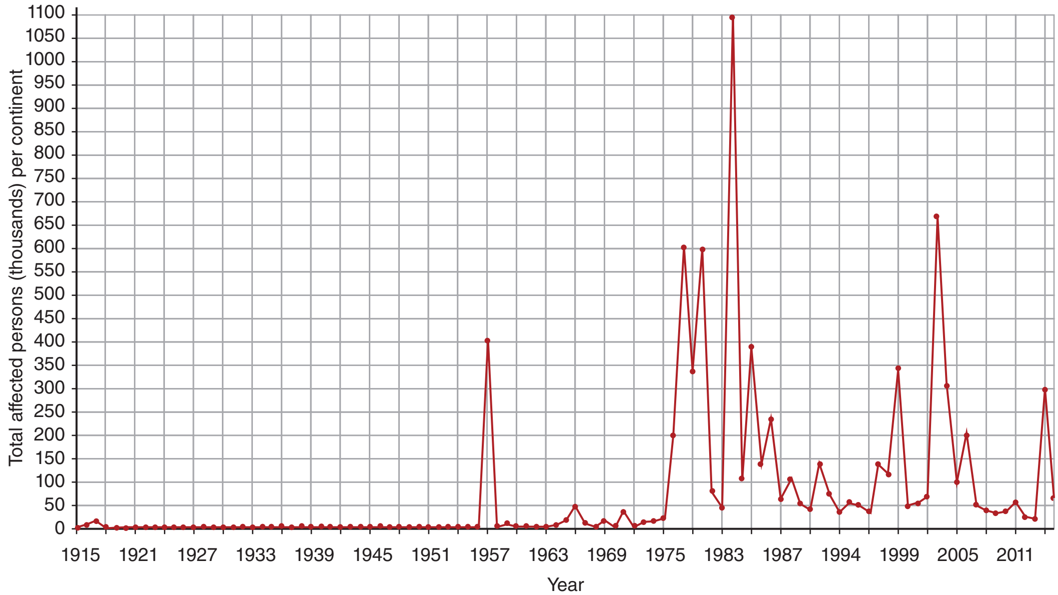

Figure 1.9 Total number of people affected by technological disasters 1915–2015 (*Source:* The OFDA/CRED EM-DAT International Disaster Database).

The trends in the increasing numbers of disasters and their impacts in terms of people being adversely impacted are due to a variety of reasons. In some cases, the number of disasters is actually increasing – for example, technological disasters such as traffic accidents and industrial incidents will increase as the numbers of vehicles and factories increase. These observations are most likely associated to countries where health and safety regulations are not very stringent or their implementation is not being suitably monitored or enforced.

Disasters associated with natural hazards could have been assumed to be constant, but as discussed earlier in this chapter, it is now generally accepted that the world's climate is changing and thus influencing the amount of disasters related to hydro-meteorological hazards such as floods and storms (IPCC, 2014). However, the increase in the number of people affected had already started to grow even before the more obvious signs of climate change, and this factor may have been exacerbated by the relatively rapid rise in the global (and increasingly urbanised) population over the last century. Some hazards, such as earthquakes, are not subject to the immediate impacts of climate change and thus the annual frequency of seismic activity has not significantly changed over the last 50 years (see Figure 1.10). Some of the increases may be due to better reporting and international awareness of disasters. The 24-hour news media and changes in the way nature and death are viewed have helped to make people more aware of how many disastrous events and associated emergencies are occurring globally.

1.6 Economic Losses

One clear increase over the last 50 years has been the rise in the cost of disasters (Figure 1.11). However, this has to be coupled with the fact that economic development has resulted in greater embodied value in buildings and infrastructure, so the re-building costs will increase in line with this. This does not necessarily mean that the incidence or the severity of the disasters has got greater, but the impact on the economy has. Low-income countries appear to suffer less in terms of economic

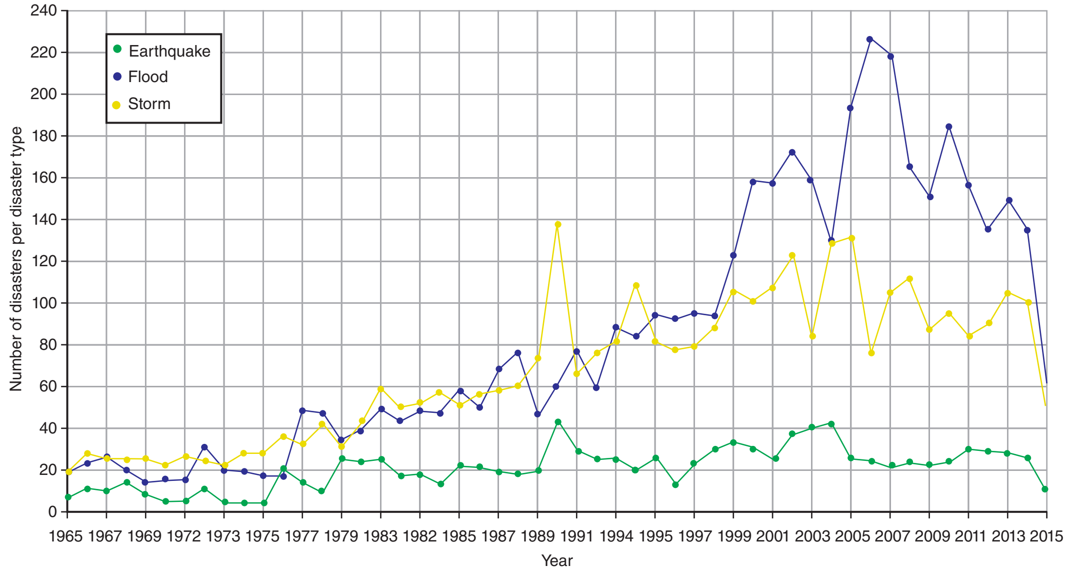

Figure 1.10 Total number of disasters associated with different types of natural hazards 1965–2015 (*Source:* The OFDA/CRED EM-DAT International Disaster Database).

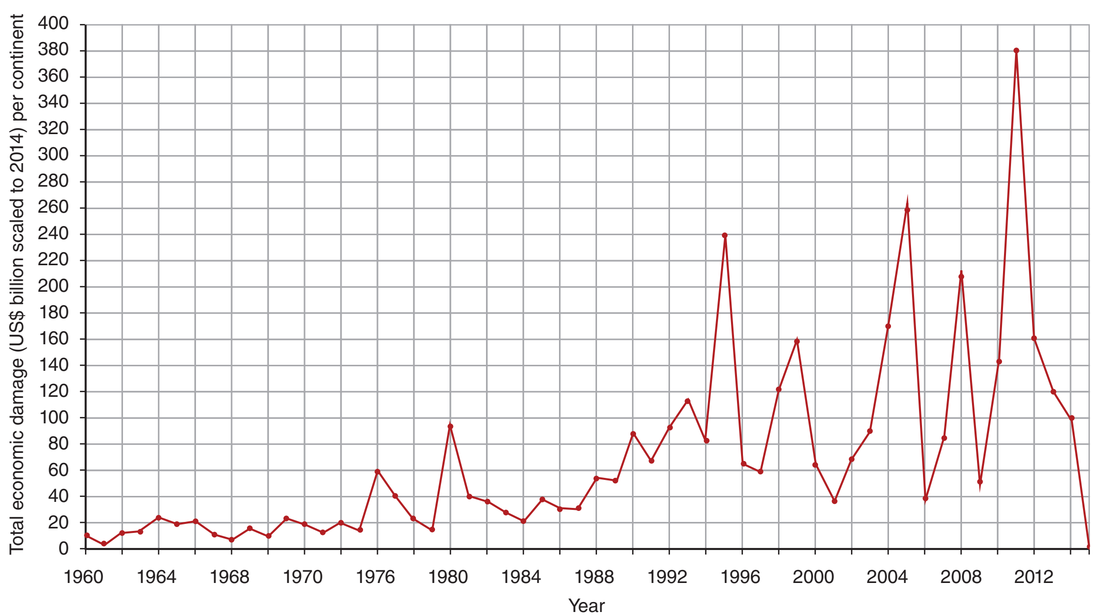

Figure 1.11 Total economic damages caused by disasters associated with natural hazards between 1960–2015 (values normalized to 2014 US$) (*Source:* The OFDA/CRED EM-DAT International Disaster Database).

loss, but that is because they may have had less (extensive/sophisticated) infrastructure to start off with. Therefore, understanding what proportion of economic loss has occurred would be better than merely comparing absolute monetary values.

The UN's Global Assessment Report (UNISR, 2015a) suggests using a new metric – 'life years' – that describes the time required to produce economic development and social progress. The loss of human life years, be it through disasters, disease or accidents, is therefore a way of measuring set-backs to social and economic development (Figure 1.12).

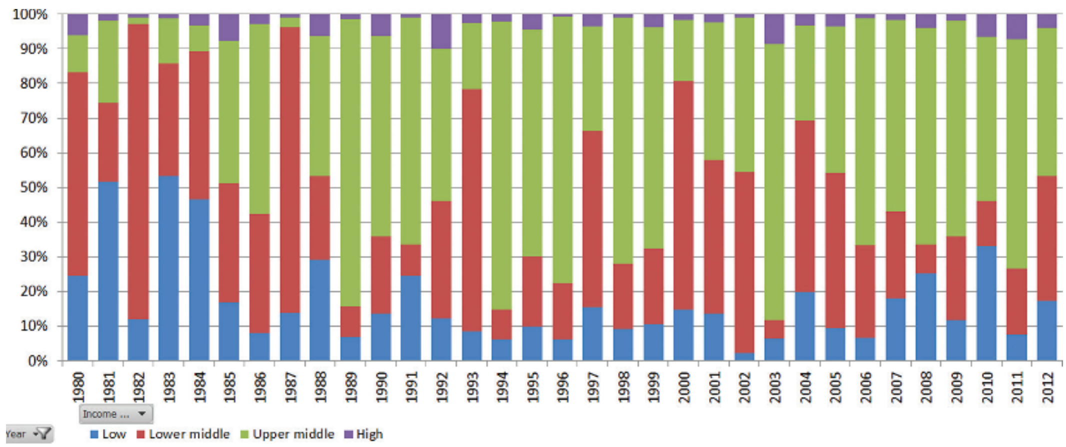

Figure 1.12 Share of life years lost across income groups (*Source:* UN, 2015).

Thinking Point 1.2

Do Not Underestimate 'Mother Nature'

Too often we only focus on the primary effects of the natural hazards, that is, those that occur as a result of a hazard itself. For example, water damage during a flood or collapse of buildings during an earthquake. However, we should not forget that most natural hazards can have larger impacts, which can last for prolonged periods of time. Secondary Effects occur only because a primary effect has caused them; for example, fires ignited as a result of earthquakes, disruption of electrical power and water services as a result of a hurricane, or flooding caused by a landslide into a lake or river. Tertiary Effects are long-term effects that are set off as a result of a primary event. These include loss of habitat caused by a flood, permanent changes in the position of river channel caused by flood, crop failure caused by a volcanic eruption etc.

In addition, a chain reaction, that is, the occurrence of a natural hazard triggered by another hazard, can also take place. Thus, on 26 December 2004, an earthquake ruptured an 800-mile length of the sea floor from northern Sumatra to the Andaman Islands. A massive series of waves rolled across the Indian Ocean. Together, the earthquake and tsunami took more than 200,000 lives in 11 countries. On the morning of 29 November 1975, a magnitude-7.2 earthquake struck the Big Island of Hawaii. Less than 45 minutes later, Kilauea Volcano starting erupting and lasted for 17 hours. The small volume of magma and brief duration suggest that the eruption was triggered by the earthquake. On 18 May 1980, a magnitude 5.1 earthquake triggered the collapse of the north side of Mount St. Helens, resulting in the largest landslide ever recorded. These examples show that hazards cannot be studied in isolation and that multi-hazard approaches should always be carried out.

1.7 The Potential Roles of the Construction Sector in DRR

During the last few decades documented increases of disastrous events have combined with theoretical developments to necessitate a fresh approach to the way in which disasters are managed. Emphasis has moved away from disaster relief and emergency preparedness, towards a more sustainable approach incorporating hazard mitigation and effective risk management (Bosher & Dainty, 2011). It is, therefore, clear that future construction practise needs to be more sensitive to mitigate the impacts of a wide range of hazards. This needs to be achieved through proactive measures. These proactive measures are likely to have a bearing on the professional training (formal and informal) and day-to-day activities of a vast range of construction practitioners; it is this range of 'activities' that is the central focus of this textbook.

It has been argued that designing and constructing a resilient built environment demands an in-depth understanding of the expertise and knowledge of how to avoid and mitigate the effects of threats and hazards (Hamelin & Hauke, 2005). The most influential disciplines that are expected to most significantly take on board DRR activities as part of their everyday duties are the design, engineering and construction professions (these will be detailed in Chapter 8).

Among other requirements, the United Nations' Hyogo Framework for Action 2005–2015 (UNISDR, 2005) and the more recent Sendai Framework for Action 2015-2030 (UNISDR, 2015b) have called on governments to mainstream disaster risk reduction considerations into planning procedures for major construction projects. Fundamentally, there is now more recognition that we (collectively) need to change the way we develop our cities, infrastructure and buildings. It is being argued that this cannot be achieved by merely mainstreaming DRR into construction practice, but as Prof Allan Lavell suggested at the 2015 Sendai conference, we need to make DRR part of the 'developmental DNA'.

What emerges is a picture of a built environment under increasing threat from a multiplicity of different hazards and threats, some well-established but difficult to mitigate, others more emergent and hence somewhat unpredictable (Bosher & Dainty, 2011). Arguably, these hazards are likely to become more significant in future years, and so it has become incumbent upon those responsible for planning, designing and constructing the built environment today to take account of these threats as a core part of their professional activity. It is the decisions taken now that will determine the burden that future generations inherit with regards to their resilience to a range of hazards. Therefore, the efficient planning, designing and constructing of resilience now will lessen the need for expensive retrofitted measures in the future.

1.8 Scope of the Book

This book examines multi-hazard and threat adaptation issues from a construction sector perspective, whilst also considering the relevant non-structural elements of multi-hazard/threat adaptation. The content encompasses international contexts, natural hazards (i.e., hydro-meteorological and geological) and some human-induced threats (i.e., unregulated urban planning and poor quality construction). The book aims to provide a multi-disciplinary perspective, by providing a multi-faceted introduction to how a broad range of risk reduction options can be mainstreamed into the construction decision-making processes and ultimately so that DRR can indeed become part of the 'developmental DNA'.

This book is an introduction and will intentionally cover broad aspects of DRR and not detailed specifics; that is, it will not attempt to supplant books that cover specific and detailed approaches such as 'earthquake engineering', 'flood risk management' and 'hazard mapping using GIS' but will signpost the reader to these types of publications if more technical details are required. The book presents the reader with a suitably broad range of options, and thus it is not intended to be a handbook of prescriptive 'solutions'; it is hoped that the contents of the book will inspire a broad range of construction practitioners to incorporate DRR thinking and innovations into their everyday practice.

1.9 Structure of the Book

Initially the reader will be introduced to key disaster risk concepts and terms that are applicable across disciplines and the global context. Following this, the core principles of effective risk management are explained; these consist of five elements that should be performed more or less, in the following order (Bosher, 2014, after BSI, 2009):

1) Identify, characterise, and assess natural hazards and human-induced threats
2) Assess the vulnerability of critical assets to specific hazards and threats
3) Determine the risk (i.e., the expected consequences of specific hazards/threats on specific assets)
4) Identify ways to reduce those risks
5) Prioritise risk reduction measures

These risk management principles will then be explained and illustrated with examples in the context of a broad range of the most prominent natural hazards and human-induce threats as outlined in the following sections:

- Hydro-meteorological hazards (floods, hurricanes, tornadoes)
- Geological hazards (earthquakes, landslides and tsunamis)

The following chapters are punctuated with strategically placed '**Thinking Points**' (designed to allow reflection as well as to generate discussions in lectures) and '**Case Studies**' (to help illustrate specific examples of disasters, their causes and/or risk reduction options). The book will conclude with an explanation of some key principles that can be adopted and adapted and a discussion of why DRR is an important, if not undervalued, component of sustainable development. The final chapters will provide some reflection on the key research and practical challenges.

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