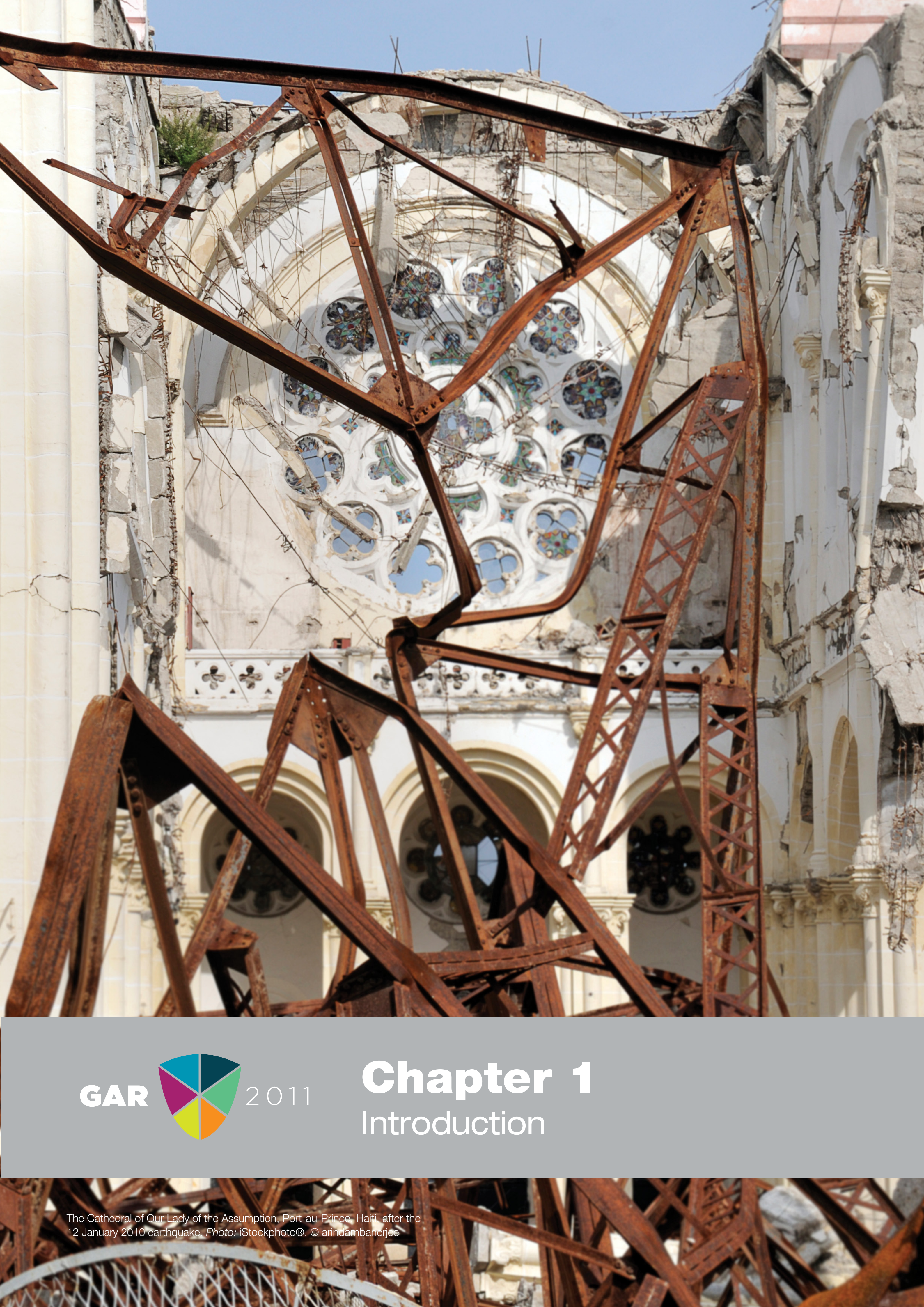


GAR 2011

Chapter 1

Introduction

The Cathedral of Our Lady of the Assumption, Port-au-Prince, Haiti, after the 12 January 2010 earthquake. *Photo:* iStockphoto®, © arindambanerjee

Chapter 1 Introduction

1.1 Unveiling disaster risk

Earthquakes, tsunamis, tropical cyclones, floods and droughts are physical events which can be measured and modelled. Although their causes and impacts are increasingly well understood, the escalating losses associated with these events indicate that most governments have yet to find effective ways of reducing and managing the risks they pose.

Father José de Cevallos was adamant. The earthquake, tsunami and fires that destroyed Lisbon in 1755 were natural events. In contrast, the earthquake and tsunami that destroyed Lima and its port of Callao in 1746 were acts of God, divine retribution for the city's libertine population (Walker, 2008). In an early example of disaster research, the conclusions of the Augustine priest, based on a study of ancient, biblical and contemporary references, were published in 1757, in Seville, Spain (Box 1.1).

The destruction of Lima, one of the most important cities in the Americas, together with a major European capital in a space of only nine years seriously disrupted the economies of Spain and Portugal, and led to intense debate on the causes of such disasters. The twin catastrophes of Lima-Callao and Lisbon marked a turning point in the way disasters were looked at and understood.

Historical evidence shows that societies have always incorporated a degree of risk management into their technological systems, urban infrastructure and cosmology. In Peru, for example, the Chimu culture portrayed the social and economic impacts of El Niño on vast adobe tapestries in the coastal city of Chan Chan (Pillsbury, 1993). Cuneiform tablets from the 17th century BC explain Babylonian cosmology and history via the epic of Atrahasis, a Noah-like hero who survived repeated floods (Lambert et al., 1969; Dalley, 1989). The Western Zhou of China interpreted disasters as signs that their rulers had lost Heaven's mandate (Shaughnessy and Loewe, 1999).

Four hundred years before the destruction of Lima-Callao and Lisbon, the North African philosopher and historian Ibn Khaldūn was already theorizing on the relationships between nature, physical hazards, development and political systems (Ibn Khaldūn et al., 1967). But it was only in the 18th century AD that an era of scientific enquiry into the causes of natural disasters was truly ushered in. The destruction of Lisbon inspired Voltaire to ridicule the view of a world overseen by a benevolent and omnipotent deity. Kant also wrote some of the first papers of this period speculating on the natural causes of earthquakes, while Rousseau started to identify the social causes of risk.

Another two hundred years passed before tectonic plate theory became scientific orthodoxy. This and other discoveries gradually led to today's acceptance that earthquakes, tsunamis, tropical cyclones, floods and droughts are physical events that can be measured and modelled.

Whereas physical hazards are increasingly well understood, the escalating losses associated with them indicate that contemporary societies still find it difficult to prevent hazards from becoming disaster risks. Peru and Indonesia, for example, are among the countries that could be hit by a devastating once-in-500-years tsunami with a height of more than six metres (UNISDR, 2009). Compared to the 6,000 people exposed to the 1746 tsunami in Callao, the city now has a population of more than 800,000. Indonesia has more than five million people and 2 percent of its GDP located in tsunami-exposed areas.

Stocks of risk and risk construction

All governments are responsible for assets, some of which will be risk-prone. Governments have explicit responsibility for the safety of publicly

Box 1.1 A tale of two disasters

On the evening of 28 October 1746, Lima was shaken by a violent earthquake. Out of a population of 50,000, only about 1,000 people died. But at about 11 pm, a tsunami devastated the neighbouring port of Callao, destroying the port itself and sweeping miles inland. In contrast to Lima, only a handful of Callao's 6,000 inhabitants survived.

Lima was then the most important city in South America, and the port of Callao exported gold and silver to Spain. The disaster was unprecedented for the Spanish in the region, and posed a critical economic threat to the colonial power.

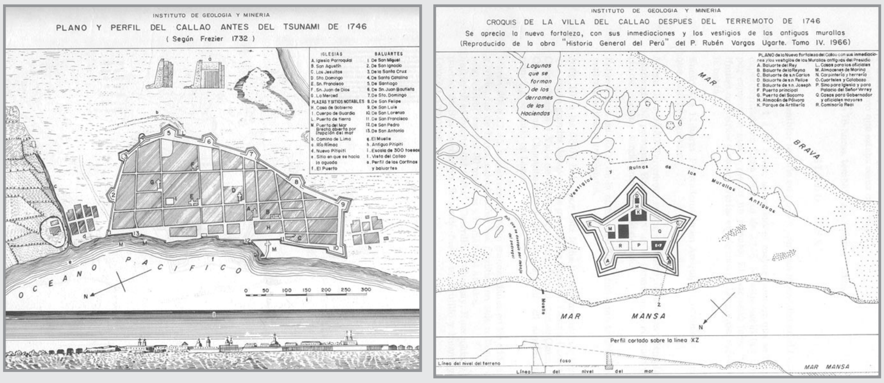


Figure 1.1
Callao, Peru, before and after the 1746 tsunami: the left hand map shows Callao before the tsunami while the right hand map shows the new fortress that was built in Callao surrounded by the remains of the city walls

The Viceroy of Peru, José Antonio Manso de Velasco, was given orders to rebuild Lima as soon as possible. An efficient administrator, he rapidly restored order. His reconstruction plan, designed by French mathematician Louis Godin, was published in early 1747 and included detailed proposals to reduce vulnerability by widening streets and lowering building height. Unfortunately, Manso de Velasco lacked the political authority to overcome opposition to the plan from Lima's aristocracy and religious authorities, and Spain never provided the required tax relief and financing needed for the reconstruction. Godin's proposal to restrict building height to one story was abandoned, as was the Viceroy's intention to reduce the number of monasteries and convents in the city. As a compromise, the authorities permitted the rebuilding of second floors with earth-rendered bamboo rather than adobe bricks, a measure that greatly reduced future earthquake losses in the city.

Nine years later, on the morning of 1 November 1755, Lisbon was struck by a catastrophic earthquake followed by a tsunami and fires, which caused its near total destruction. It is estimated that between 30,000 and 40,000 of Lisbon's population of 200,000 lost their lives, and that 85 percent of the city's buildings were destroyed. Unlike Manso de Velasco in Lima, the Prime Minister of Portugal, the Marques of Pombal, had far greater political authority and was able to repress religious opposition to his reconstruction plan. Explicitly accepting that the earthquake and tsunami had natural causes, Pombal used the reconstruction process to radically reorganize the city, giving it a more rational layout.

(Source: Pérez-Mallaína, 2008; Walker, 2008)

owned assets, including schools, hospitals and clinics, water supplies, sanitation, electricity grids, communication networks, roads, bridges and other parts of the national infrastructure. At the same time, they have a responsibility for protecting the lives, livelihoods and uninsured private assets of households and communities after disasters.

This stock of risk-prone assets is socially constructed, often over long periods by layers of decisions and consequent investments by individuals, households, communities, private businesses and the public sector, to different degrees and at different scales (Maskrey, 1996; Oliver-Smith, 1999). Physical hazards may be modified accordingly: for example, a decision to drain wetlands may increase the occurrence of flooding in a city downstream. The number of people and the value of assets exposed may increase due to decisions to locate economic and urban development in hazard-prone areas. Low-income urban households living in flood-prone areas may accept vulnerability to flooding as the 'least bad' of a set of heavily constrained options.

Whereas public investment usually represents only a small proportion of total investment in a country (UNFCCC, 2007), governments play a key role in shaping these risk construction processes through their own investments in infrastructure and public services, and through planning and regulation. Public investment is particularly important for the welfare of low-income households and communities, whose risk is often characterized by structural poverty and a deficit of services and infrastructure.

As new development decisions and investments interact with the existing stock of public risk, they have impacts which may not be immediately apparent. It may be years or even decades before these impacts manifest, in loss of life, destroyed livelihoods, or damaged infrastructure. If these losses go unmanaged, they may have further and longer-term effects such as increasing poverty, declining human development and reduced economic growth.

Extensive risks

The vast majority of these losses and impacts are extensive in character, occurring throughout a country's territory (Figure 1.2). As risk accumulates over time, it manifests as a large and rising number of localized disasters, mainly associated with storms, flooding, fires and landslides, and linked to climate variability. These localized disasters may account for only a small proportion of overall disaster mortality but, closely mirroring development processes (UNISDR, 2009), they are responsible for significant damage to housing, crops, livestock and local infrastructure, and particularly affect low-income households and communities.

Intensive risks

When extensive risk accumulates in areas prone to major hazards, such as earthquakes, tsunamis, tropical cyclones or flooding in large river basins, it paves the way for infrequent but highly destructive intensive disasters. Disasters, such as those associated with the 2010 earthquake in Haiti which reportedly killed 222,517 people and injured another 310,928 (UNOCHA, 2010), or Hurricane Katrina in the USA in 2005 which caused losses estimated at US$125 billion (EM-DAT, 2011a), are responsible for the vast majority of global mortality and direct economic loss, but only

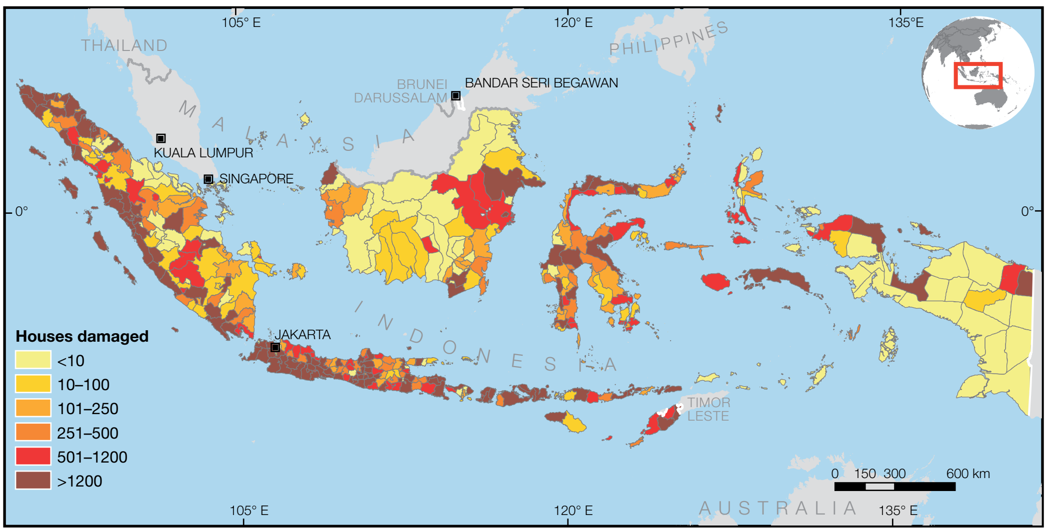


Figure 1.2
Houses damaged and destroyed in extensive disasters in Indonesia, 1970–2009

(Source: DIBI, 2010)

occur relatively infrequently in any one place. The *2009 Global Assessment Report* noted that between 1975 and 2008, 0.26 percent of the disasters recorded in the EM-DAT database accounted for 78.2 percent of all the recorded mortality (UNISDR, 2009). Historically, as the examples of Lisbon and Lima-Callao illustrate, many societies have suffered catastrophic loss from such intensive manifestations of risk, for which they seemed to be neither prepared nor adapted.

Hazard and risk estimates, largely produced by and for the insurance industry, provide increasingly sophisticated models of the probable maximum losses associated with major hazards. Other studies identify areas where, for example, major earthquakes could occur (Aon Benfield, 2010). As this information becomes more widely available to governments, there are fewer and fewer excuses to be as unprepared as Manso de Velasco or the Marques of Pombal in 18th century Lima and Lisbon.

Nonetheless, there are still important gaps in our knowledge. In 1356, a strong earthquake destroyed Basel, Switzerland, but historical and instrumental records do not go back far enough to provide a reliable guide to the largest earthquakes that could occur in Central Europe (Stewart, 2003). In other regions, inadequate monitoring of climatic, seismic and volcanic activity may lead to an underestimation of hazard. In Central America, for example, the imbalanced distribution of weather stations, which are concentrated on the Pacific coast, may lead to poor forecasting and monitoring of drought on the Caribbean side of the isthmus (Brenes Torres, 2010).

Emerging risks

Even if these knowledge gaps can be filled, existing assumptions about disaster are being increasingly challenged, as new drivers of risk emerge and interact.

Between 1601 and 1603 Russia suffered the worst famine in the country's history. It is estimated that over 100,000 people starved to death in Moscow alone and perhaps two million in Russia as a whole (Borisenkov and Paseckij, 1988). It was only recently, however, that climate researchers established a conclusive link between the failure of harvests in Russia in 1601 and the ash cloud produced by the catastrophic explosion of the Huaynaputina volcano in southern Peru on 19 February 1600

Box 1.2 'Synchronous failure': the earthquake, tsunami and nuclear crisis in Japan, March 2011

On 11 March 2011, a massive earthquake producing intensities of up to XII on the Modified Mercalli scale occurred 130 km off Japan's eastern coast causing a tsunami that, together, may have killed more than 20,000 people. The Great East Japan Earthquake also disrupted critical sections of Japan's power grid, including the power supply needed to cool the spent fuel at the Fukushima Daiichi nuclear power plant. Back-up generators kicked in but were disabled when the tsunami struck the plant, which was located on the coast. The loss of power to the nuclear plant and the inability to cool the spent fuel appear to have led to partial meltdowns of at least three of the plant's reactors, causing the worst nuclear disaster since that at Chernobyl in 1986.

The earthquake, its aftershocks, the tsunami and the nuclear emergency illustrate what a 'synchronous failure' looks like: a multi-sectoral system's collapse. The full consequence of the trauma and costs will not be known for years to come. However, in the immediate aftermath of the disaster, it became evident that even in this highly sophisticated and well-prepared society, the impact of physical hazards on infrastructure can quickly lead to outcomes normally associated with poorer countries: large-scale food and water shortages, shelter crises and logistical collapse.

(Source: Kent, 2011)

Box 1.3 Heat wave and wildfires in western Russia and Ukraine in 2010

In 2010, western Russia experienced the hottest summer since the beginning of systematic weather data recording 130 years ago. Lack of rainfall in early 2010 and July temperatures almost 8°C above the long-term average led to parched fields, forests and peat lands that posed a high wildfire risk. Analysis of satellite data reveals that most fires started in agricultural areas and around villages, but dry lightning storms also caused some severe forest and peat-land fires.

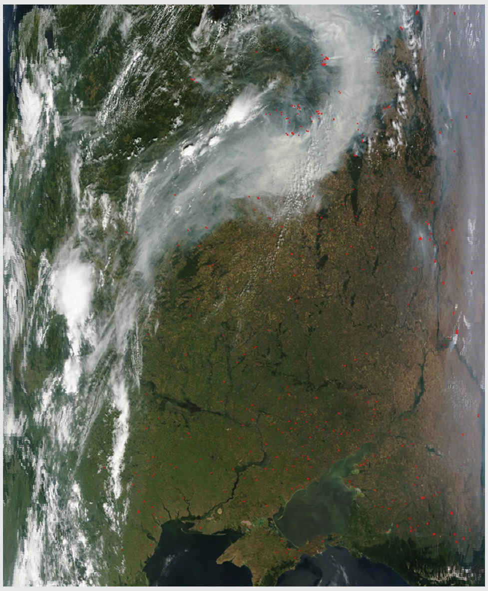
One of the most significant effects of the fires, which affected around 800,000 hectares in western Russia between July and September 2010, was the persistent near-ground air pollution. Moscow and its surroundings, with more than 15 million inhabitants, were covered by smoke for many weeks. People with cardiovascular and respiratory diseases, the elderly and the very young were particularly affected. During and after the wildfires, Russia's mortality rate increased by 18 percent. In August alone, 41,300 more people died as compared to August 2009, due to both the extreme heat and smoke pollution. The direct losses from fires in western Russia included the deaths of more than 50 civilians and firefighters, some 2,000 houses burnt down including more than 30 villages completely destroyed, large areas of crop land ruined, and more than 60,000 flights cancelled or delayed. The medium- to long-term effects of smoke pollution on morbidity and premature mortality, however, have not yet been calculated.

Social and economic change has greatly increased the risk posed by wildfires in rural western Russia. Traditional agricultural and pastoral livelihoods have declined, accompanied by the migration of young people to cities. Many villages are now primarily weekend or summer retreats, reducing responsibility for the careful and sustainable management of surrounding forests. National responsibility for forestry in the former Soviet Union had been highly centralized with strong control and management. The subsequent decentralization of these responsibilities and the exploitation of forests by the private sector may have also contributed to declining standards of forest management and protection, increasing wildfire risks.

Figure 1.3

Impact of forest and wildfires in Russia and Ukraine, 2010 (satellite images: MODIS sensor on NASA's Terra and Aqua satellites)

Multiple forest fires in Nizhny Novgorod Oblast (26 July 2010)



Smoke plume drifting from Nizhny Novgorod Oblast (Russia) to Kiev (Ukraine) (1 August 2010)

Total loss of gardens and smallholder agricultural land in Mokhove village, Lukhovitski district, Moscow region (after 30 July 2010)

(Source and images: GFMC, 2010)

(Thouret et al., 1997; Briffa et al., 1998; de Silva and Zielinski, 1998; Thouret et al., 2002).

Like this example of a disaster caused by an event on the other side of the world, a growing number of potential and plausible risks are either so difficult to identify or have such profound potential consequences, that it is difficult to find an entry point for risk modelling and analysis. Very low-probability hazards, such as geomagnetic storms or volcanic eruptions affecting global weather systems, have always existed. However, there may be no precedent for the emerging risks associated with these hazards as research reveals the increasingly complex vulnerabilities related to the growing interconnection and interdependency of modern societies. As such, there is a growing probability of 'simultaneous crisis' where different hazards occur at the same time, 'sequential crisis' where hazards trigger cascading disasters in a range of interlocked systems, and 'synchronous failures' where different risks converge and interact (Box 1.2).

In 2010, western Russia experienced a 'sequential crisis' as a severe drought created conditions for wildfires, exposing layers of new and emerging vulnerabilities that cascaded into impacts in areas as diverse as health and air traffic for which there was no historical precedent (Box 1.3).

1.2 Extreme events or extreme risks?

Countries with weak governance are likely to find it difficult to address the underlying risk drivers. These include badly managed urban and regional development, the degradation of hazard-regulating ecosystems such as wetlands, mangroves and forests, and high levels of relative poverty. With some exceptions, these tend to be low- and lower-middle-income countries.

Extreme hazards and events are not synonymous with extreme risks. When similar numbers of people are affected by hazards of similar severity, wealthier and poorer countries generally experience radically different losses and impacts (Box 1.4) (UNISDR, 2009). GAR09 highlighted that poverty is both a cause and consequence of disaster risk. Across all the major hazards, poorer countries with weaker governance tend to experience far higher mortality and relative economic loss compared to wealthier countries with stronger governance. Mortality risk, for example, is approximately 225 times greater in low-income countries compared to OECD countries when similar numbers of people are exposed to tropical cyclones of the same severity (Peduzzi et al., 2011). Governance refers to the actions, processes, traditions and institutions by which authority is exercised and decisions are taken and implemented. Whereas relative wealth is a key determinant, governance factors such as the strength of democracy (Keefer et al., 2010), inequality (UNISDR, 2009) and voice and accountability (UNISDR, 2009), all play roles in the social construction of risk.

The quality of a country's governance appears to have a significant influence on the underlying drivers of risk. Drivers identified in GAR09 include badly planned and managed urban and regional development, the degradation of hazard-regulating ecosystems such as wetlands, mangroves and forests, and increasing poverty and inequality (UNISDR, 2009). These drivers interact through multiple feedback loops and together translate hazards into disaster risk.

Figure 1.5 presents a composite index that measures the quality of governance and how well countries are addressing these three underlying risk drivers. Countries with weak governance and that have great difficulty addressing underlying drivers are, with some exceptions, mostly low- and lower-middle-income countries. Those at the bottom of the index, such as Haiti, Chad or Afghanistan, are also experiencing conflict or political instability. This index thus provides insight into whether a country's risk governance capacities and arrangements are effective in addressing underlying risk drivers.

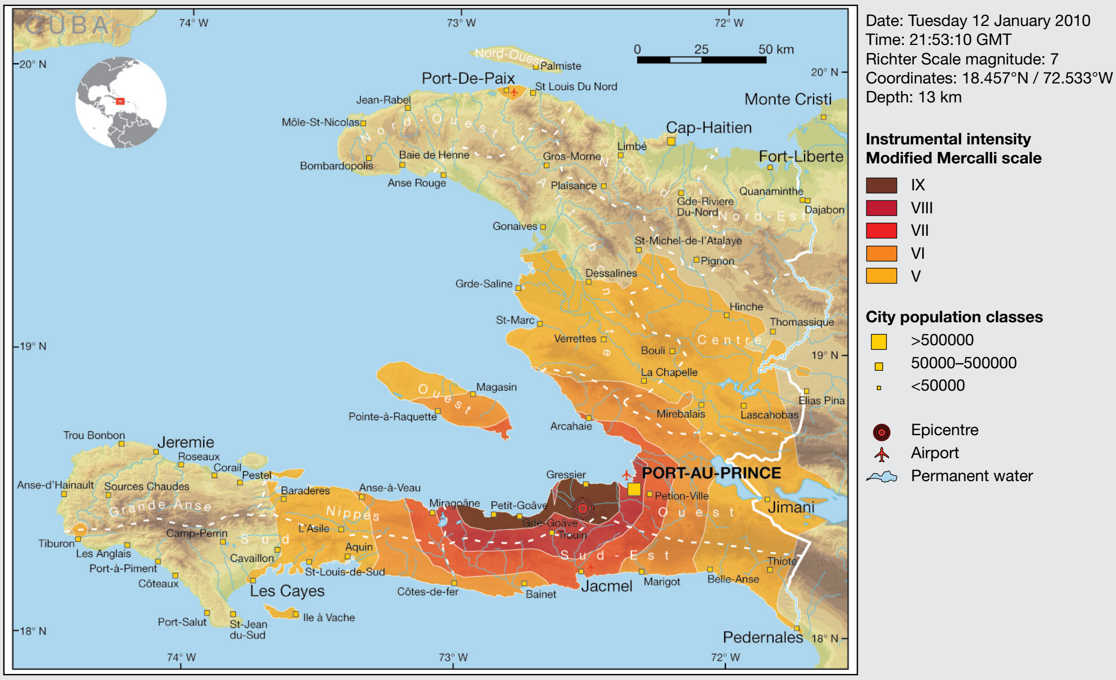
Box 1.4 Haiti, Chile and New Zealand, 2010

Extreme hazards are translated into risk through exposure and vulnerability, as tragically illustrated in all its dimensions by the earthquake that struck Haiti on 12 January 2010. The earthquake produced severe intensities of VII to IX on the Modified Mercalli scale, and mortality was very high, with 222,517 fatalities (UNOCHA, 2010).[1] This high death toll reflected the exposure of large numbers of people, and vulnerability factors such as extreme poverty, corruption, a fragile democracy, and a lack of earthquake experience in a country where they only occur infrequently (Keefer et al., 2010).

In contrast, the 27 February 2010 earthquake in Chile was by any standards an extreme event, releasing five hundred times more energy than the earthquake in Haiti the previous month. However, it only killed 486 people, a fraction of those who died in Haiti. In contrast to Haiti, exposure was lower, and Chile has a history of dealing with earthquakes. It is also an upper-middle-income country with a consolidated democracy and low levels of corruption.[2]

The earthquake that hit Christchurch, New Zealand, on 3 September 2010 also produced intensities of up to IX on the Modified Mercalli scale. However, only some 500 buildings were destroyed and no lives were lost. While an estimated 154 people were killed in another earthquake on 22 February 2011 (New Zealand, 2011), the low casualty rate in both events reflects tough building regulations, strict enforcement, and experience in dealing with earthquakes.

Figure 1.4
Shakemap of Haiti Earthquake in 2010



(Source: UNEP/GRID-Europe, 2010)

Economic studies (Albala-Bertrand, 1993; Kahn, 2005; Noy, 2009; Cavallo et al., 2010) provide conflicting evidence as to how and when disasters affect productivity, capital growth, employment, inequality and other macroeconomic parameters (Moreno and Cardona, 2011). However, evidence indicates that poorer countries with weak governance have less capacity to absorb and recover from disaster loss, and less ability to prevent losses spilling over into other parts of the economy (Noy, 2009). The penetration of catastrophe insurance in such countries is also still incipient. Although there are a growing number of parametric crop insurance schemes (World Bank, 2009), these reach less than 5 percent of eligible households in India, and only 17 percent in Malawi (Cole et al., 2008; Giné et al., 2008).

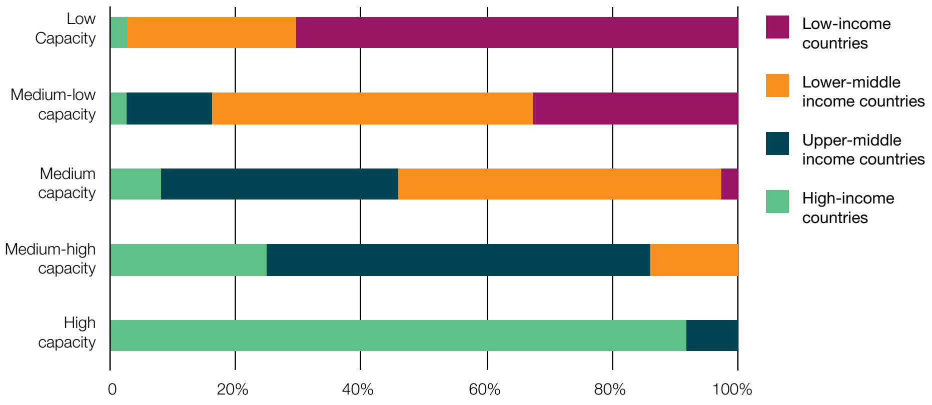


Figure 1.5
Risk governance capacity and World Bank country classification

This composite graph displays countries' risk governance capacities and their relative wealth by World Bank income regions. Approximately 90 percent of the countries with the strongest capacities are high-income countries. In contrast, low- and lower-middle income countries account for more than 95 percent of the quintile with the lowest capacities. These rankings derive from an analysis of indicators of the disaster risk drivers identified in GAR09: poverty, weak urban and local governance, ecosystem degradation, and government effectiveness and accountability. Each quintile is then subdivided based on the number of countries per World Bank category within it.[3]

(Source: DARA, 2011; Lavell et al., 2010 (adapted by UNISDR))

Within countries, different localities also have widely varying risk governance capacities. As Figure 1.6 shows, whereas Hurricane Mitch engulfed a large part of Central America in October 1998, most mortality in Honduras, the worst-affected country, was concentrated in a relatively small number of highly vulnerable and exposed municipalities. Following the hurricane, poorer households lost a greater proportion of their assets than wealthier households and had significantly more difficulty in recovering (Morris and Wodon, 2003; Carter et al., 2006).

1.3 Reducing disaster risk

The main opportunities for reducing risk lie in reducing vulnerability. This means addressing the underlying risk drivers by strengthening risk governance capacities. Extensive risks are largely shaped by these drivers. In contrast, intensive risks are more heavily determined by the location, severity and frequency of the associated hazard, meaning that there are limits to vulnerability reduction.

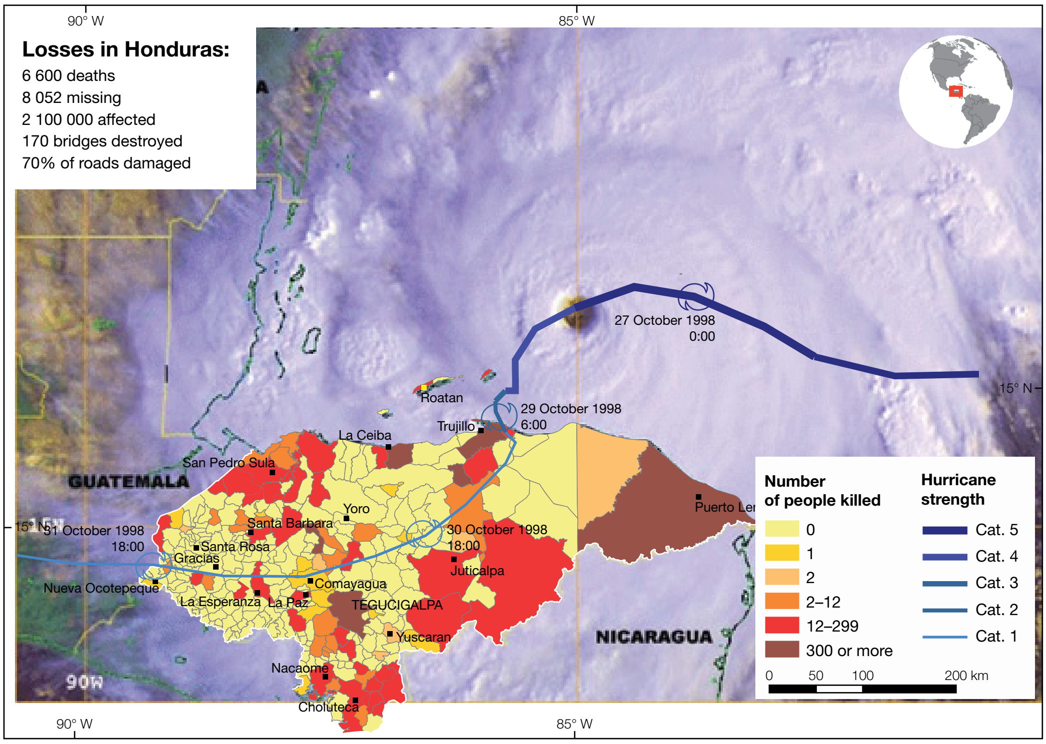
Governments cannot influence the severity of droughts, earthquakes, tsunamis and tropical cyclones, except in the case of weather-related hazards through international action to mitigate climate change. Similarly, the exposure of people and assets is largely fixed by the location of historical investments in infrastructure, urban and economic development, as well as by social and cultural attachment to place, or by geographical constraints such as on small islands. If hazard severity and exposure cannot be reduced, the main opportunities for reducing risk lie in reducing vulnerability.

Extensive risks are largely shaped by underlying risk drivers and can thus be more easily reduced by a strengthening of risk governance capacities. In contrast, intensive risks are more heavily determined by the location, severity and frequency of the associated hazard, meaning that there are limits to how much risk can actually be reduced.

In the case of tropical cyclones, for example, the variation in mortality appears to be affected by a combination of three factors: the severity of the cyclone, the number of people exposed, and GDP per capita, the latter being a reasonable proxy indicator of a country's vulnerability. As Table 1.1 shows, GDP per capita explains 91 percent of the variance in mortality risk with Category 1 cyclones, but only 37.1 percent with powerful Category 4 cyclones. In contrast,

Figure 1.6

Translating hurricane hazard into disaster risk: the impact of Hurricane Mitch in Honduras, 1998. Number of people killed



(Source: Image (NOAA, 1998); Damage (COPECO, 1998); Hurricane path (USGS, 1998). Collage by UNISDR)

the numbers of people exposed explains only 9 percent of the risk variance with Category 1 cyclones, but 62.9 percent with Category 4 cyclones. The implication is that if a country reduces its vulnerability, it can significantly reduce the mortality risk associated with Category 1 cyclones. Reducing the risk associated with Category 4 cyclones, however, particularly when accompanied by storm surges in low-lying coastal areas, is far more challenging (Table 1.1).

This does not imply that intensive risk cannot be reduced. All intensive risk is underpinned by vulnerability to some degree. As highlighted by the impact of Category 5 cyclone Yasi in Australia in February 2011, sound disaster management can go a long way to minimize mortality, even in the case of very severe cyclones. However, reducing vulnerability to very severe hazards may have unacceptably high costs and trade-offs. In the Cayman Islands, for example, building regulations specify resistance to a Category 3 cyclone. Increasing standards to withstand Category 4 or 5 cyclones would lead to an exponential increase in the cost of building, making the country less attractive for investment.

Table 1.1 Contribution of cyclone severity, exposure and vulnerability parameters to tropical cyclone risk

Risk factors	Correlation	Category 1	Category 2	Category 3	Category 4
Population exposure	Positive	9.0%	46.4%	45.1%	62.9%
GDP per capita	Negative	91.0%	53.6%	46.3%	37.1%
Distance to city	Positive	Not significant	Not significant	8.6%	Not significant
	Total	**100%**	**100%**	**100%**	**100%**

Tropical cyclone severity is measured on the Saffir-Simpson scale in five Categories. Category 5 cyclones occur very infrequently but are the most destructive, while Category 1 cyclones are more frequent but less severe.

(Source: UNEP, 2010)

In practice, these trade-offs are often already reflected in codes and regulations. Many building codes specify protection against earthquakes that occur once every 475 years but not those which occur less frequently, and national insurance regulators may require insurers to have reserves (including reinsurance) to cover risks up to a return period of 1,500 years (see Chapter 5). Different countries value the trade-offs in different ways, however. The Netherlands, for example, has constructed its dykes to resist a 10,000-year storm surge (ECA, 2009), but in most low- and middle-income countries, such investments are not affordable even if they were technically feasible and politically important.

In the case of destructive tsunamis, as illustrated by the examples of Lisbon and Callao and recently in Japan, vulnerability may be almost binary: meaning that all people exposed to the hazard are vulnerable, irrespective of income and capacities. In the case of large cities exposed to tsunamis that may reach the shoreline in a matter of minutes,[3] the effectiveness of early warning is relative. The 11 March tsunami may have killed more than 20,000 people in Japan, which has a highly regarded tsunami early warning system with six decades of experience. Also, even where civil engineering works that could protect a city against tsunamis are technically possible, the costs of their construction and maintenance would not necessarily make economic sense given long return periods (World Bank, 2010a).

It is not only the severity of hazards such as these that makes intensive risks more difficult to reduce. It is also the unexpectedness of events for which there may be no historical precedent, at least in living memory, and for which societies are thus not prepared. All other factors being equal, earthquake mortality for example, is lower in countries that experience more earthquakes, and is higher where earthquakes occur only infrequently (Keefer et al., 2010). In the absence of frequent major earthquakes, governments are less likely to find political incentives to invest in disaster risk management. If a major earthquake does occur, the absence of such investment leads to higher actual mortality.

1.4 Climate change adaptation

The challenge of adapting to climate extremes gives increased urgency to addressing underlying risk drivers, reducing vulnerability and strengthening risk governance capacities. If disaster risks can be reduced, then the magnifying effect of climate change will also be reduced, and adaptation will be facilitated. The contemporary tendency to characterize all weather-related disasters as manifestations of climate change underplays the role of the underlying risk drivers, and may point policy and planning in the wrong direction.

Climate change is gradually altering average temperature, sea level, and the timing and amount of precipitation, with potential for more drastic changes if carbon emissions are not successfully limited and reduced. Climate change also contributes to more frequent, severe and unpredictable weather-related hazards such as droughts, tropical cyclones, floods and heat waves (IPCC, 2007). Therefore, climate change adaptation can be understood as: (a) adapting to gradual changes in average temperature, sea level and precipitation; and (b) reducing and managing the risks associated with more frequent, severe and unpredictable extreme weather events, including those for which there may be no historic precedent.

Adapting to gradual changes in climate averages is a medium- to long-term process, involving long-term planning of investments in strategic infrastructure that take into account changing climatic conditions. For example, new hydroelectric plants and urban drainage systems need to account for future changes in rainfall, and investments in both urban and agricultural development need to take into account expected changes in water availability and rising sea levels.

However, the degree to which any society is adapted to its climate is socially constructed rather than environmentally determined (Berger and Luckmann, 1966). Countries that may find it most difficult to adapt are likely to have fewer resources to invest in new infrastructure and technologies, have limited social protection systems in place, and experience food insecurity, high vulnerability to disasters and extreme trade limitations (Corrales, 2010).

As Box 1.5 highlights, it is worth remembering that until the 19th century, much of the population of pre-industrial Europe was *maladapted* to its climate, and as a result, suffered devastating famines. It was only with the technological and material changes that accompanied the industrial revolution that Europe *adapted*.

Changing climate averages, such as decreasing precipitation or higher temperatures, can threaten development and thus may increase vulnerability and undermine resilience in many high-risk countries and regions. Climate change also modifies hazard intensity, frequency, patterns and seasonality. Countries will thus have to spend more time dealing with the unfamiliar, such as glacial lake outburst floods (GLOFs), even allowing for improvements in forecasting and early warning.

Reducing and managing the risks associated with more frequent, severe and unpredictable extreme weather events is fundamentally similar to DRM. Although attention is currently focused on how climate change is altering weather-related hazards, climate risks in the short term will be shaped by existing

Box 1.5 Adaptation and climate variability

Until the industrial revolution, the material and technological basis of agricultural production in Europe barely supported the subsistence needs of most households, even in years with good harvests. Climate variations such as colder and damper summers typically led to lower yields and crop losses, and were rapidly reflected in drastic increases in mortality and decreases in marriage and birth rates.

Agricultural productivity increased by approximately 60–65 percent between the 13th and 19th centuries (Braudel, 1979), but Europe was still constantly devastated by famines. France, for example, experienced 89 major famines between the 10th and 18th centuries (Braudel, 1979), not including the likelihood of many hundreds of localized famines. Technological limitations meant that it was impossible to transport large volumes of food and energy over long distances (Harvey, 1996), and most urban centres were therefore dependent on their immediate hinterland for food and firewood. This not only limited their growth but made them as vulnerable as rural areas to shortfalls in agricultural production.

The failure of cereal harvests associated with climate variability had drastic demographic impacts. It is estimated that the population of France fell by 1.3 million in 1693–1694, after several years with cold and wet summers devastated cereal production (Le Roy Ladurie, 2004). The following century, 196 days of rain between December 1769 and November 1770 had equally disastrous impacts. The number of births in rural France fell from 896,000 in 1769 to 829,000 in 1771, the number of marriages fell from 232,000 to 175,000, and there were at least 100,000 famine-related deaths (Le Roy Ladurie, 2006).

From the latter half of the 18th century onwards, famine risk was reduced by European industrialization and urbanization. Between 1772 and 1775, for example, British cereal imports increased by a factor of 26 (Le Roy Ladurie, 2006), buffering the impact of local production shortfalls.

The year of 1816 was the “year without a summer” in the Northern Hemisphere. On 10 April 1815, the Tambora volcano erupted in Indonesia. The resulting cold summer in Europe provoked failures in cereal production comparable with previous crises. However, the demographic impact in industrializing France was minimal, if compared to that of 1693–1694 or 1770–1771. In France, the number of deaths in 1817 was only 18,500 greater than in 1816 or 1818. In contrast, the increase in mortality in less industrialized regions of Europe may have been as high as 40 percent (Le Roy Ladurie, 2006).

risk patterns and increasing exposure of people and their assets, as much as by climate change itself (ECA, 2009). From that perspective, the contemporary tendency to characterize weather-related disasters as manifestations of climate change underplays the role of the underlying risk drivers, and may point policy and planning in the wrong direction.

As with DRM in general, the challenge of adapting to climate extremes requires increased attention to underlying risk drivers, reducing vulnerability, and strengthening risk governance capacities. If disaster risks can be reduced, then the magnifying effect of climate change will also be reduced and adaptation facilitated.

1.5 Strengthening risk governance capacities

Governments need to invest in anticipating, reducing and transferring the different levels of extensive, intensive and emerging risks. However, political and economic incentives required for this may be lacking, and risk governance capacities may be inadequate for the task. Contemporary societies need to strengthen their risk governance capacities in order to reduce those risks that can be reduced, transfer those that cannot, and anticipate and prepare for emerging and realistic risks that cannot be easily identified or measured.

Prospective risk management (Lavell and Franco, 1996; Lavell et al., 2003) refers to actions that ensure that development does not add new risks to the stock of risk-prone assets. There are many examples. Land use planning can be used to steer urban development away from high-risk areas. Improved building standards can be used to reduce vulnerability in new construction. Enhanced water management can reduce drought risk. Ecosystems that mitigate hazards, such as forests, wetlands and mangroves, can be protected.

Corrective risk management refers to removing risks that are already present before they manifest as loss. This may include relocating highly exposed and vulnerable settlements, adapting and upgrading existing facilities such as schools and hospitals, or restoring degraded ecosystems. Prospective and corrective risk management are not mutually exclusive, because risk itself is constantly changing. Housing, infrastructure networks and cities as a whole are processes more than things, and investment is constantly being made in their renewal, renovation, remodelling, and replacement of component parts. Renewing obsolete infrastructure to a higher specification for example, or introducing strengthened structures when remodelling an old building, are corrective and prospective at the same time.

As already highlighted, it is generally easier to reduce extensive risks. The more intensive risks, which may not be practically or cost-effectively reduced, have to be addressed through compensatory risk management. This can include risk transfer mechanisms such as insurance and reinsurance, contingent financing complemented by social protection measures at the household level, such as conditional transfers and temporary employment programmes. These measures do not reduce risk per se,[4] but compensate for loss, avoiding the spill-over of impacts into other areas such as health, education, nutrition and productivity. Disaster management mechanisms at different scales, including early warning systems, preparedness, rapid response and recovery measures, also play key roles in reducing loss of life and injury, and avoiding poverty outcomes.

For many governments faced with known and urgent risks, it may be difficult to justify investment in protecting against future unknowns. However, developing plausible future risk scenarios is the first step in a process of identifying and anticipating what might happen, before then developing strategies to manage them. The 2003 heat wave in Europe, which killed more than 14,800 people in France alone (Pirard et al., 2005), highlighted that even wealthy countries with strong risk governance capacities can find if difficult to deal with unfamiliar hazards for which they are neither adapted nor prepared. As Box 1.6 highlights, improved awareness of future risks and preparedness could have greatly reduced the impact of the volcanic ash cloud that largely closed down European airspace in April 2010. After the 2003 European heat wave, France put in place a sophisticated early warning system to anticipate the impacts of future weather extremes (Pascal et al., 2006), which has subsequently served as the model for a regional early warning system (Auld, 2008).

Each country has its own unique risk profile or signature with different kinds and proportions of extensive, intensive and emerging risks. To reduce their risks, therefore, governments will normally need to adopt a mix of prospective, corrective and compensatory risk management strategies, together with strategies to manage disasters and anticipate emerging risks.

Unfortunately, without systematically accounting for disaster losses and impacts, and comprehensively assessing the full range of risks they face, few countries have been able to find the political and economic incentives to identify the costs and benefits and trade-offs that could inform a balanced and effective portfolio of risk management strategies. As Chapter 2 of this report shows, countries that have invested in strengthening their disaster management capacities have witnessed a steady decline in mortality risk, at least with respect to weather-related hazards. However, the institutions and capacities for risk governance in most countries still appear inadequate to address the risks associated with the rapid increase in asset exposure that, particularly in the last decade, has been fuelled by rapid economic growth in many low- and middle-income countries. Although these countries have strengthened their capacities and reduced their vulnerabilities, these improvements have proved largely insufficient.

The catastrophes of Lima-Callao and Lisbon catalysed the scientific study of physical hazards. But, as Manso de Velasco and the Marques of Pombal discovered when they were rebuilding their cities, reducing disaster risk is primarily an issue of identifying the political and economic incentives and negotiating trade-offs – as true today as it was then. Although much has changed over the last 250 years, if the objective of the Hyogo Framework for Action (HFA) is to be achieved, if progress is to be made towards the UN's Millenium Development Goals, and

Box 1.6 Unexpected or unprepared?

The volcanic ash cloud that affected Europe in April 2010 is estimated to have caused US$521 million in lost GDP in the United Kingdom alone and US$4.7 billion in global GDP (Oxford Economics, 2010). Although the disaster was called an unprecedented and unexpected event, it was neither. Rather, it illustrates the challenges posed by risks for which governments are not prepared.

Volcanic activity in Iceland comparable to the 2010 Eyjafjallajökull eruption is not unusual, occurring every 20 to 40 years on average (Sammonds et al., 2010). This volcanic activity becomes a problem for Europe when it coincides with north to north-westerly air movements, which occur only 6 percent of the time. Thus, whereas the ash cloud could be considered unusual, it was far from unprecedented, and not unexpected. In fact, the volcano had been in eruption for four weeks before the ash cloud reached the airspace of the United Kingdom on 15 April, which was more than ample time to have put into effect contingency plans, had these existed. The losses caused were largely due to a failure to anticipate the risks, meaning that countries were taken by surprise.

if adaptation to climate change is to be possible, that challenge still remains.

Fortunately, a new paradigm in disaster risk reduction is starting to emerge, largely driven by innovations in loss accounting and risk assessment, in the adaptation of development planning and investment instruments and in risk governance by those governments that have recognized the importance of *investing today for a safer tomorrow*. An opportunity to reduce disaster risk now begins to open: learning from, building on, and up-scaling these innovations; revealing risk and redefining development.

Notes

1 The real death toll may be much lower. Some commentators have cited 40,000–50,000 (Suárez et al., 2010). Disaster mortality rates may be drastically over-reported, even by international organizations (UNISDR, 2009).

2 Chile had the lowest level of corruption in Latin America according to the *2009 Corruption Perceptions Index* (CPI), and was ranked the 25th least corrupt country in the world (Transparency International, 2009).

3 Notwithstanding this affirmation, in tsunami-exposed Pagang, Indonesia, building artificial hills has been proposed, called Tsunami Evacuation Raised Earth Parks (TEREPs), that would allow the vertical evacuation of people in the case of a tsunami warning (GeoHazards International, 2010). However, the effectiveness of this approach has yet to be proved in practice.

4 Though, if well designed, they can incorporate incentives for risk reduction and create community assets that reduce vulnerability.