GAR 2011

# Chapter 2
## Revealing risk

A submerged bus near the town of Dadu, Pakistan, during the July–August 2010 floods.
*Photo:* Andrew McConnell/Panos Pictures

## **Chapter 2** Revealing risk

Disaster risks can increase or decrease over time according to a country's ability to reduce its vulnerability and strengthen risk governance capacities.

In recent decades, countries in all regions have strengthened their capacities to reduce mortality risks associated with major weather-related hazards such as tropical cyclones and floods. Despite more and more people living in flood plains and along cyclone-exposed coastlines, mortality risk relative to population size is falling. In East Asia and the Pacific, for example, it is now only a third of what it was in 1980.

In contrast, many countries are struggling to address other risks. Economic loss risk to tropical cyclones and floods is growing as exposure of economic assets increases, outstripping reductions in vulnerability. Losses suffered by low-income households and communities due to frequently occurring extensive disasters are often under-recorded and are increasing rapidly. The improvement in risk governance capacity and reduction in vulnerability in low- and middle-income countries as they develop, are insufficient to address the run-away increase in asset exposure, particularly in countries that are experiencing rapid economic growth.

Underlying risk drivers continue to increase risk, such as poverty, badly planned and managed urban and regional development, and ecosystem decline. Whereas the links between risk and poverty are well established, new evidence confirms that disaster losses particularly affect child welfare and development, and contribute to internal displacement. These impacts, which are rarely properly accounted for, highlight the need for disaster risk management (DRM) policies sensitive to the needs of children and the displaced.

## 2.1 Disasters under construction

Dhaka's rapid expansion highlights how drivers such as badly planned and managed urbanization, ecosystem decline, and poverty, accumulate risk over time.

Dhaka, Bangladesh. The 1897 Assam earthquake (also known as the Great Indian Earthquake), one of the largest ever recorded in South Asia, caused extensive damage to the city's buildings and infrastructure (Al-Hussaini, 2003). At that time, Dhaka's metropolitan population was less than 100,000. Now it is estimated to be around 15 million. However, it is not only the 150-fold increase in exposed population that has led to Dhaka's current level of earthquake risk. The city has also been unable to address the processes that shape and accumulate that risk over time.

Many areas surrounding central Dhaka are flood prone during the rainy season, and until recently were occupied by natural water bodies and drains, vital to the regulation of floods. Land use planning instruments such as the Dhaka Metropolitan Development Plan restrict development in many of these areas. Despite the Plan, these areas are still being rapidly urbanized through private- and public-sector projects (Box 2.1).

### Box 2.1 Constructing earthquake risk on wetlands

Large areas of Dhaka are highly susceptible to liquefaction during earthquakes, and many have been used as construction sites for buildings and infrastructure in recent decades. Figure 2.1 shows the shrinking and disappearance of water bodies (circled) in one such area, West Dhaka, between 1996 and 2009.

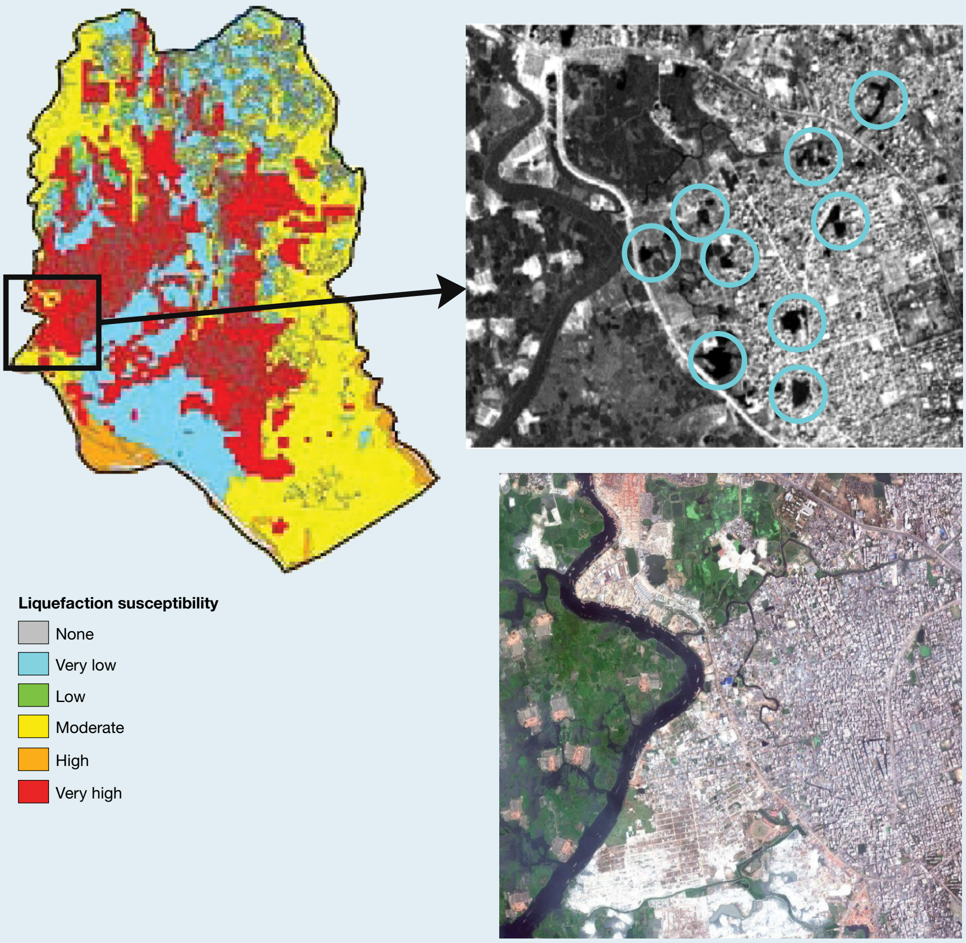



**Figure 2.1**
Areas of Dhaka susceptible to liquefaction and change in water and the built environment in West Dhaka between 1996 and 2009

*(Source: Rahman, 2010, adapted from IRS Image 1996 and Google Earth)*

Destroying retention ponds and drains increases risks of seasonal flooding just as building in drained wetlands increases earthquake risk. During an earthquake, sands and silts can liquefy to the point where the soil no longer supports the weight of buildings and infrastructure, which may subsequently collapse or suffer heavy damage. Dhaka's wetlands, drained and filled with sand for housing development, are prime candidates for liquefaction.

With little contemporary experience of earthquakes, Dhaka is vulnerable and ill-prepared. The older part of the city is home to densely populated, multi-storey, unreinforced brick buildings predisposed to heavy damage in a strong earthquake (Paul and Bhuiyan, 2010). And despite guidelines for earthquake-resistant construction, faulty design and poor quality materials and workmanship mean that many modern reinforced concrete buildings are also vulnerable.

An innovative cyclone shelter programme has helped Bangladesh dramatically reduce cyclone mortality since the 1970s. In the past four decades, Bangladesh has been struck by three severe cyclones: Bhola (1970), Gorky (1991) and Sidr (2007). Bhola caused an estimated 300,000 deaths and Gorky was responsible for more than 138,000. The death toll for Sidr, however, was 'only' around 4,000 (EM-DAT, 2010a).[1] Unfortunately, the disaster management capacities that have reduced cyclone mortality have not been able to address earthquake risk in Dhaka. Consistent with this, Bangladesh's Hyogo Framework for Action (HFA) report (see Chapter 4 for more on HFA reporting) highlights that although there is an Earthquake Zoning Plan for Dhaka, its enforcement and general urban improvement remain major challenges. Dhaka's expansion vividly illustrates how drivers such as badly planned and managed urbanization, ecosystem decline and poverty interact to build risk over time (UNISDR, 2009).

Until recently there was only one seismic observatory in Bangladesh (in Chittagong in the country's southeast), although in recent years seismic monitoring capacity has increased, with new observatories in Sylhet, Rangpur and Gazipur (Paul and Bhuiyan, 2010). This means that earthquake hazard in the area may not be fully understood, despite the certainty of a severe earthquake one day. With its population growing at around 6 percent annually, risk can only increase unless vulnerability is drastically reduced.

Dhaka highlights the complex processes that configure risk and the challenges they pose for effective disaster risk governance. For example, extensive risk associated with flooding can contribute to intensive risk associated with earthquakes (see the Preface for definitions of extensive and intensive risk). However, apparent success in reducing mortality from tropical cyclone disasters has not translated into improvements in the management of earthquake risk. The multiple feedback loops that exist among urbanization, ecosystem decline, poverty and governance, configure risk while simultaneously obscuring causality. In attempting to reduce risks associated with a range of hazards, authorities must make trade-offs between them.

To begin to unravel the complexity of multiple interrelated risk drivers, this chapter explores global trends in the mortality and economic loss risk associated with tropical cyclones and floods (Box 2.2), and with the losses and damages associated with extensive risks. It also examines the impacts of disasters on children and on internal displacement, and introduces a number of potential emerging risks.

## Box 2.2 Updating the global risk analysis

GAR09 analysed global patterns of mortality risk and economic loss risk for tropical cyclones, floods, landslides and earthquakes, and the underlying risk drivers that explained those patterns. In GAR11, all the datasets used in the global risk analysis have been updated to 2010 and can be explored for tropical cyclones, floods and landslides using the online Global Risk Data Platform (www.preventionweb.net/gar). The same methodology and statistical models that underpinned the GAR09 analysis of global risk have been used for GAR11, given that two years of additional data is unlikely to lead to significant changes in the value of the statistical regressions (Peduzzi et al., 2010).[2]

Following an in-depth revision of the earthquake risk model,[3] it was decided not to update the earthquake risk analysis until new datasets from the United States Geological Survey and the Global Earthquake Model become available. GAR11, therefore, does not include an earthquake risk analysis.

GAR11 explores trends over time between 1970 and 2010 for tropical cyclones and floods for World Bank geographic and income regions.[4] These trends are explored using modelled disaster risk rather than recorded disaster losses which do not provide a solid platform for estimating trends. Most recorded losses are concentrated in a very small number of infrequent intensive disasters with long return periods. The occurrence of one or more intensive disasters in any given decade, therefore, distorts any underlying trend. In addition, trends identified using reported losses also reflect improved disaster reporting over time. Satellite data indicate that on average, between 142 and 155 countries have been hit by tropical cyclones every year since 1970 (Table 2.1).[5] However, the number of internationally reported cyclone disasters tripled between the 1970s and 2010. This trend is only partly due to increasing exposure and cyclone severity; it is mostly induced by improved reporting and access to information (Peduzzi et al., 2010, 2011).

Table 2.1 Trend of tropical cyclones reported versus tropical cyclones detected by satellite during the last four decades.

| | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2009 |
|---|---|---|---|---|
| Number of tropical cyclones (TCs) as identified in best track data (average per year) | 88.4 | 88.2 | 87.2 | 86.5 |
| Number of countries hit by TCs as detected by satellite (average per year) | 142.1 | 144.0 | 155.0 | 146.3 |
| Number of disasters triggered by TCs, reported by EM-DAT (average per year) | 21.7 | 37.5 | 50.6 | 63.0 |
| Reported disasters as a percentage of number of countries hit by TCs | 15% | 26% | 33% | 43% |

The trend analysis estimates changes in vulnerability and exposure. Although factors such as climate change and variability and environmental degradation influence hazard levels, data limitations mean that, in the case of floods, hazard has been treated as constant. In contrast, thanks to a new and more complete data set, changes in the frequency and severity of tropical cyclones have been accounted for in the calculation of tropical cyclone exposure (Tables 2.3 and 2.5 and Figure 2.10). Tropical cyclone risk (Figures 2.12, 2.15 and 2.17) has been estimated using modelled exposure and modelled tropical cyclone frequency based on observations from 1970 to 2010. It is expected that trends in extreme hazards will be addressed in more detail in the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), which is scheduled for publication in 2011.

## 2.2 Global disaster risk trends

As the case of Dhaka illustrates, earthquake mortality risk may be increasing, particularly in countries experiencing rapid urban growth. In contrast, mortality risk associated with major weather-related hazards is now declining globally, including in Asia, where most of the risk is concentrated. Although the number of people exposed to tropical cyclones and floods continues to increase, countries are successfully reducing their vulnerabilities and strengthening their disaster management capacities. In East Asia and the Pacific, mortality risks for both floods and cyclones are now about one third of what they were in 1980, relative to the size of the region's population: a major achievement. South Asian countries have struggled to reduce mortality risks, but these have also fallen over the last decade.

### 2.2.1 Weather-related mortality risk remains highly concentrated in countries with low GDP and weak governance

Figures 2.2 to 2.7 show an updated global distribution of mortality risk for three weather-related hazards (tropical cyclones, floods and rain-triggered landslides). In these maps, the areas of highest risk correspond to areas where high concentrations of vulnerable people are exposed to severe and frequent hazards. The risk model highlights that flood mortality risk is highest in rural areas with a dense and rapidly growing population in countries with weak governance; cyclone mortality risk is highest in isolated rural areas with low GDP per capita;[6] and landslide risk is highest in areas with low GDP per capita. For all weather-related hazards, countries with low GDP and weak governance tend to have drastically higher mortality risks than wealthier countries with stronger governance.

### 2.2.2 Exposure to floods and tropical cyclones is increasing rapidly, growing fastest in low-income countries

Between 1970 and 2010, the world's population increased by 87 percent (from 3.7 billion to 6.9 billion). In the same period, the average numbers exposed to flooding every year increased by 114 percent (from 32.5 to 69.4 million annually).[7] Relatively speaking, ever more people are living in flood plains, suggesting that the economic advantages of living in such an environment must outweigh the perceived risks of flooding. Populations in cyclone-prone areas are also growing, highlighting the attractiveness of tropical coastlines for tourism as well as for economic and urban development in general.[8] Global physical exposure to tropical cyclones almost tripled (increasing by 192 percent) between 1970 and 2010.

Low- and lower-middle-income countries not only have the largest proportion of their population exposed to floods, but their exposure is also growing faster than in middle-income and Organisation for Economic Co-operation and Development (OECD) countries (Figure 2.8). More than 90 percent of the global population exposed to floods live in South Asia, East Asia and the Pacific (Table 2.2), but exposure is growing most rapidly in sub-Saharan Africa. In contrast, exposure is increasing only marginally in OECD countries whereas in eastern and south-eastern Europe and Central Asia it is stable, reflecting a broader trend of demographic changes.

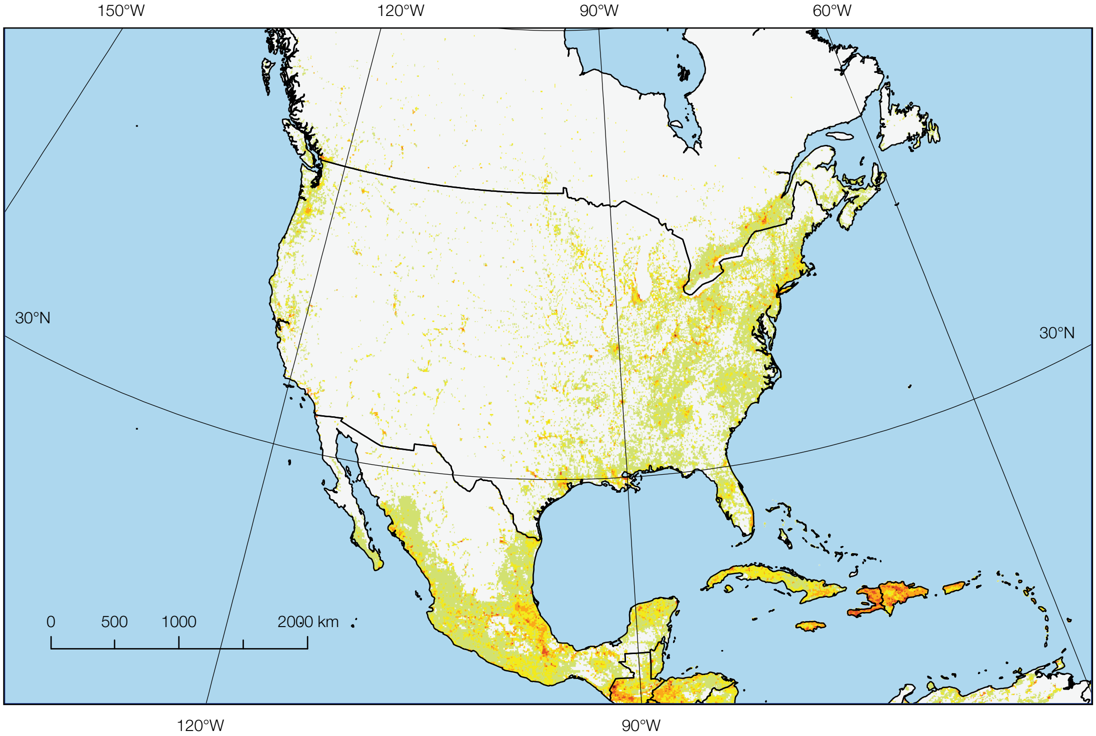



**Figure 2.2**

Mortality risk distribution from weather-related hazards (tropical cyclones, floods and rain-triggered landslides) in North America and the Caribbean as modelled


**Figure 2.3**

Mortality risk distribution from weather-related hazards (tropical cyclones, floods and rain-triggered landslides) in South America and the Caribbean as modelled

**Figure 2.4**

Mortality risk distribution from weather-related hazards (tropical cyclones, floods and rain-triggered landslides) in Europe as modelled

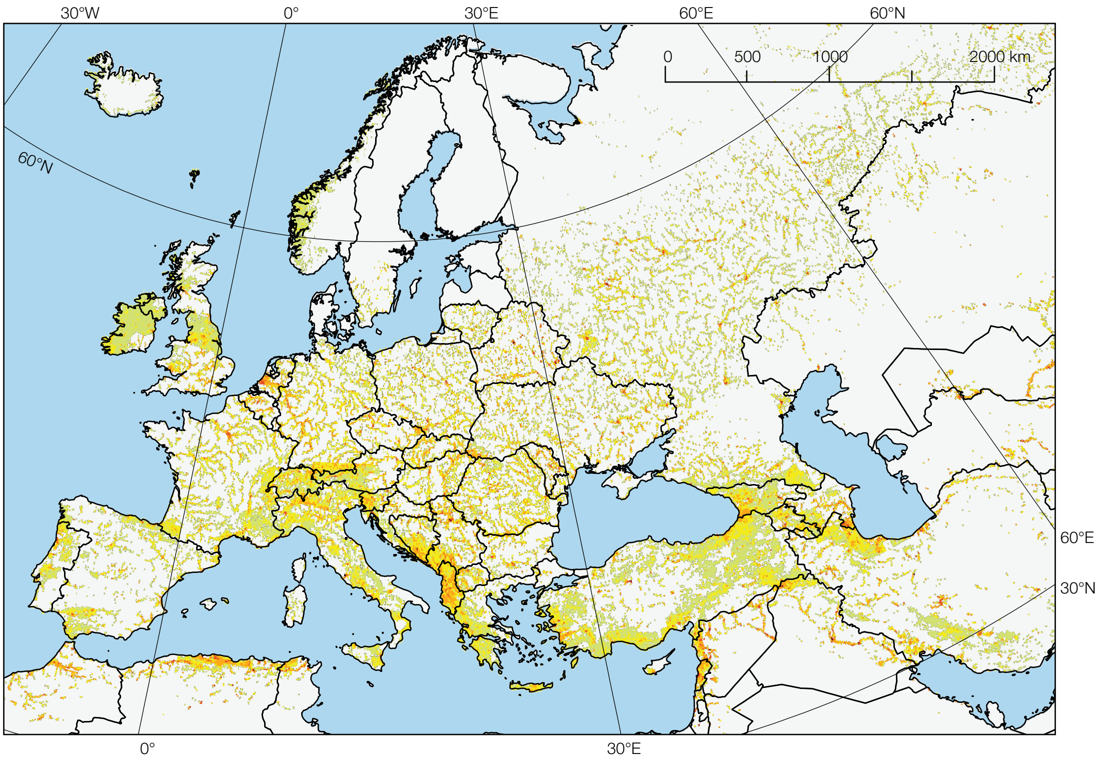
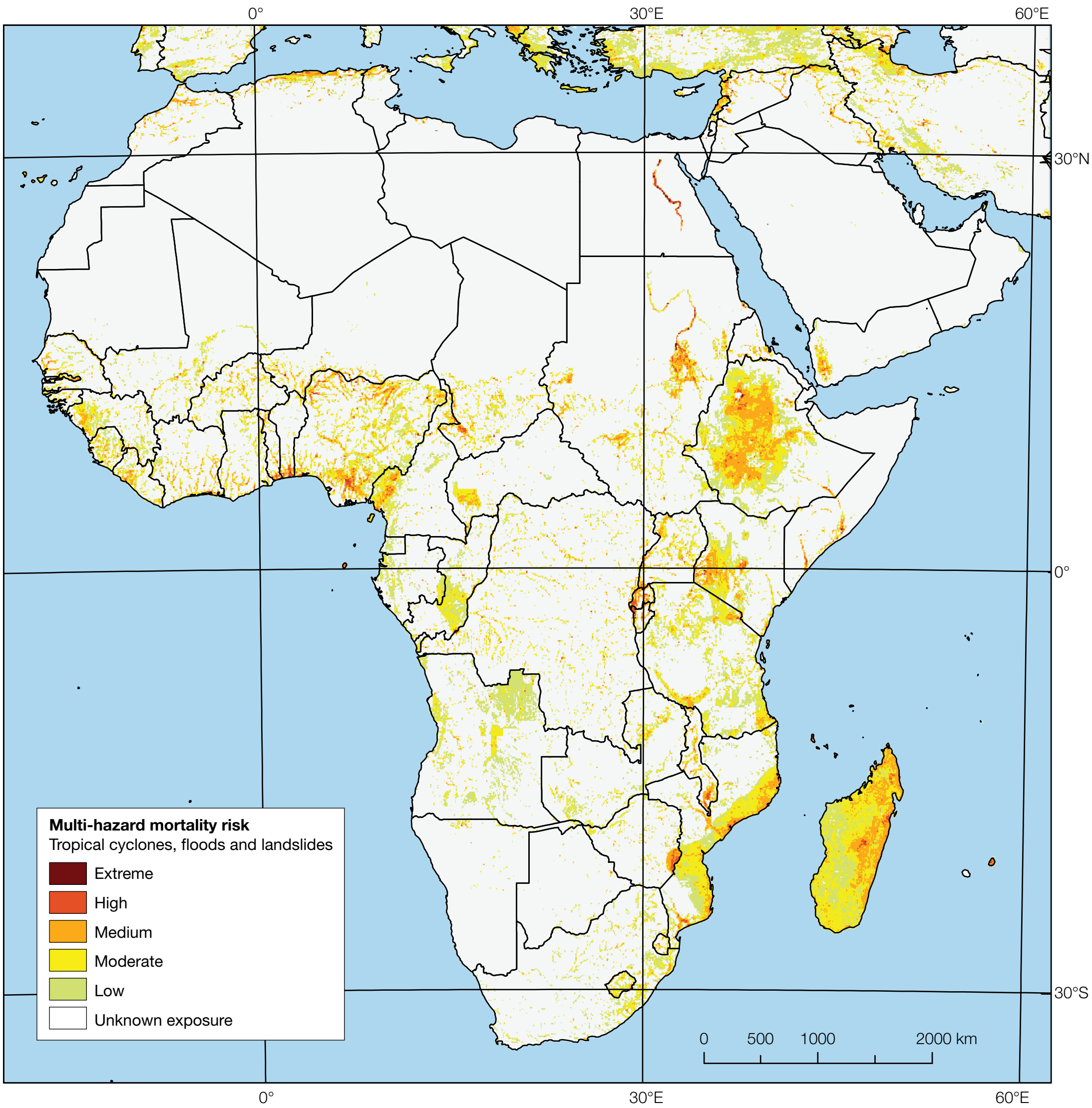



**Figure 2.5**

Mortality risk distribution from weather-related hazards (tropical cyclones, floods and rain-triggered landslides) in Africa as modelled



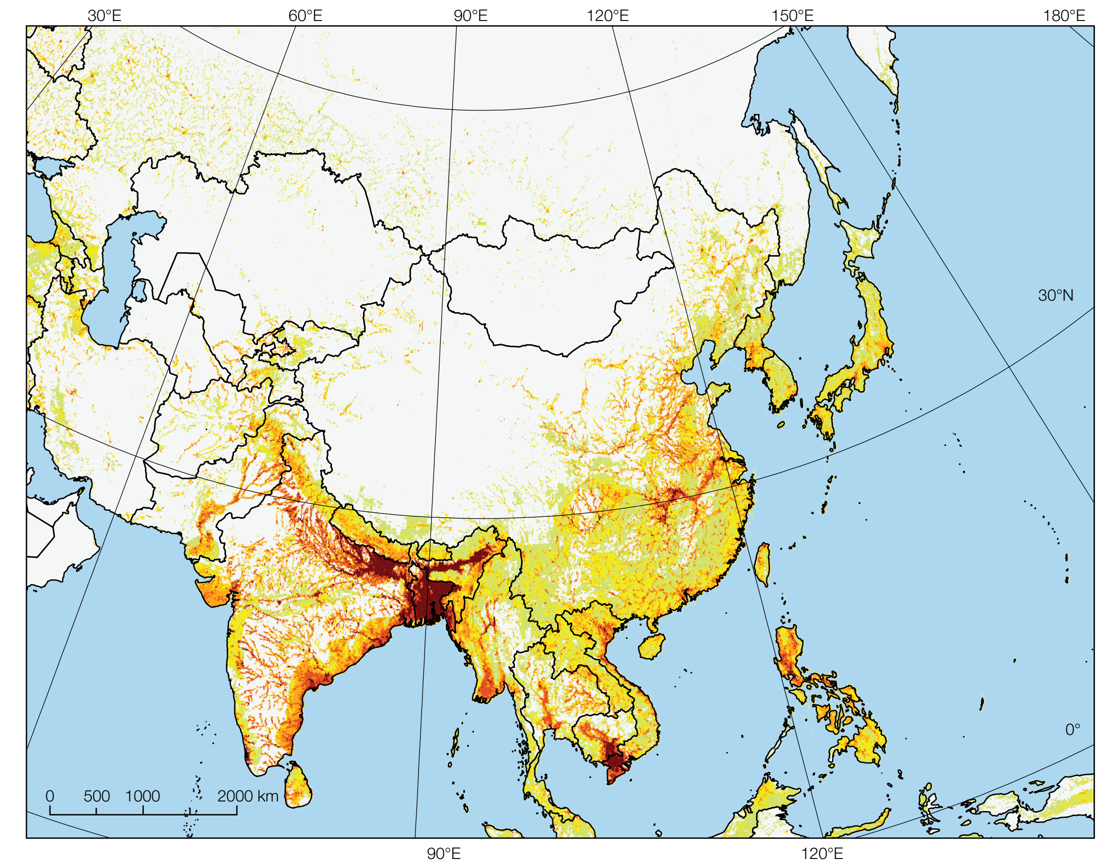



**Figure 2.6**
Mortality risk distribution from weather-related hazards (tropical cyclones, floods and rain-triggered landslides) in Asia as modelled

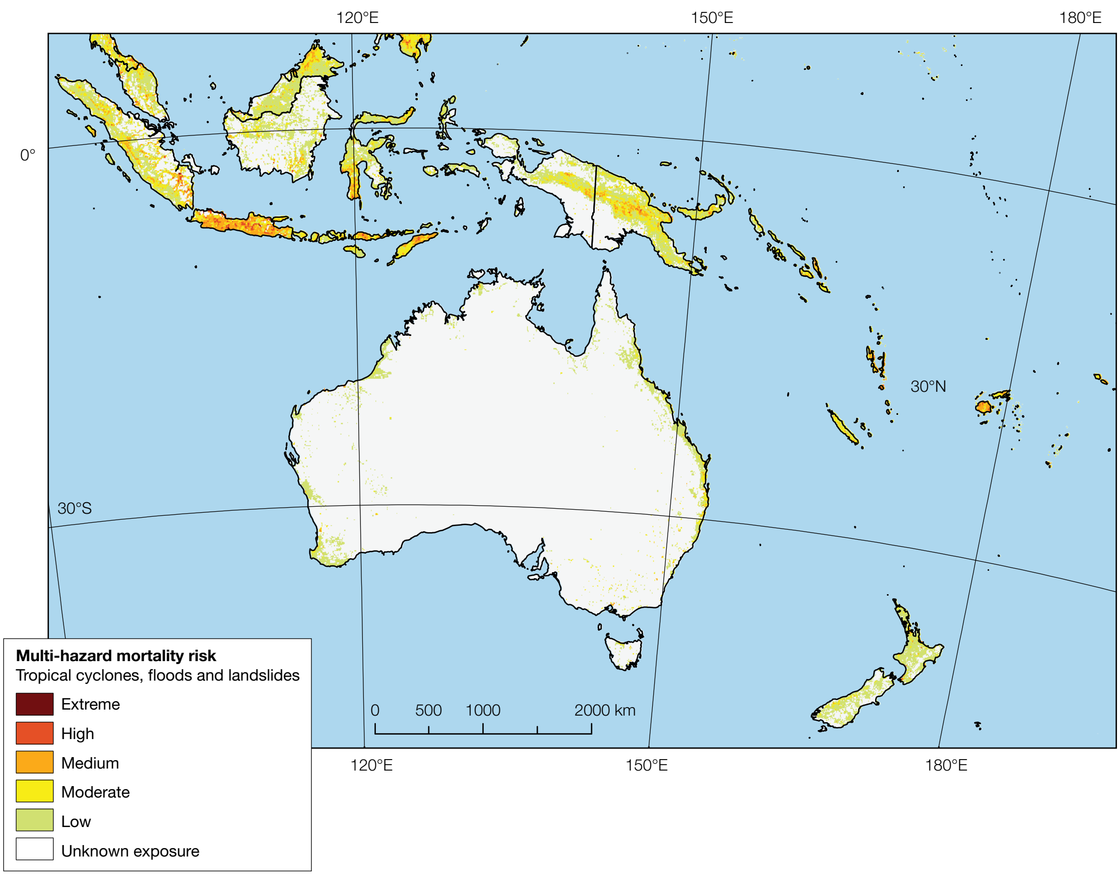



**Figure 2.7**
Mortality risk distribution from weather-related hazards (tropical cyclones, floods and rain-triggered landslides) in Oceania and South East Asia as modelled

**Figure 2.8**
Trend in flood exposure per income region as modelled

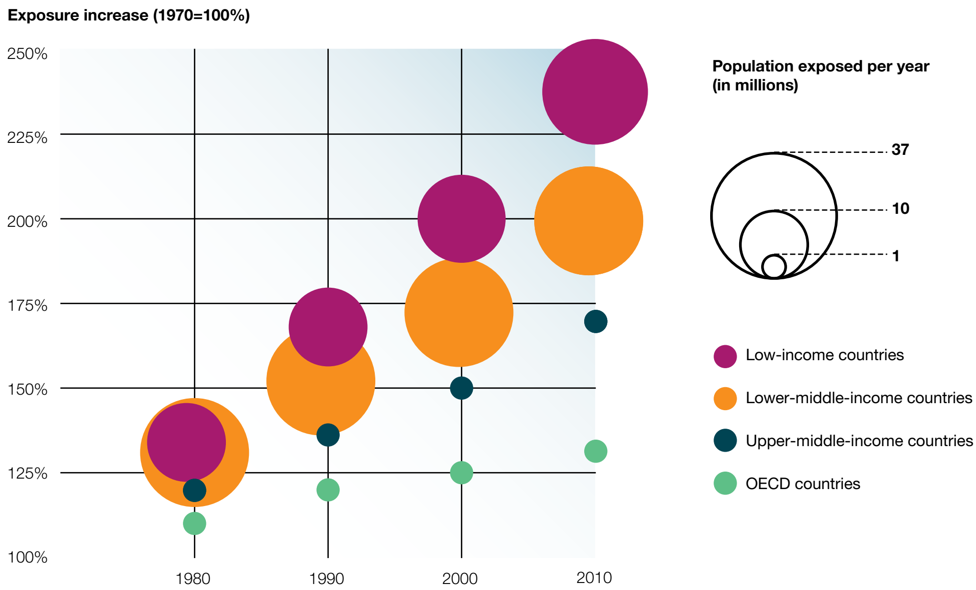



Table 2.2 Flood exposure by World Bank region as modelled[9] (million people per year)

| Region | 1970 | 1980 | 1990 | 2000 | 2010 |
|---|---|---|---|---|---|
| East Asia and the Pacific (EAP) | 9.4 | 11.4 | 13.9 | 16.2 | 18.0 |
| Europe and Central Asia (ECA) | 1.0 | 1.1 | 1.2 | 1.2 | 1.2 |
| Latin America and the Caribbean (LAC) | 0.6 | 0.8 | 1.0 | 1.2 | 1.3 |
| Middle East and North Africa (MENA) | 0.2 | 0.3 | 0.4 | 0.5 | 0.5 |
| OECD countries (OECD) | 1.4 | 1.5 | 1.6 | 1.8 | 1.9 |
| South Asia (SAS) | 19.3 | 24.8 | 31.4 | 38.2 | 44.7 |
| Sub-Saharan Africa (SSA) | 0.5 | 0.7 | 1.0 | 1.4 | 1.8 |
| **World** | **32.4** | **40.6** | **50.5** | **60.5** | **69.4** |

*(Sources: PREVIEW flood global model; Landscan, 2008 (extrapolated from 1970 to 2010 using UN world population))*

Since 1970 there has been little change in the overall number of tropical cyclones (Figure 2.9). The number of recorded Category 1 and 2 cyclones has been decreasing whereas the number of Category 4 and 5 cyclones has been increasing.[10] Over half of all tropical cyclones that made landfall affected East Asia and the Pacific and OECD countries (mainly Japan, the United States of America and Australia) (Table 2.3). Although most of the annual average exposure to tropical cyclones is concentrated in lower-middle- and high-income countries, exposure is growing most rapidly in low-income countries (Figure 2.10) where it has increased almost eight-fold since the 1970s (the dip in exposure in the 1990s reflects fewer cyclones in that decade).

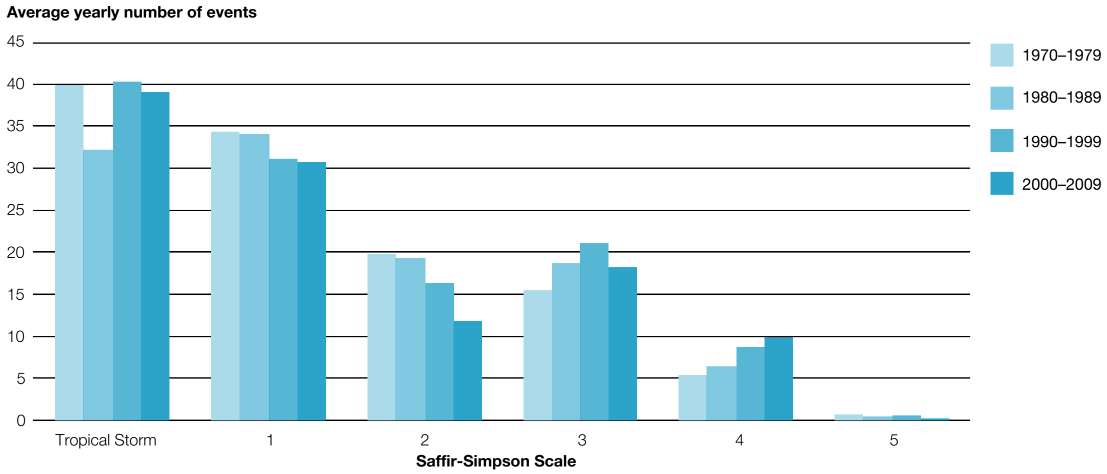



**Figure 2.9**
Average annual number of tropical cyclones by Saffir-Simpson Category between 1970 and 2009 as observed

Table 2.3 Exposure to tropical cyclones by World Bank region as modelled from observed events (in million people per year)

| Region | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2009 |
|---|---|---|---|---|
| East Asia and the Pacific (EAP)[11] | 36.6 | 42.2 | 44.3 | 53.7 |
| Latin America and the Caribbean (LAC) | 1.1 | 1.6 | 1.2 | 5.2 |
| Middle East and North Africa (MENA) | 0.0 | 0.0 | 0.0 | 0.1 |
| OECD countries (OECD) | 26.2 | 27.2 | 39.7 | 53.2 |
| South Asia (SAS) | 1.5 | 7.8 | 11.1 | 7.6 |
| Sub-Saharan Africa (SSA) | 0.5 | 0.9 | 1.5 | 2.7 |
| **World** | **65.9** | **79.8** | **97.8** | **122.5** |

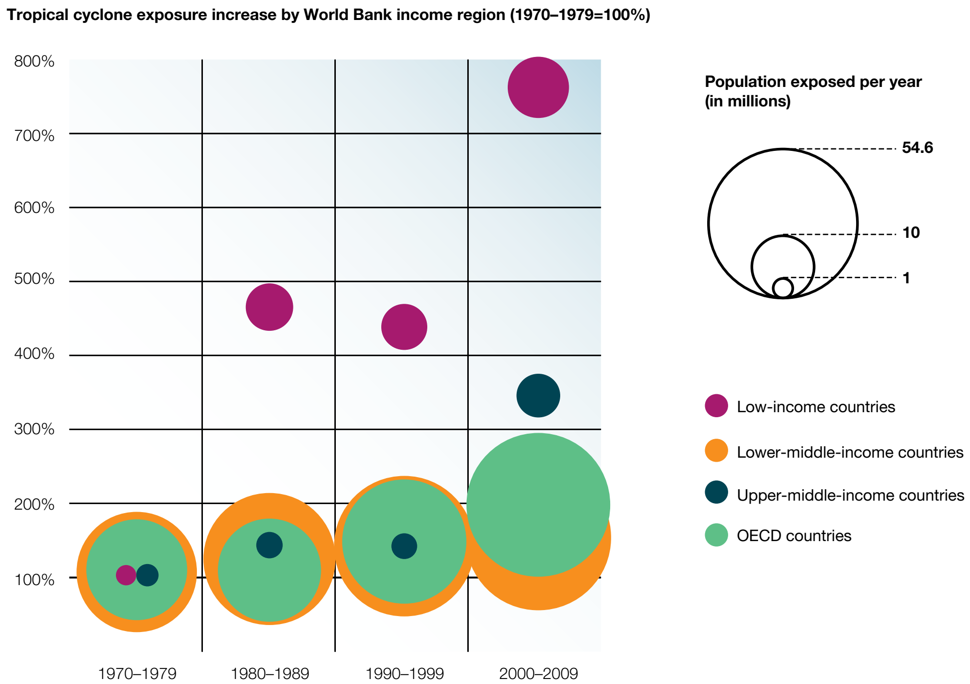


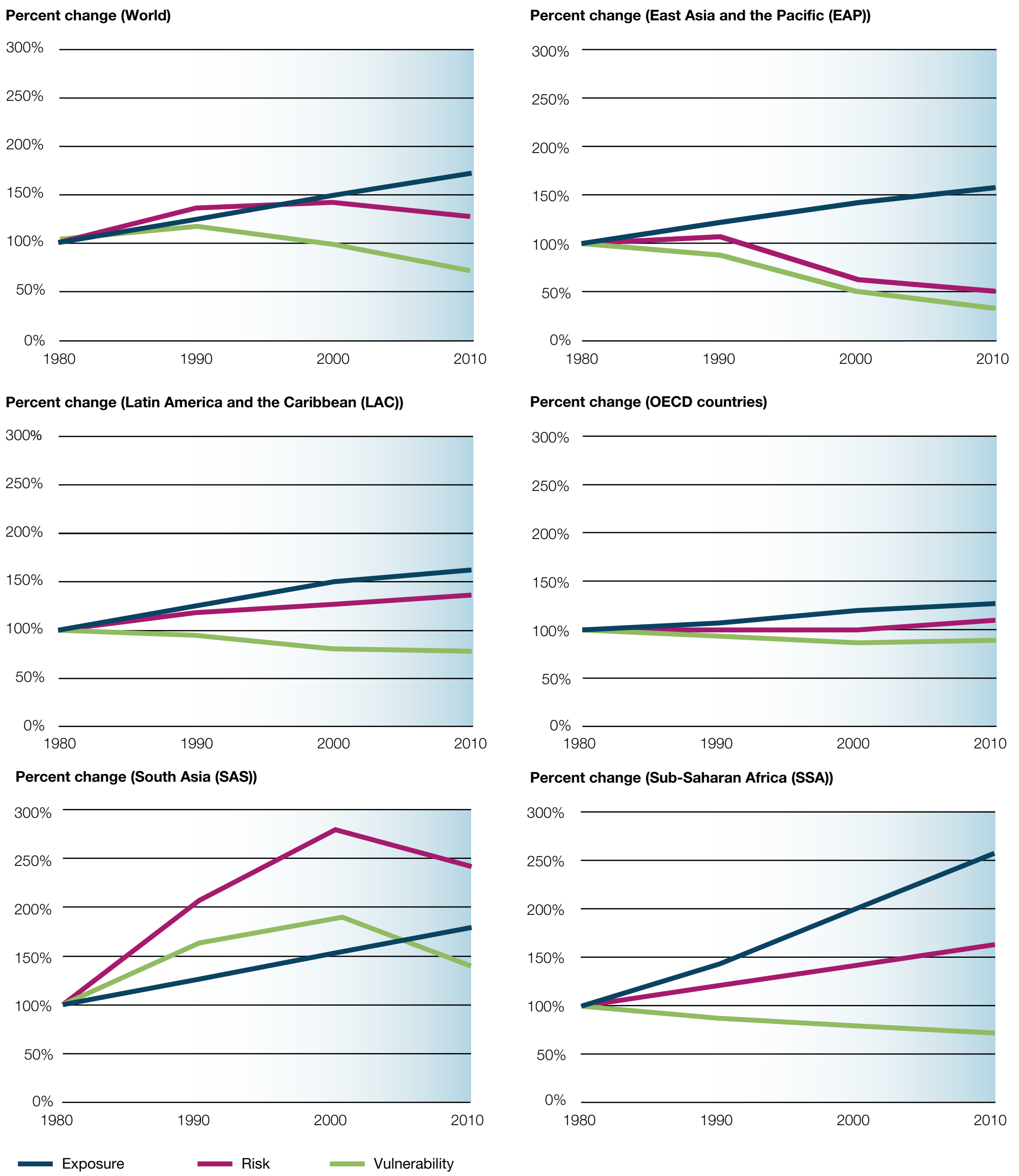

**Figure 2.10**
Trend in exposure to tropical cyclones per income region as observed

## 2.2.3 Tropical cyclone and flood mortality risk is decreasing

Global vulnerability to flood hazard has decreased since 1990, with South Asia the only region where vulnerability was still increasing during the 1990s (Figure 2.11). Since then, vulnerability has declined in all regions except Europe, Central Asia and the OECD, where it has remained stable. These figures are regional averages and may include individual countries in which vulnerability is increasing. In general, however, the statistics reflect how development has reduced vulnerability and strengthened DRM capacities.

Figure 2.11 also shows that global flood mortality risk was increasing until 2000, but it has subsequently declined and is now lower than in 1990. There are, however, important regional differences. In the Middle East and North Africa, Latin America and the Caribbean, and sub-Saharan Africa, flood mortality risk is still increasing, indicating that growing exposure continues to outpace reductions in vulnerability. The positive global trend is largely determined by Asia, where risk is falling. The major success story has been East Asia and the Pacific, where despite rapidly increasing exposure, flood mortality risk has more than halved since 1990. South Asia is reducing its vulnerability at a much slower pace,

**Figure 2.11**
Percentage change in flood mortality risk, exposure and vulnerability, as modelled, from 1980–2010 (compared to baseline year 1980)




*(Sources: Killed as modelled (GRID-Europe), Flood exposed (UNEP/GRID-Europe))*

meaning that risk in 2010 is higher than it was in 1990 (Box 2.3).

Vulnerability to tropical cyclones has decreased in all regions since 2000 (Figure 2.12). However, even though the vulnerability of low-income countries in 2010 was about 20 percent lower than in 1980, it was still 225 times higher than in OECD countries. The most significant reduction in vulnerability has been in lower-middle-income countries, where vulnerability in 2010 was less than half that in 1980.

Global tropical cyclone mortality risk is also decreasing (Figure 2.12), a trend largely controlled by a very significant reduction in risk in East Asia and the Pacific. In the OECD and sub-Saharan Africa, increased exposure is being offset by reduced vulnerability. However, in Latin America and the Caribbean, and South Asia, risk in 2010 remained higher than in 1990.

The picture is even more optimistic when looking at risk relative to population size. Flood mortality risk has fallen since 1980 in all regions apart from South Asia (Figure 2.14). In East Asia and the Pacific, in particular, it has declined by about two-thirds.

In relative terms, cyclone mortality risk has fallen in all regions since 2000 (Figure 2.15), and is now lower than in 1980. This is an important achievement considering the extent to which exposure has increased over the same

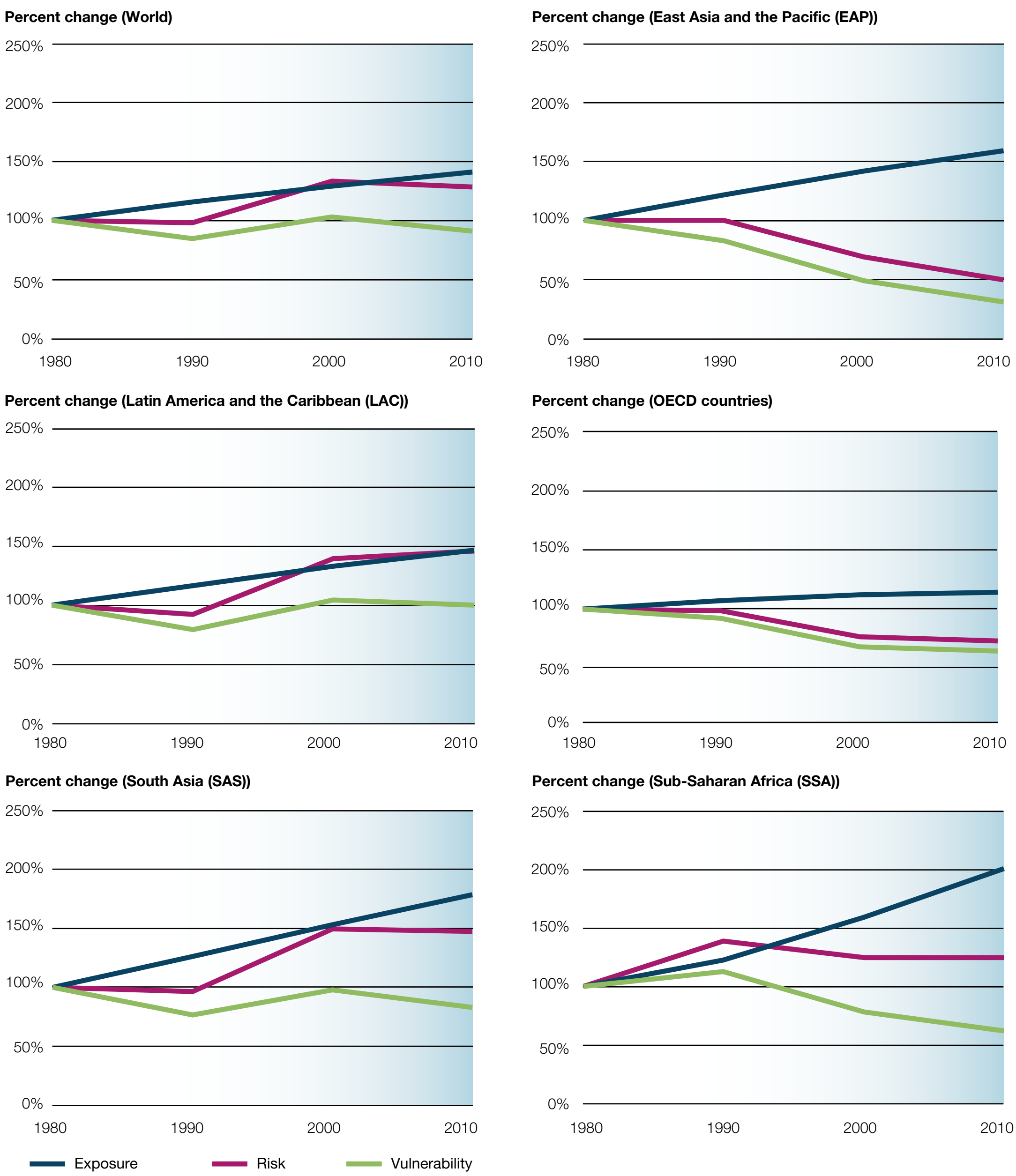
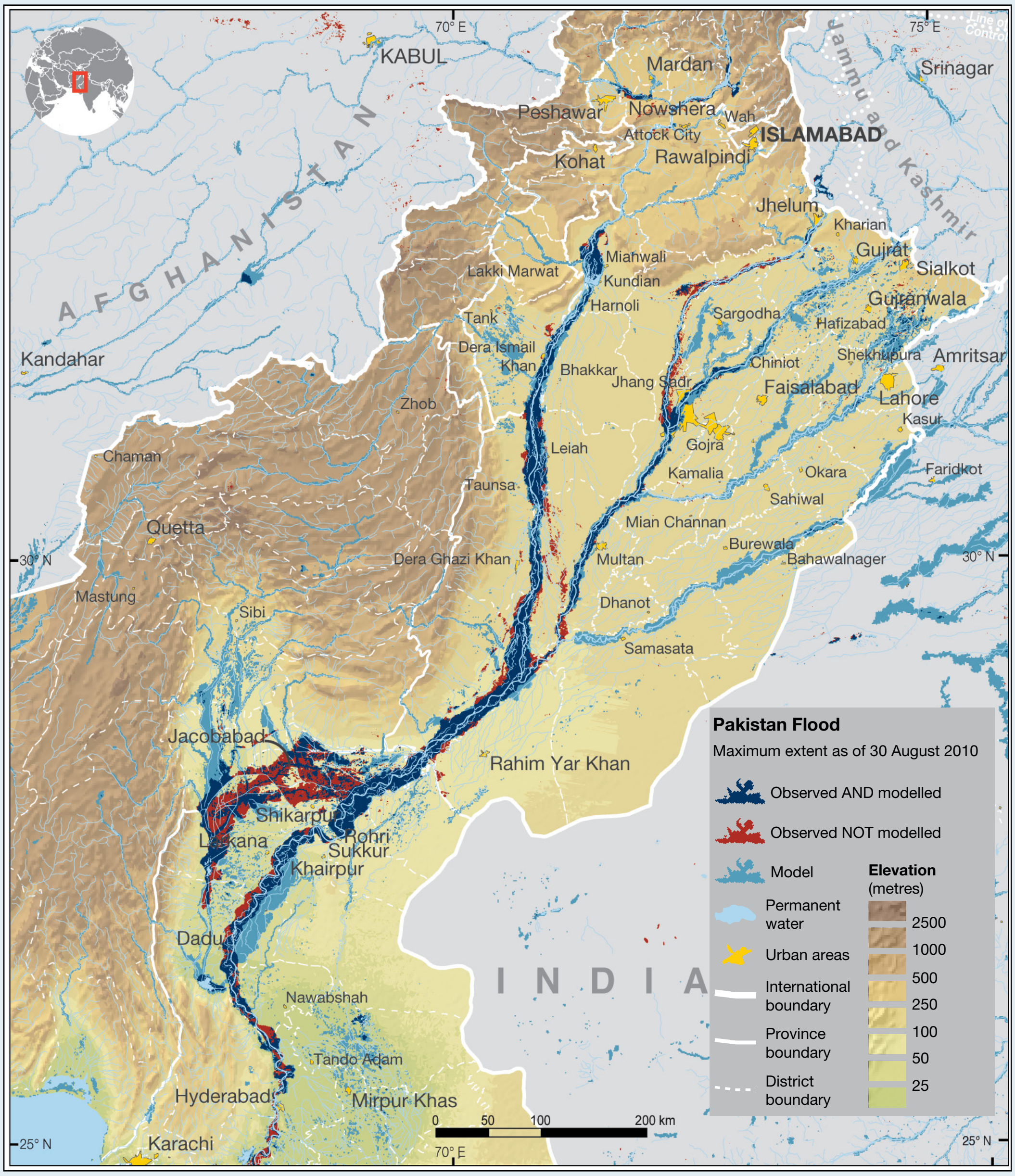



**Figure 2.12**

Percentage change in tropical cyclone mortality risk, exposure and vulnerability, as modelled, 1980–2010 (compared to baseline year 1980)

## Box 2.3 The August 2010 floods in Pakistan

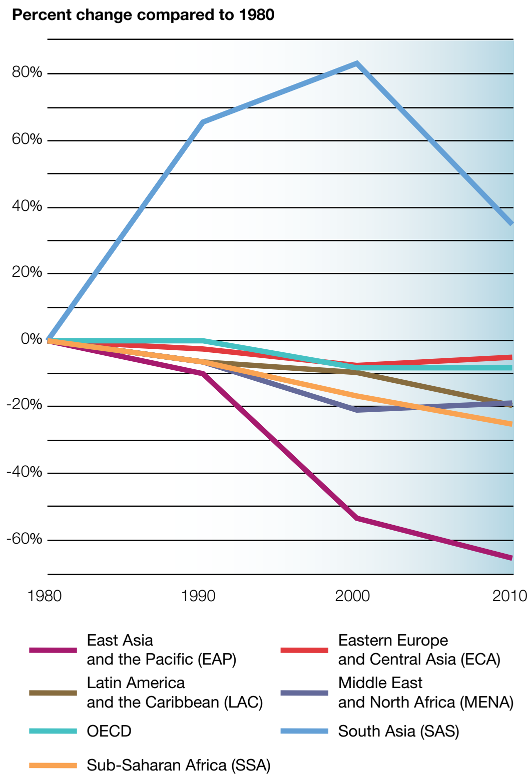
**Figure 2.13**
Extent of flooding in Pakistan on 30 August 2010




*(Source: UNEP/GRID-Europe, 2010)*

The challenges to reducing flood risk in South Asia were highlighted by the August 2010 floods in Pakistan, which killed approximately 1,700 people and caused US$9.7 billion in damage to infrastructure, farms and homes, as well as other direct and indirect losses (ADB/World Bank, 2010). The map contrasts the areas that actually flooded with those areas that the GAR09 risk model predicted would be flooded during a 1-in-100-year flood (Herold and Mouton, 2011). As with any flood, some areas the model predicted would flood were spared, and some flooded areas were not captured by the model. The flooding was concentrated in rural areas with rapidly growing populations that lacked a prominent political voice—risk factors that contributed to the high mortality.

The risk model also predicted a mortality rate approximately four times higher than that reported, suggesting the reduction in flood mortality in South Asia described earlier may be conservative. That the risk could be modelled at all highlights that this was not an *unexpected* disaster.



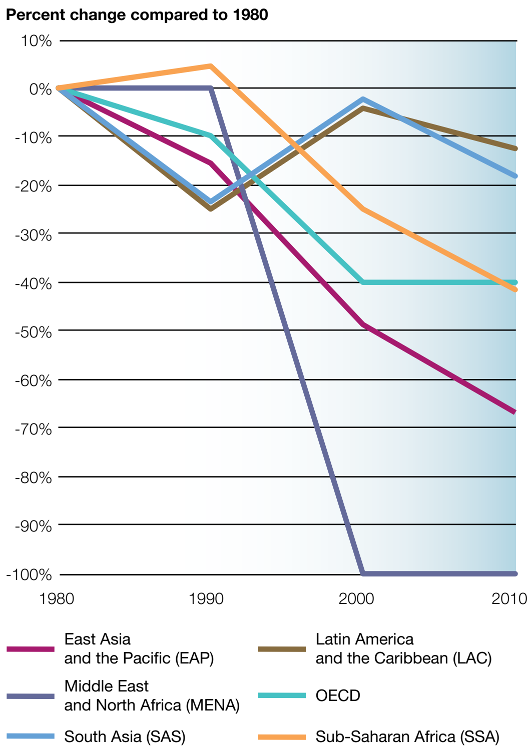




**Figure 2.14 (left)**

Percentage change in relative flood mortality risk by region as modelled, 1980–2010 (compared to baseline year 1980)

**Figure 2.15 (right)**

Percentage change in relative tropical cyclone mortality risk by region as modelled, 1980-2010 (compared to baseline year 1980)

*(Source: UNEP/GRID-Europe, 2010)*

period. For example, in East Asia and the Pacific, relative mortality risk has fallen by about two-thirds since 1980, and has almost halved in sub-Saharan Africa.

## 2.2.4 Tropical cyclone and flood economic loss risk is increasing

In contrast to mortality risk, estimated economic loss risk associated with floods and tropical cyclones is increasing in all regions. As with mortality risk, as countries develop they strengthen their risk governance capacities and reduce their vulnerabilities. However, these improvements have failed to offset the very rapid increase in exposure fuelled by rapid economic growth. Increases in such capacities do not immediately reduce the vulnerability of existing fixed assets, such as buildings and infrastructure, which are often used beyond their expected lifespan. Similarly, as will be further explored in Chapter 6, instruments such as land use planning and building regulation have struggled to reduce vulnerability, particularly in rapidly urbanizing areas.

In the case of floods, economic loss risk is increasing faster in OECD and high-income countries than in other geographic and income regions, even though exposure in these countries is increasing at a far slower rate than elsewhere, for example Latin America and the Caribbean (Figure 2.16). As the 2011 floods in Germany and Australia illustrate, even high-income countries struggle to manage increasing exposure. Although GDP exposure to floods (Table 2.4) is increasing faster than GDP per capita in all regions, the risk of economic damage is only growing faster than GDP per capita in high-income countries.

The proportion of the world's GDP exposed to tropical cyclones increased from 3.6 percent in the 1970s to 4.3 percent in the first decade of the 2000s. During that time, the absolute value of global GDP exposed to tropical cyclones tripled, from US$525.7 billion to US$1.6 trillion (Table 2.5).[12] GDP exposure increased rapidly in the OECD in the 1990s, and in East Asia and the Pacific and in Latin America and the Caribbean in 2000–2009. In East Asia and the Pacific in 2009, the GDP exposed

**Figure 2.16**

Percentage change in economic loss risk, exposure and vulnerability to floods in the OECD and in Latin America and the Caribbean as modelled, 1990–2010 (compared to baseline year 1990)

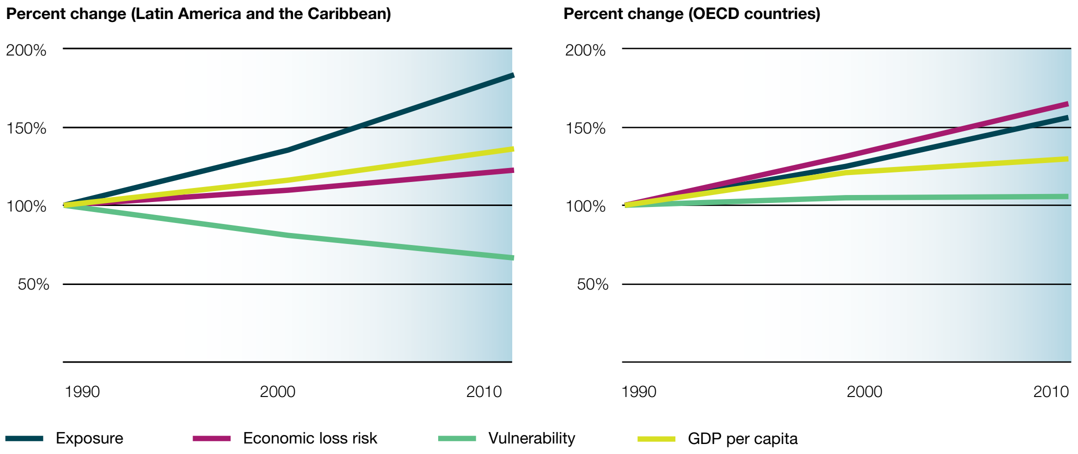



Table 2.4 Average annual global GDP exposed to floods as modelled (in billion 2000 US$)

| Region | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2009 |
|---|---|---|---|---|
| East Asia and the Pacific (EAP) | 2.8 | 5.1 | 10.2 | 21.5 |
| Europe and Central Asia (ECA) | 2.2 | 2.7 | 2.7 | 3.1 |
| Latin America and the Caribbean (LAC) | 2.5 | 3.1 | 3.9 | 5.4 |
| Middle East and North Africa (MENA) | 0.3 | 0.4 | 0.6 | 0.9 |
| OECD countries | 24.1 | 32.8 | 43.5 | 52.9 |
| South Asia (SAS) | 3.9 | 5.4 | 8.7 | 15.4 |
| Sub-Saharan Africa (SSA) | 0.4 | 0.5 | 0.6 | 0.9 |
| **World** | **36.2** | **50.0** | **70.2** | **100.1** |

Table 2.5 Average annual global GDP exposed to cyclones from observed events (in billion 2000 US$)[13]

| Region | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2009 |
|---|---|---|---|---|
| East Asia and the Pacific (EAP) | 16.0 | 25.3 | 39.5 | 90.2 |
| Latin America and the Caribbean (LAC) | 2.3 | 4.9 | 3.7 | 24.3 |
| Middle East and North Africa (MENA) | 0 | 0 | 0 | 1.0 |
| OECD countries (OECD) | 506.6 | 665.1 | 1,247.1 | 1,455.0 |
| South Asia (SAS) | 0.3 | 2.6 | 4.2 | 4.3 |
| Sub-Saharan Africa (SSA) | 0.5 | 1.1 | 1.3 | 1.7 |
| **World** | **525.7** | **699.0** | **1,295.8** | **1,576.5** |

was nearly six times greater than in 1970. In contrast, although most of the exposed global GDP is concentrated in OECD countries, it was only three times greater in 2009 than it was in 1970.

Economic loss risk for cyclones is increasing in all regions. It has almost quadrupled (increasing by 265 percent) since 1980 in the OECD, almost tripled in sub-Saharan Africa (181 percent), and is more than two-and-a-half times greater in other regions (over 150 percent higher). In East Asia and the Pacific, and South Asia, risk is increasing because reductions in vulnerability are not offsetting rapidly increasing exposure (Figure 2.17). In terms of income regions economic loss risk has almost quadrupled (increasing by 262 percent) in high-income countries, and is more than two-and-a-half times greater in upper-middle-income countries (165 percent), lower-middle-income countries (152 percent) and low-income countries (155 percent). Thus economic strength has failed to reduce economic loss risk, even in the OECD.

GDP per capita has grown by more than eight times (703 percent) in East Asia and the Pacific and has almost quadrupled (increasing by 293 percent) in South Asia, outpacing the growth in exposure in both regions. As such, estimated risk has fallen relative to GDP per capita. In all other regions, however, both exposure and the estimated risk of economic loss are growing faster than GDP per capita. Thus the risk of losing wealth in disasters associated with tropical cyclones is increasing faster than wealth itself is increasing.

### 2.2.5 Countries that are falling behind in their development achievements have less resilience to disaster loss

Disaster losses must be put into perspective. Economic losses due to floods in South Asia are in absolute terms far smaller than those in the OECD. Relative to the size of South Asia's GDP, however, flood losses there are approximately 15 times greater than losses in the OECD. Thus, although economic loss risk in the OECD may be increasing faster, such losses threaten OECD countries' economies far less than they do those of most low- and middle-income countries.

Low-income countries have less capacity to absorb and recover from flood-inflicted economic losses. Similarly, larger economies are more able to absorb losses than smaller ones (including many Small Island Developing States). Larger economies tend to be more diverse geographically and economically, and are thus better able to compensate for losses in any one region or sector (Corrales, 2010). Furthermore, they can better absorb migration

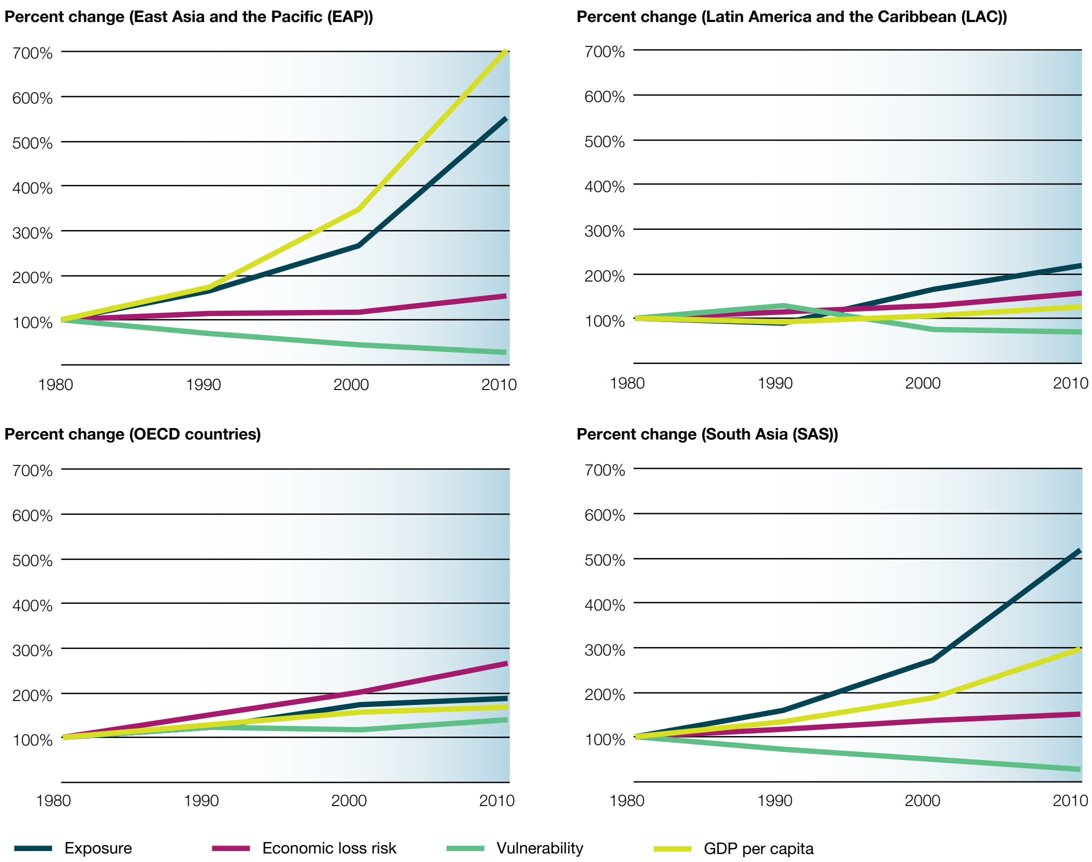



**Figure 2.17**

Percentage change in economic loss risk, exposure and vulnerability to tropical cyclones in East Asia and the Pacific, South Asia, Latin America and the Caribbean, and OECD countries as modelled, 1980–2010 (compared to baseline year 1980) and are more likely to be able to counter the longer-term economic effects of severe loss of productive assets, interrupted supply chains or distorted markets after a disaster. The ability to withstand losses is not solely dependent on a country's share in world trade or on trade volumes, but also on the diversity of its products and trade partners. Limitations in both make a country more vulnerable to disaster-induced trade shocks and disruptions.

As Figure 2.18 shows, over the last 30 years, the gap in development achievements between many lower-income countries and the OECD has grown and is likely to widen further as a result of climate change.[14] Although GDP per capita, human development, capital formation and competitiveness of some low- and middle-income countries has approached those of the OECD, others have fallen further behind both their low- and middle-income counterparts and the OECD. Some of these divergent economies may be experiencing 'resilience traps', where disaster losses and impacts cause negative feedback into slow development and structural poverty. Climate change may further test the resilience of many of these countries.

## 2.3 Extensive disaster risk trends

The past 20 years have seen an exponential increase in the number of local areas reporting losses, the number of houses damaged, the number of people affected, and the damage to health and educational facilities associated with extensive disasters. Increasing extensive risk is closely related to the challenges low- and middle-income countries face in addressing underlying risk drivers and reducing vulnerability.

**Figure 2.18**
Development achievements 1980–2010


*(Source: Corrales, 2010)*

Extremely heavy and persistent rains fell across a broad area of the Central Valley and Pacific coast of Costa Rica on 2–3 November 2010. Just south of San José, a mudslide destroyed the small community of Calle Lajas in San Antonio de Escazú, killing 23 people and destroying 25 houses. The losses in Calle Lajas, however, were only the most intensive of those associated with a large number of floods and landslides that affected 50 municipalities and 681 communities in Costa Rica. The disaster damaged or destroyed 2,540 houses (Figure 2.19), four schools and 85 bridges (CNE, 2010).

Whereas these disasters were characterized as a consequence of unexpectedly heavy rains, in reality they were the outcome of an unseen but continuous accumulation of risk. Costa Rica is ranked 59th out of 184 countries on risk governance capacities (Lavell et al., 2010), ahead of most low- and middle-income countries. However, many municipalities do not have land use plans informed by risk assessments, and over the years building and urban development have been authorized in many hazard-prone locations. Although Costa Rica has good levels of environmental protection, it is having difficulty managing rapidly increasing hazard exposure from urban development, and ensuring the security of public infrastructure such as roads and bridges.

It was anticipated that the 2010 rainy season would be more intense than usual given the presence of La Niña[15] in the region. Although a scientific study had already identified the risk of landside in Calle Lajas, local authorities were unable to address this because of a combination of ineffective planning and enforcement mechanisms, responsibilities spread over many different public bodies with unclear accountability, and a resistance to relocation from many of the households at risk.[16]

These extensive disasters in Costa Rica are representative of the way in which risk is unfolding in low- and middle-income countries. Analysing trends in extensive risk is important for three reasons.

First, although extensive disasters are responsible for only a small proportion of global disaster mortality (Figure 2.20), they account for a very significant proportion of damage to public assets, such as health and educational facilities and infrastructure, as well as to the livelihoods, houses and assets of low-income groups. Many countries are making progress in systematically

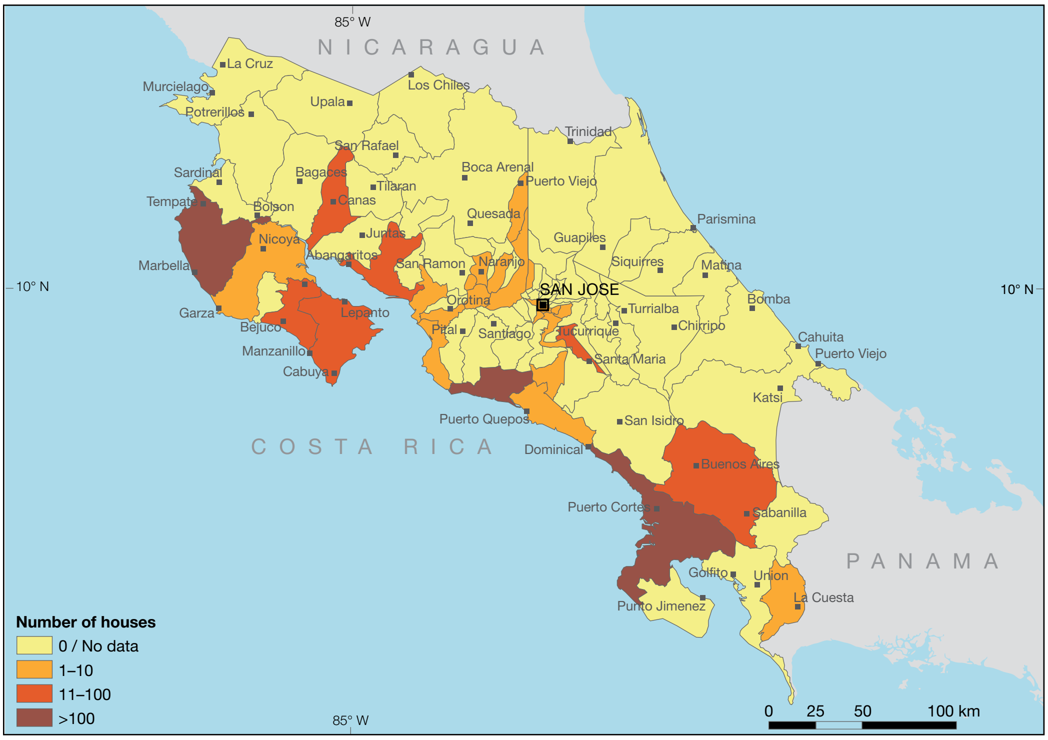
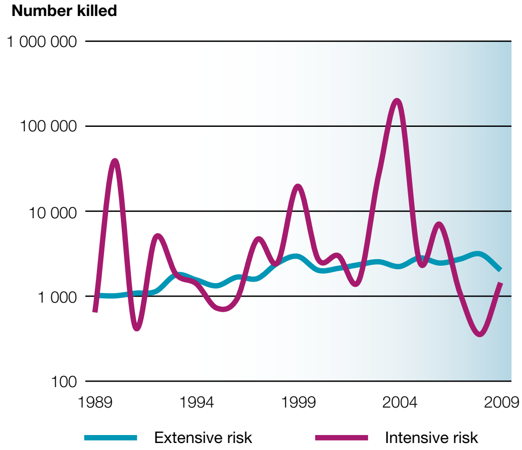



**Figure 2.19** Number of houses damaged in different municipalities as a result of the November 2010 rains in Costa Rica

**Figure 2.20**

Mortality from extensive and intensive disasters, 1989–2009 in 21 countries[17] in Africa, Asia, Latin America and the Middle East




recording disaster loss, but most extensive disaster losses go unaccounted for (see Box 2.4). The invisibility of such a high proportion of disaster loss is one reason why so many countries find it politically and economically difficult to prioritize investments in DRM.

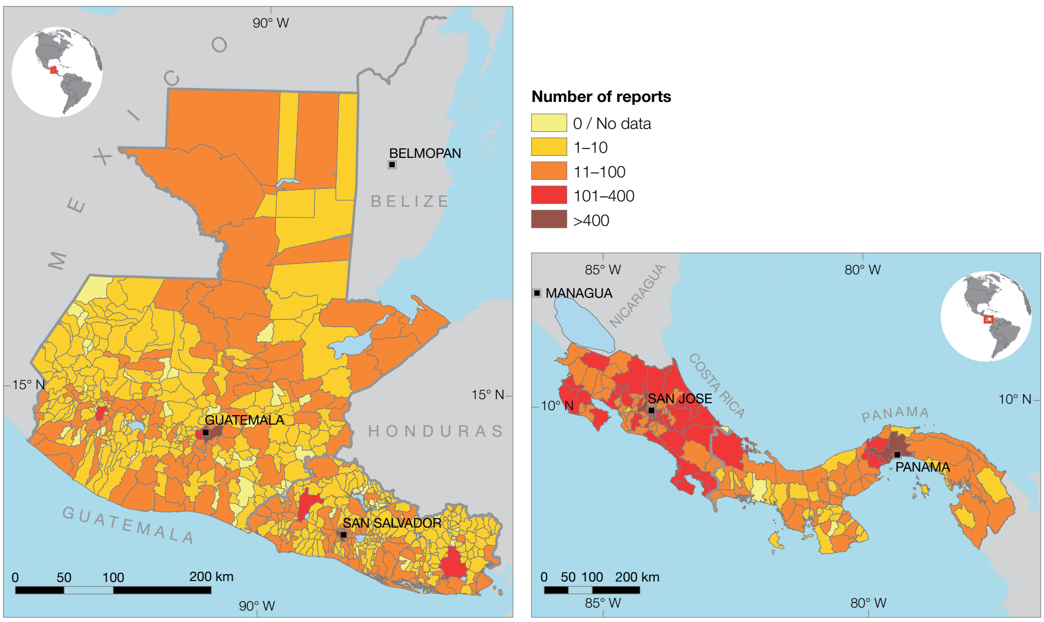
Second, as highlighted in Section 2.2, economic loss risk is increasing because countries have been unable to strengthen their risk governance capacities fast enough to address the rapidly increasing exposure that accompanies economic growth. Analysing extensive risk provides a unique real-time view of this challenge. Extensive risk, along with many of the localized weather-related hazards with which it is associated, is directly constructed by risk drivers such as badly planned and managed urbanization, environmental degradation, and poverty. Given that almost all (97 percent) of extensive disaster loss reports are weather-related, extensive risk analysis also provides an opportunity to view the impact of climate variability. Extensive risk, unlike intensive risk, is not dependent on the location of earthquake fault lines or cyclone-prone coastlines. The Central American countries of Costa Rica, El Salvador, Guatemala and Panama illustrate this issue, where extensive risk exists wherever development occurs (Figure 2.21). All Panama's municipal areas report extensive disaster losses even though the country lies south of the Caribbean hurricane belt and earthquakes are infrequent.

Third, and precisely because it reflects risk construction processes in operation, extensive risk is also an indicator of new intensive risk hotspots. As illustrated in the case of Dhaka, increased seasonal flooding is also an indicator of growing intensive earthquake risk.

Globally, the analysis of new and updated local disaster loss data from a wider geographical sample of countries in Africa, Asia, Latin America and the Middle East (see Box 2.5) confirms the trends first identified in 2009 (UNISDR, 2009).

**Figure 2.21**

Number of reports of extensive disaster loss in Costa Rica, El Salvador, Guatemala and Panama



## Box 2.4 Updating the extensive risk analysis

To improve the analysis of extensive risk, GAR11 has incorporated substantial new data. All the databases of GAR09 have been updated to include disaster loss data for 2008 and 2009, and nine new countries have contributed data for the analysis (Chile, El Salvador, Guatemala, Indonesia, Jordan, Mozambique, Panama, Syrian Arab Republic and Yemen). The dataset (see Table 2.6) now includes almost 200,000 local level disaster reports covering a 40-year period from 21 countries: Argentina, Bolivia, Colombia, Costa Rica, Ecuador, India (Orissa and Tamil Nadu), Iran (Islamic Republic of), Mexico, Nepal, Peru, Sri Lanka and Venezuela in addition to the nine new countries. Combined, these countries and states comprised a population of more than 850 million people in 2009.

'Extensive' and 'intensive' risks are relative terms. As such, any quantitative threshold between extensive and intensive manifestations of risk is arbitrary no matter the scale. Given that each country or locality has a unique risk footprint, hybrid loss exceedance curves would be most appropriate to define what is extensive or intensive in any given country (see Box 5.3 for more information). At present, such curves have only been constructed for three of the countries in the data universe (Colombia, Mexico and Nepal). For the purpose of this analysis of 21 countries and states, a statistically robust quantitative threshold was calculated for the data universe as a whole, rather than for individual countries or regions, and was used to filter the most intensive manifestations of risk. The threshold for intensive risk used in GAR11 was established at 25 deaths or 600 houses destroyed in any one local level loss report (Freire, 2010; OSSO, 2011a).

The analysis showed that extensive risk accounts for only 9.6 percent of the deaths and 20 percent of the houses destroyed (a proxy for direct economic loss). Damage is much more extensively spread, with extensive risk accounting for 53.9 percent of houses damaged, 80 percent of people affected, 83.1 percent of people injured, 45.2 percent of damage to schools, and 55.2 percent of damage to health facilities.

Table 2.6 Summary of the GAR11 loss data universe

| Risk type | Hazard type | Reports | % | Deaths | % | Houses destroyed | % | Houses damaged | % |
|---|---|---|---|---|---|---|---|---|---|
| Extensive | Weather-related | 188,236 | 96.3 | 59,911 | 9.2 | 1,096,891 | 18.3 | 5,674,114 | 50.1 |
| Extensive | Geological | 5,565 | 2.8 | 2,861 | 0.4 | 104,451 | 1.7 | 431,613 | 3.8 |
| Intensive | Weather-related | 1,293 | 0.7 | 182,723 | 27.9 | 3,079,749 | 51.4 | 3,806,413 | 33.6 |
| Intensive | Geological | 464 | 0.2 | 408,303 | 62.5 | 1,717,405 | 28.6 | 1,410,417 | 12.5 |
| **TOTAL** | | **195,558** | **100.0** | **653,798** | **100.0** | **5,998,496** | **100.0** | **11,322,557** | **100.0** |

### 2.3.1 Weather-related disaster damage is increasing exponentially

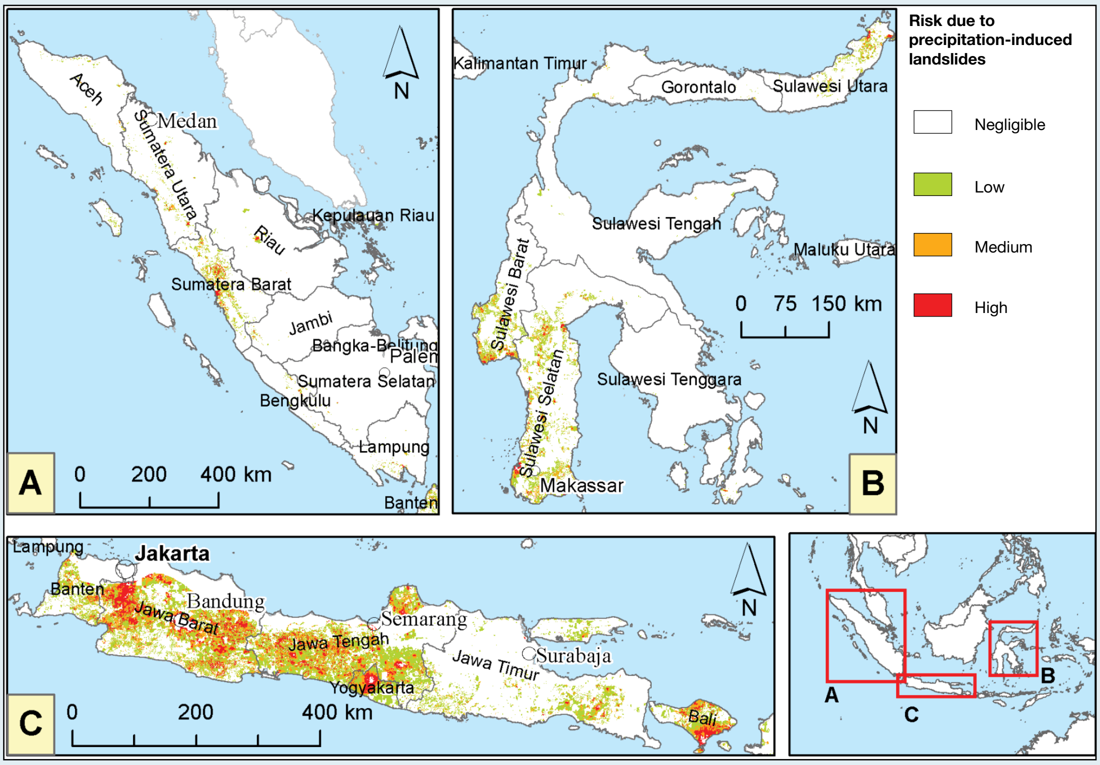
Across the 21 countries and states (see Box 2.4), disaster occurrence and loss was down significantly in 2009. Given that most extensive risk is weather-related, its manifestations are closely related to climate variability, associated for example with the El Niño Southern Oscillation. As such it can be expected that both the number of events and losses increased again in 2010. Looking at the longer-term picture, the past 20 years have seen a significant increase in the number of local areas reporting losses, the number of houses damaged, the number of people affected and the damage to health and educational facilities associated with extensive

## Box 2.5 Progress in recording local level disaster impacts and losses

In the past two years, a number of countries have made significant progress in developing information systems to systematically record and document disaster loss.

The Indonesian Disaster Data and Information Management Database (DIBI) is based on official government data from 1815 to 2009. DIBI is already being used as the basis for national policy, planning and budgeting in disaster risk reduction and is informing development planning decisions. For example, Indonesia's National Disaster Management Agency (BNPB) has used DIBI to identify hazard-prone areas across Indonesia in order to prioritize the creation of district level disaster reduction structures. Within Indonesia's National Development Planning Agency (BAPPENAS), the Directorate for Poverty Eradication is using DIBI to establish priorities for its own and donor-funded programmes. Ongoing work to improve DIBI includes incorporating additional attributes such as school-age children, health status, infrastructure, public facilities, income levels, types of livelihoods and spatial planning data. DIBI has also been used for pioneering applications in risk assessment, applying the methodology used in the GAR global risk model at the sub-national level (Figure 2.22).

**Figure 2.22**
Landslide risk in Indonesia




*(Source: Cepeda et al., 2010)*

The Mozambique National Disaster Database, built and hosted by the government's National Institute for Disaster Management (INGC) has the best documented set of reports of agricultural losses in the entire data universe. About 30 percent of its records (1,394) contain detailed information on the area and type of crops destroyed and affected. These records provide unique insight into how extensive risk manifests in the agricultural sector and affects rural livelihoods.

In 2010, Egypt, Jordan, Morocco, the Syrian Arab Republic and Yemen also began a pioneering initiative to collect local level disaster loss data in the Arab states, where until then, the absence of systematic information on disaster impacts had been a major obstacle to strengthening capacities for disaster risk reduction. Jordan, the Syrian Arab Republic and Yemen (Figure 2.23) have recently

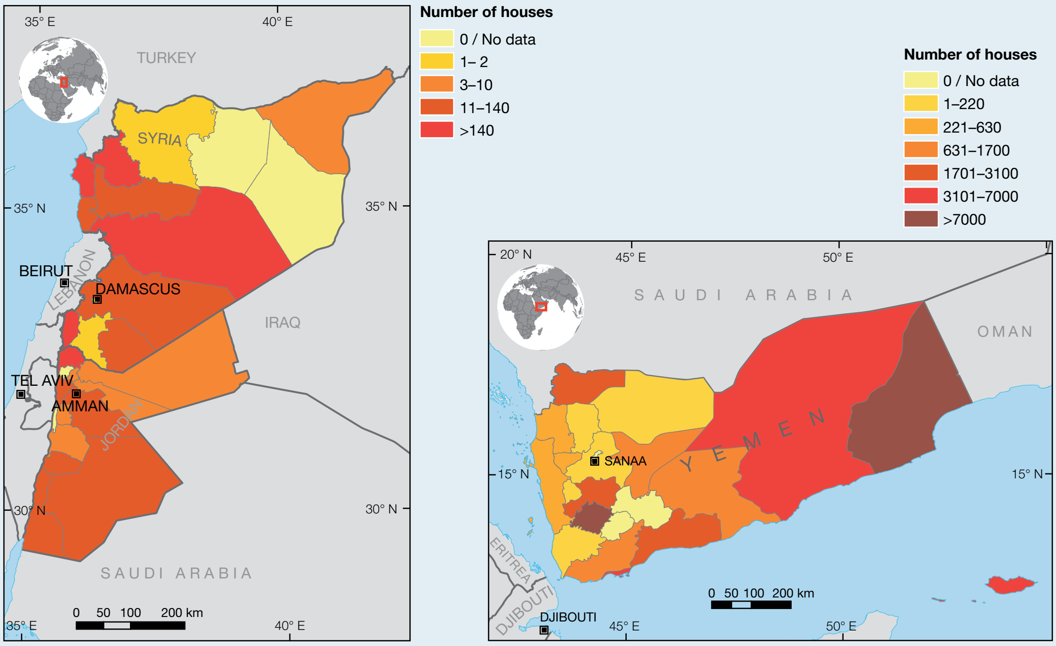



**Figure 2.23**
Housing damage by governorate in Jordan and the Syrian Arab Republic (left), and by province in Yemen (right), 1989–2009

published national disaster inventories, included in GAR11, and it is expected that the other two countries will soon follow. Mozambique and the Arab states also plan to include age- and gender-enabled indicators when such information is available.

Viet Nam has been collecting comprehensive disaster loss data as part of the DANA initiative of the Central Committee of Flood and Storm Control. The database contains historical data at the provincial level dating back to 1989, and was used to assess disaster impacts on children in Chapter 2 (Tarazona and Gallegos, 2010).

Latin America has been recording local level disaster loss data since the mid-1990s. Until recently, countries in this region (with the exception of Panama) struggled to institutionalize these loss databases. In the past two years, however, regional organizations as well as governments in Bolivia, Ecuador, El Salvador and Guatemala have made progress on institutionalizing systematic disaster reporting and analysis.

disasters (Figure 2.24). This reinforces the view that the rapid increases in both population and GDP exposure described in Section 2.2 have not been addressed by commensurate reductions in vulnerability.

Extensive risk is also rising in relative terms. The number of houses damaged relative to population growth in all 21 countries and states has increased by approximately 600 percent since the early 1990s (Figure 2.25). The enormous difference between this increase and the increasing economic loss to major hazards, described in Section 2.2, reflects how extensive disaster loss is largely unaccounted for, disguising a transfer of risk within countries to low-income households and communities.

## 2.3.2 Extensive risk is expanding geographically

Spatially, the expansion of extensive risk mirrors urban and regional development and hence increasing population and asset exposure. Across all 21 countries and states, the number of local administrative areas reporting disaster losses has increased more or less continuously over the past 20 years (Figure 2.26). In Mozambique, for example, more local administrative areas reported losses more often between 1999

**Figure 2.24**

Extensive risk trends by indicator (for the 21 countries and states included in the GAR11 analysis)

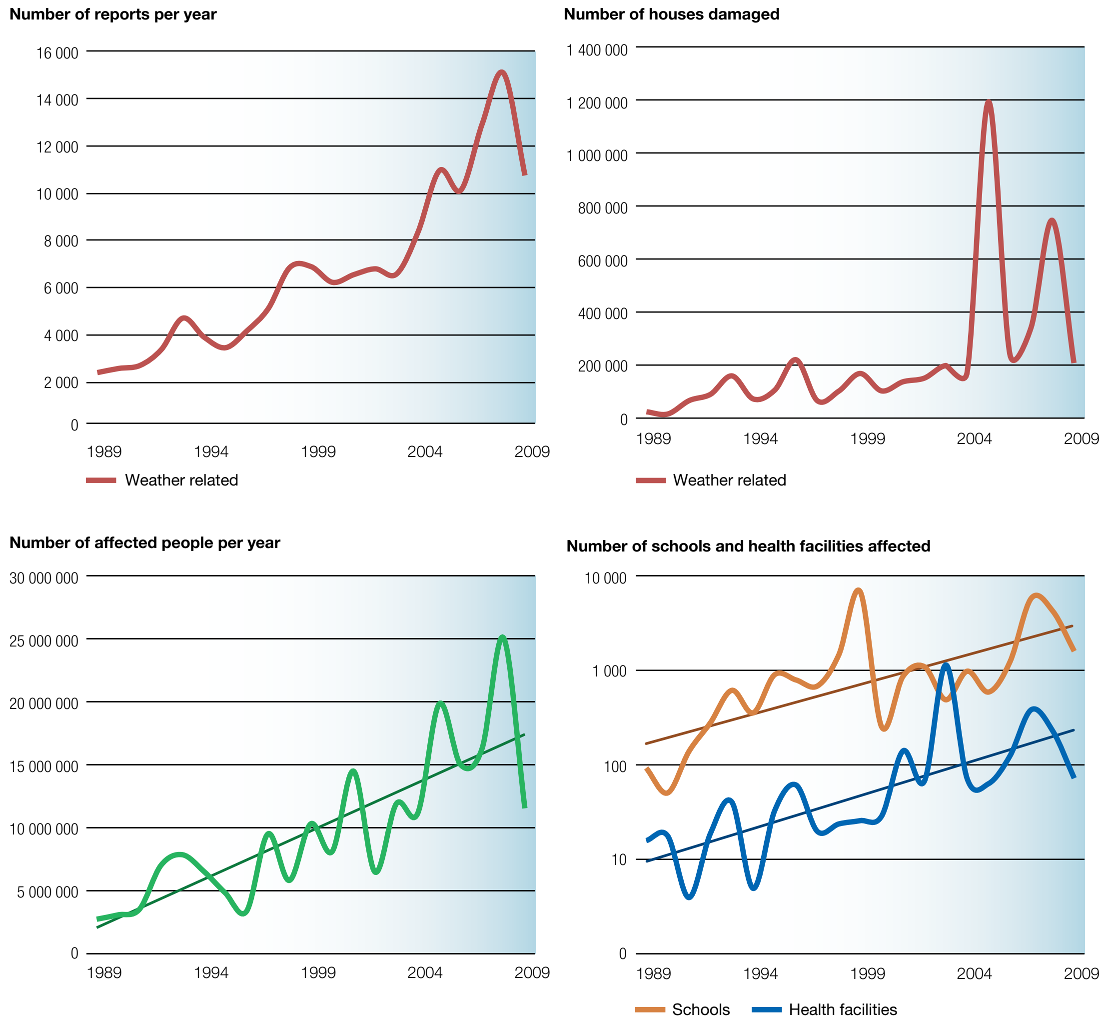
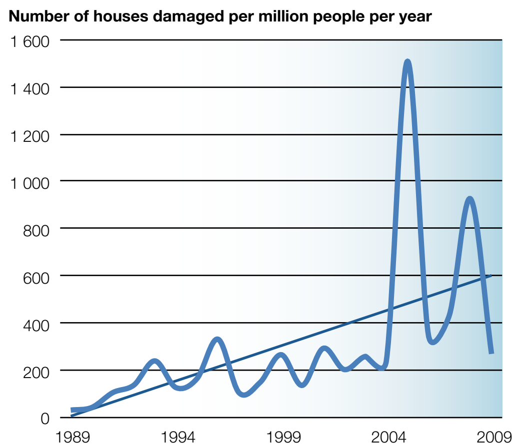


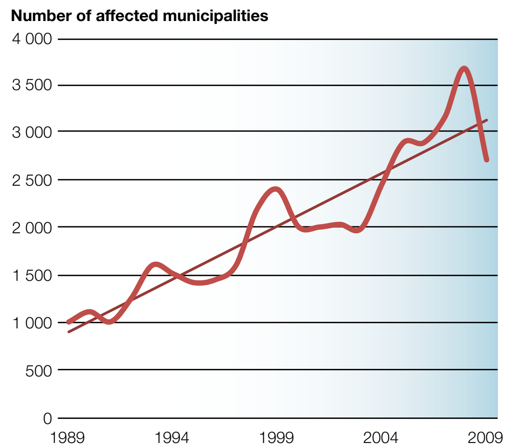

**Figure 2.25 (left)**

Number of houses damaged per million people per year (using all 22 datasets)

**Figure 2.26 (right)**

Number of local administrative areas annually reporting extensive disaster losses




and 2009, than between 1989 and 1999 (Figure 2.27).

### 2.3.3 Mortality is still rising in the countries with the weakest risk governance capacities

These global trends in risk vary widely from country to country, indicating that risk accumulation processes that mirror development are as heterogeneous as development itself. However, confirming again the findings of Section 2.2, countries with stronger risk governance capacities appear better able to reduce mortality than to reduce the numbers of houses damaged and people affected (Table 2.7). The increase in extensive mortality risk reported in countries

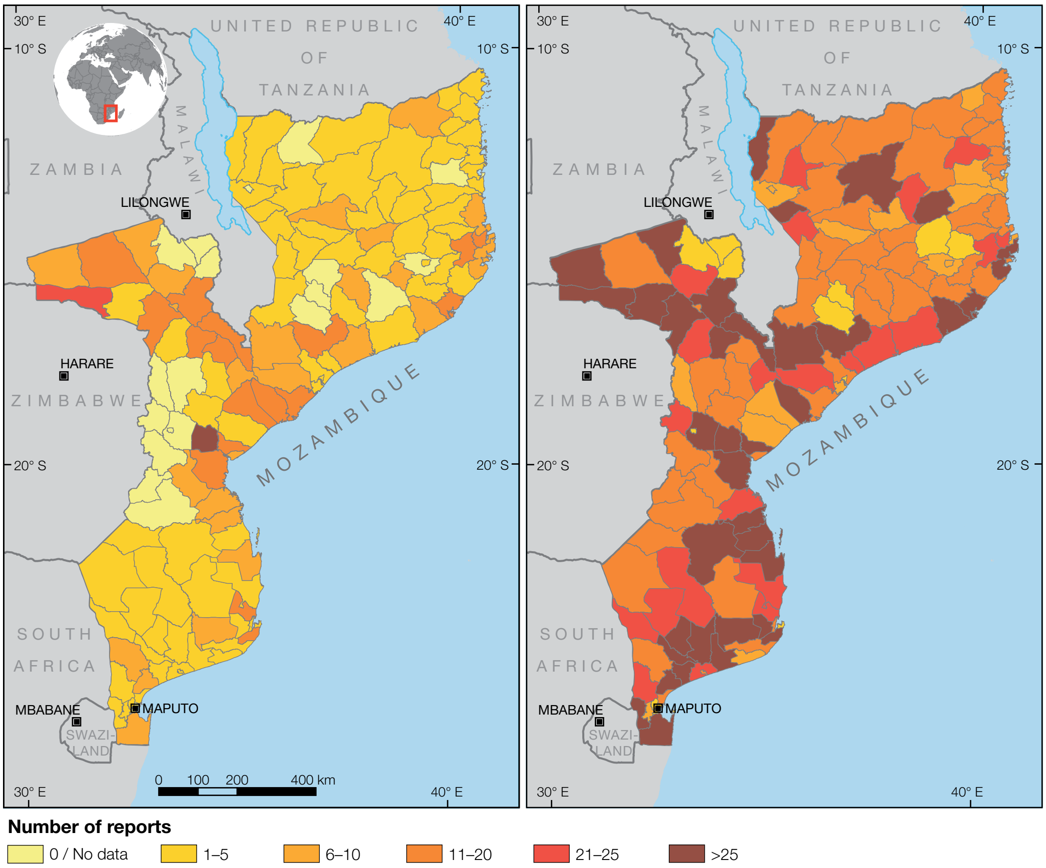



**Figure 2.27**
Spatial extent of extensive risk in Mozambique: number of reports per district, 1989–1999 and 1999–2009

*(Source: INGC, 2010)*

like Bolivia, Mozambique, Nepal and Yemen reflect low levels of development. In contrast, mortality risk in Chile and Costa Rica is falling while the rate of housing damage is rising. The heterogeneous nature of risk is further illustrated in Box 2.6, which explains that even in the world's largest economy, the United States of America, there are major differences in risk governance capacities among wealthier and poorer states and counties.

## 2.3.4 Revisiting the underlying risk drivers

Improved reporting of disaster impacts and losses makes it difficult to determine with precision the cause of any increase in reports of disaster impacts and losses over time, even in the last 20 years. In the case of national disaster databases, there is certainly evidence of improved reporting in some countries such as Costa Rica and Sri Lanka, where new official data sources began to contribute to the datasets during the GAR11 analysis period. Nevertheless, improved reporting alone does not appear to explain the increase in damaged housing, for example, across the 21 countries and states used in the GAR11 analysis.

New case study evidence supports GAR09's finding that increasing extensive risk is closely related to the challenges low- and middle-income countries face in addressing underlying risk drivers and reducing vulnerability. Risk is increasing most rapidly in small- and medium-sized urban centres with relatively weak capacities for managing urban growth (Table 2.8). Compounding this, landslide and flood risk at the local level is closely associated with poverty, and overall risk is magnified by deforestation and the destruction of coastal ecosystems.

Table 2.7 Extensive risk trends: houses damaged, people affected and mortality

| Country (or state) | Average annual change in housing damage rate, 1989–2009 | | Average annual change in number of people affected, 1989–2009 | | Average annual change in mortality rate, 1989–2009 | | Risk governance capacity |
|---|---|---|---|---|---|---|---|
| | Annual change | Trend | Annual change | Trend | Annual change | Trend | Ranking |
| Chile | 33.3 | ↑ | 2154.7 | ↑ | -0.0846 | ↘ | 39 |
| Costa Rica | 40.1 | ↑ | 40.6 | → | -0.1054 | ↓ | 51 |
| Argentina | 1.9 | → | -111.0 | ↘ | 0.1123 | ↗ | 56 |
| Jordan | -0.6 | → | 34.3 | → | -0.1093 | ↘ | 62 |
| Panama | 56.2 | ↑ | 414.5 | ↗ | -0.0569 | ↘ | 74 |
| Colombia | 79.9 | ↑ | 734.8 | ↗ | -0.0372 | → | 75 |
| Mexico | 99.1 | ↑ | 1262.3 | ↑ | 0.0697 | ↗ | 80 |
| Sri Lanka | 30.4 | ↑ | 2428.3 | ↑ | 0.1375 | ↗ | 98 |
| Ecuador | 12.3 | ↗ | -318.3 | ↘ | -0.2104 | ↓ | 105 |
| Peru | -3.8 | ↘ | 163.9 | ↗ | -0.0529 | ↘ | 107 |
| Indonesia | 9.9 | ↗ | 744.5 | ↗ | 0.0771 | ↗ | 109 |
| El Salvador | 50.4 | ↑ | 332.6 | ↗ | 0.4370 | ↑ | 110 |
| Iran (Islamic Republic of) | -0.3 | → | -74.0 | → | -0.0257 | → | 111 |
| Syria | 0.3 | → | 326.6 | ↗ | 0.3042 | ↑ | 112 |
| India (Orissa) | 117.19 | ↑ | 6892.1 | ↗ | 0.6544 | ↑ | 114 |
| India (Tamil Nadu) | 25.6 | ↑ | 671.5 | ↗ | 0.0864 | ↑ | 114 |
| Venezuela | 9.7 | ↗ | 485.9 | ↗ | -0.0033 | → | 117 |
| Guatemala | 23.6 | ↗ | 857.6 | ↗ | 0.1144 | ↗ | 118 |
| Bolivia | 3.9 | ↗ | -16.3 | → | 0.1912 | ↑ | 126 |
| Nepal | -0.3 | → | -145.7 | ↘ | 0.2804 | ↑ | 146 |
| Mozambique | 10.7 | ↗ | 4977.6 | ↑ | 0.2914 | ↑ | 153 |
| Yemen | -0.3 | → | 3.4 | ↗ | 0.2190 | ↑ | 169 |

↑ High increase ↗ Moderate increase → Stable ↘ Moderate decrease ↓ High decrease

*(Source: GAR11's 22 disaster loss databases; Lavell et al., 2010)*

## 2.4 Impacts on children and internal displacement

Children make up a large proportion of those who are most vulnerable to disasters, and they are affected particularly severely when they occur. Disasters can also contribute heavily to internal displacement, even when mortality is relatively low.

The mechanisms through which disaster losses contribute to poverty were explored in depth in GAR09 (UNISDR, 2009). This year's report expands on the different and specific disaster impacts that affect child welfare and development.

Children are affected particularly severely by disasters and constitute an extremely large percentage of those who are most vulnerable (Bartlett, 2008). This is supported by a number of studies on how disasters affect children's medium-term development (Baez and Santos,

## Box 2.6 Extensive risk in the United States of America

Anyone looking for a safe place to live in the United States of America should consider moving to Prince of Wales – Outer Ketchikan County in Alaska, the only county that does not report disaster losses in the SHELDUS database.[18] SHELDUS contains more than 640,000 local level disaster loss reports in the United States of America for the period 1960–2009 (Borden and Cutter, 2008) and provides a unique look at extensive risk in a high-income country.

Unlike low- and middle-income-countries, mortality due to disasters in the United States of America is extensively distributed. Most (89 percent) of the mortality since 1960 corresponds to extensive disasters (Figure 2.28). SHELDUS records 26,936 deaths between 1960 and 2008 compared with 18,273 in the Emergency Events Database (EM-DAT). In contrast, two-thirds of the economic loss is intensively concentrated in only 0.4 percent of the reports.

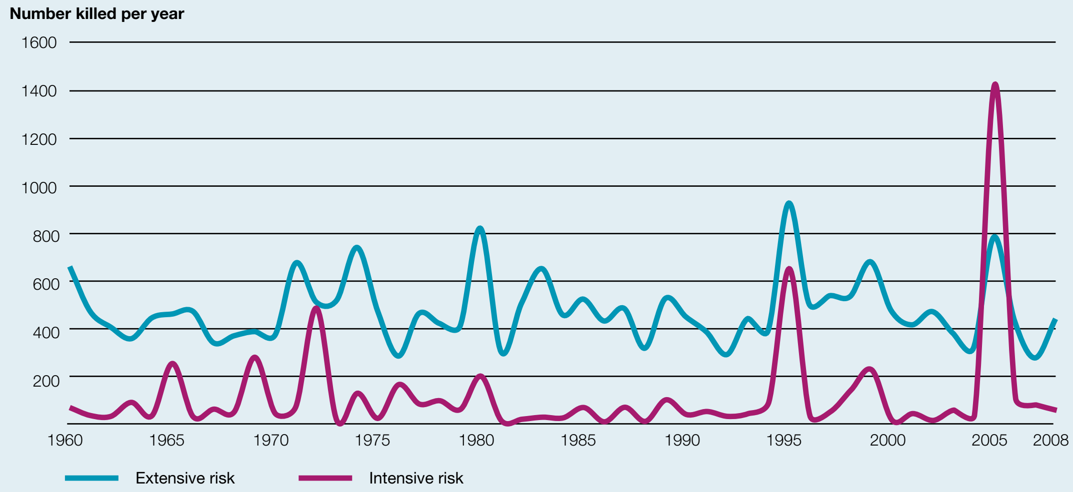
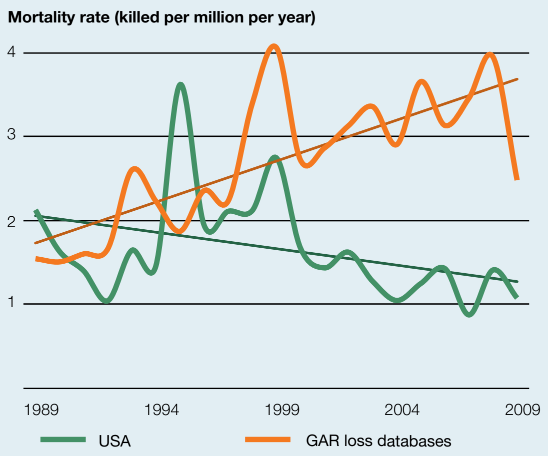



**Figure 2.28**
Extensive and intensive mortality in the USA

Figure 2.29 shows that, compared with the other countries in the data universe, mortality in extensive disasters in the United States of America is falling. Figure 2.30, however, shows that even when normalized by GDP per capita, economic loss is rising.



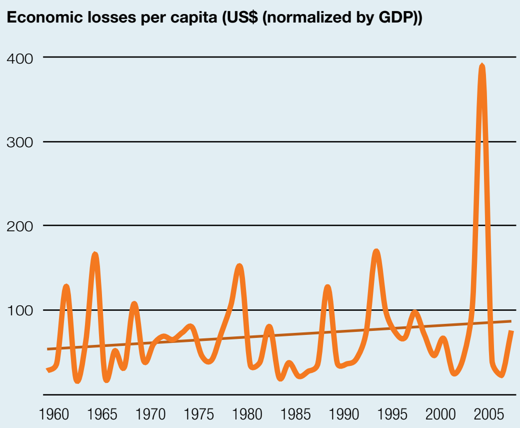



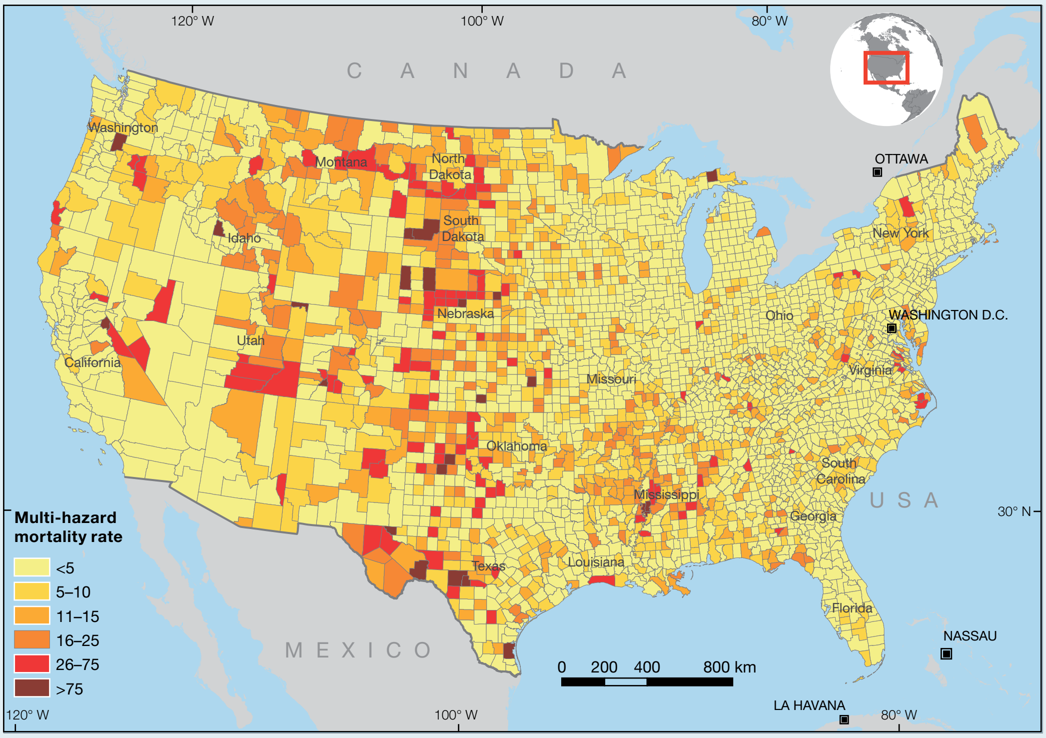

**Figure 2.29 (left)**
Mortality per capita per year in extensive disasters: United States of America compared with Africa, Asia, Latin America and the Middle East

**Figure 2.30 (right)**
Economic loss per capita, normalized by GDP

The highest extensive risk mortality rates are strongly associated with a wide geographical corridor that stretches from the north to the southwest of the United States of America, through the states of North and South Dakota, Nebraska, Kansas, Oklahoma and Arkansas (Figure 2.31).

**Figure 2.31**

Multi-hazard crude mortality rate (accumulated mortality per million per year) per county, United States of America, 1960–2009

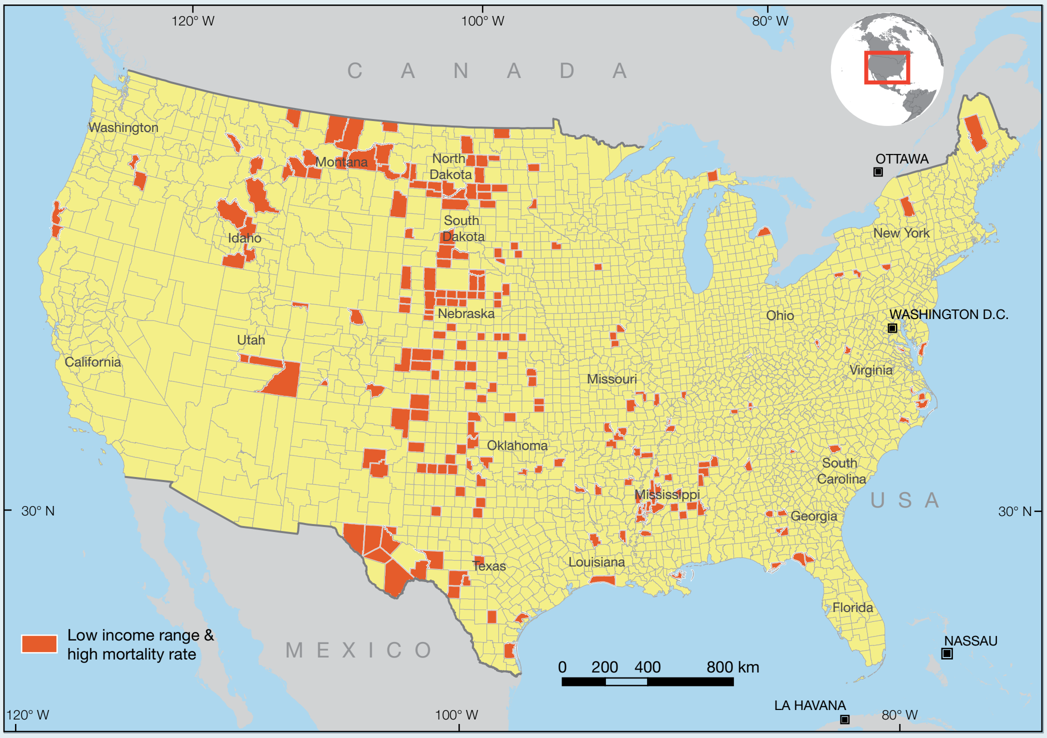



*(Sources: mortality rates from SHELDUS (without Hurricane Katrina); population year (2006) from the US Census Bureau)*

As Figure 2.32 shows, 220 out of the 302 counties (73 percent) with annual mortality rates greater than 15 per million had average annual household incomes of less than US$40,000. Many are sparsely populated counties in the north-to-southwest corridor mentioned above.

**Figure 2.32**

Counties with low average annual income and high mortality rates, United States of America, 1960–2009




*(Sources: income and population (2006) from the US Census Bureau; loss data from SHELDUS. Mortality due to Hurricane Katrina not included)*

*(Source: Serje, 2010a)*

Table 2.8 Risk drivers and disaster outcomes

| Risk driver | Outcome |
|---|---|
| **Badly planned and managed urban development**<br>Disaster risk may be increasing faster in rapidly growing small- and medium-sized urban centres than in either rural areas or larger cities. Compared with small and medium urban centres, large urban centres and megacities generally have stronger risk governance and investment capacities along with slower growth, both of which facilitate planning and urban management. | **Latin America**<br>In most Latin American countries, the number of disasters reported in small and medium urban areas is increasing at a faster rate than in large urban centres and megacities (Mansilla, 2010).[19] More than 80 percent of all reports of disaster loss in Latin America occur in urban areas. Although each country has a different urban structure, 40–70 percent of all nationally reported disasters occur in urban centres of less than 100,000 inhabitants, and 14–36 percent in small urban centres. This proportion is growing. In Mexico for example, small and medium urban centres accounted for 45.5 percent of total municipal disaster loss reports in the 1980s, and 54 percent since 2000. |
| | **Colombia**<br>In Colombia, municipalities with the most rapidly growing urban population between 1995 and 2005 were also more likely to experience more disasters and have higher numbers of houses damaged (Serje, 2010b). |
| **Ecosystem decline**<br>Deforestation in tropical areas is a critical global driver of climate change. It also has important and often negative local feedbacks, leading to increases in mean temperatures and decreases in mean precipitation.<br><br>Coastal ecosystems, including coral reefs, sea grasses, mangroves and other beach vegetation, play a key role in mitigating impacts of storm surges and coastal flooding. Unfortunately, coastal ecosystems in many areas are in decline, simultaneously increasing disaster risk while threatening the sustainability of local economies. | **Peru**<br>In the Peruvian Amazon, deforestation at least partly explains why some watersheds experience greater disaster loss and damage as a result of floods and landslides than others. To establish this link, satellite images in selected watersheds of the upper Amazon were analysed to determine the rate of conversion of forest into agricultural land and other uses between 1986 and 1998. Statistical correlations suggest that those watersheds with the highest rates of deforestation are likely to experience greater disaster mortality and housing damage (Serje, 2010b; Tonini et al., 2010). Note, however, that the clear link between deforestation and disaster loss does not mean that deforestation causes the loss directly. Deforestation usually occurs in areas with an expanding agricultural frontier and growing small urban centres, and other factors including increasing hazard severity, exposure and vulnerability, also shape risk. |
| | **Jamaica**<br>In Negril, Jamaica, up to 55 metres of beach depth has been lost in some areas as a consequence of the degradation of coral reefs, the removal of sea grass meadows, the loss of mangroves, and increasing urban and agricultural pollution. Coral reefs, for example, provide ecosystem services that include shoreline protection, supply of beach material, tourism revenue and local fishing. In Negril, coral reefs have been degraded in numerous ways: damage inflicted by major storms (such as Hurricane Ivan in 2004); coral bleaching through increased sea temperatures; pollution from sewage and agricultural run-off causing algal growth that suffocates coral; invasive predators such as lion fish; and destructive fishing practices. Mangroves protect beaches and shorelines by dissipating near-shore waves and play a vital role as a breeding habitat for fish and shellfish, but they have been harvested for firewood and building materials. Sea grass meadows are also a significant natural source of beach material but are in decline mainly because of removal by the tourism industry. Other coastal ecosystems suffering degradation include wetlands and forests. This degradation of coastal ecosystems has increased storm surge risk in Negril. A 1-in-50-year hurricane has the potential to produce storm waves of almost 7 metres, affecting around 2,500 local residents, more than 60 hotels and their guests, and water and sanitation infrastructure (UNEP, 2010). |

| Poverty | Indonesia |
|---|---|
| Within countries, poorer areas tend to have higher disaster risk, illustrating the complex interactions between poverty and disaster risk analysed in detail in GAR09 (UNISDR, 2009). | In Indonesia, mortality risk from landslides is higher in areas with low levels of human development and higher levels of poverty. Detailed information on hazard factors, population exposure and a range of socioeconomic indicators was used to build a landslide risk model with a sub-national level of resolution, calibrated with disaster loss data from the recently developed DIBI information system (see Box 2.5). Landslide mortality risk correlated positively with physical exposure and the Human Poverty Index, and negatively with the Human Development Index. Poverty explained a significant proportion of the variance in landslide risk between provinces (Cepeda et al., 2010). The poorer the province the greater the risk, and vice versa. |
| | **Colombia** |
| | A similar modelling exercise in Colombia showed that those municipalities with a greater proportion of unsatisfied basic needs and lower GDP per capita were more likely to see more people affected and more houses damaged during floods (OSSO, 2011b). |

2007; López-Calva and Ortiz-Juárez, 2009; Rodriguez-Oreggia et al., 2010). For example, destroyed or damaged schools together with the loss of household assets and livelihoods can force children out of school, and infant malnutrition caused by loss of food supplies may cause stunting and lead to poor educational achievement and greater propensity to disease.

Recent studies conducted in Bolivia, Indonesia, Mexico, Mozambique, Nepal, the Philippines and Viet Nam provide evidence of how extensive disasters negatively affect children's education, health and access to services such as water and sanitation, though it was difficult to establish significant relationships between intensive disasters and child welfare (Tarazona and Gallegos, 2010; Seballos and Tanner, 2011). Given the importance of primary education for human and long-term economic development, these findings should serve as a warning to governments.

In areas in Bolivia that experienced the greatest incidence of extensive disasters, the gender gap in primary education achievement widened, pre-school enrolment rates decreased and dropout rates increased. Equivalent areas in Nepal and Viet Nam saw, respectively, reduced primary enrolment rates and a drop in the total number of children in primary education. Extensive disasters also led to an increased incidence of diarrhoea in children under five years of age in Bolivia, an increased proportion of malnourished children under three in Nepal, an increased infant mortality rate in Viet Nam, and an increase in the incidence of babies born with low birth weight in Mozambique. This study also found evidence of negative impacts in terms of access to water and sanitation in Mexico and Viet Nam. These impacts indicate a need for greater consideration of children's vulnerability (Box 2.7).

Disasters also contribute to internal displacement (Box 2.8). Hazards such as floods, although causing relatively low mortality, destroy many houses and hence cause considerable displacement. Between 1970 and 2009 in Colombia, for example, 24 of the country's 35 disaster loss reports detailed floods that killed fewer than 10 people but destroyed more than 500 houses (IDMC, 2010). In total, around 26,500 houses were destroyed, potentially displacing more than 130,000 people. In the Indian state of Orissa, 265 floods with similar low mortality rates destroyed more than half a million houses.

Intensive disasters also lead to large-scale internal displacement. Pakistan's 2010 floods have to date left an estimated 6 million people in need of shelter; India's 2008 floods uprooted roughly 6 million people; Hurricane Katrina displaced more than half a million people in the United States of America; and Cyclone Nargis uprooted eight hundred thousand people in Myanmar and South Asia (IDMC, 2010).

## Box 2.7 Child-centred approaches to dealing with climate stresses and extreme events

A number of estimates suggest that at least 66.5 million children are affected by disasters annually (Penrose and Takaki, 2006; Bartlett, 2008; Costello, 2009; Sanchez et al., 2009). Addressing high child mortality rates as well as the significant psychological impacts of disasters on children requires new approaches that recognize the role of children as agents of change. On the one hand, these approaches should include child-sensitive policy and programming, where existing social protection, school feeding programmes and structural strengthening of school buildings all contribute to child welfare. On the other hand, they extend to participatory DRM policy and programming in which children and young people are actively engaged in decision-making and accountability processes. These usually have the benefit of improving communication and integrated planning within communities, and increasingly serve to promote effective preparation and prevention.

Engaging children in DRM remains constrained by lack of finance, skills and knowledge. This hampers both the processes and delivery of risk management and the engagement of children in planning and decision-making. Also, perceptions of children as passive, subordinate and unable to participate hinder them from actively voicing their risk perceptions, needs and potential.

There are examples of how an enabling policy environment can help change this. In the Philippines, the Strategic National Action Plan and the Local Government Code provide a policy environment in which decentralization of disaster risk management responsibilities opens up opportunities for child-centred initiatives. Sangguniang Kabataan are youth councils that are directly involved in decision-making at village level and are represented at municipal, provincial and national levels. However, it is political will and local capacities above and beyond these supporting policies that facilitate child-centred participatory DRM. With external support and guidance, youth groups have made good progress in changing attitudes and providing opportunities for participatory DRM.

*(Source: Seballos and Tanner, 2011)*

## Box 2.8 Floods and internal displacement in Tumaco, Colombia

On 16 February 2009, the Mira and Telembí rivers in Nariño, Colombia, flooded four municipalities on the Pacific Coast: Tumaco, Barbacoas, Roberto Payán and Magüí Payán. Two people were killed, with a further 20 reported missing, but 1,125 houses as well as schools, health centres, and roads were destroyed. The government declared a municipal emergency on 23 February in Tumaco, but there was no international appeal for relief.

Based on the number of houses destroyed, there were an estimated 5,625 displaced people. However, the actual number recorded by the authorities was more than 25,000, of whom 14,000 were forced into shelters, with the remainder staying with friends and families.

One reason for the discrepancy may be that people whose houses were damaged (but not destroyed) were nevertheless displaced during the peak of the flood. Around 1,400 houses were damaged by the floods, likely generating another 8,000 displaced people. In addition, the number of displaced may include those who evacuated during the floods as a preventive measure, and who most likely returned after a few days or weeks. The number of destroyed houses is therefore more likely to be a better indicator for long-term displacement than for short-term displacement during emergencies.

*(Source: IDMC, 2010)*

Assuming a family size of five in the 21 countries and states included in the GAR11 analysis, the destruction of 5.9 million houses in intensive disasters between 1970 and 2009 would have displaced almost 30 million people. Although extensive disasters account for less than one-fifth (19 percent) of destroyed housing, this implies an additional 7.5 million displaced people, who are typically less visible than those displaced in intensive disasters subject to large-scale international humanitarian assistance.

## 2.5 Emerging risks

Countries are faced with a range of emerging risks associated with extremely low-probability hazards such as volcanic eruptions or extreme space weather, and new patterns of vulnerability associated with the growing complexity and interdependency of the technological systems on which modern societies depend, including: energy, telecommunications, finance and banking, transport, water and sanitation. These new vulnerabilities multiply disaster risks and can trigger cascading and concatenated system breakdowns at different scales which are difficult to model, but which can exponentially magnify impacts.

### 2.5.1 Volcanic eruptions affecting the global weather system

The eruption of Huaytaputina in 1600 showed that the mid-latitudes of the northern hemisphere can experience slight winter warming and marked summer cooling due to the spread of volcanic ash and gas from the tropics by global air circulation patterns (Pyle, 1998). Of the more than 550 active volcanoes in the world, 154 erupted between 1990 and 1999 (Siebert and Simkin, 2011), and the direct risks associated with these can be estimated. In Europe, for example, there is US$87 billion of exposed value at risk to the 10 volcanoes that potentially affect population centres of at least 10,000 inhabitants (Spence et al., 2009). Despite a 30 percent probability of an eruption occurring in the 21st century the size of that of Tambora (Indonesia) in 1815 (Sparks, 2010), it remains a challenge to calculate or quantify the human or economic risks arising from volcanic eruptions affecting the global weather system.

### 2.5.2 Extreme space weather

Geomagnetic storms represent another low-probability, sequential risk whose impacts are difficult to measure. These storms are characterized by severe disturbances of the upper atmosphere and near-Earth space environment, caused by the magnetic activity of the sun. Such disturbances have always occurred but are a growing hazard for modern societies and the global economy, which are increasingly dependent on interconnected electric power grids and telecommunications and other systems affected by these disturbances. For example, Canada's Hydro-Quebec power grid collapsed during a geomagnetic storm in March 1989, leaving millions of people without electricity for up to nine hours (National Research Council, 2008).

Although the probability of such blackouts is low, the potential for cascading impacts in vulnerable systems that depend on power grids is increasingly high, such as banking and finance, government services, transport and communications, and drinking water. The evolving connectedness and interdependency of these systems increases the probability of joint failures and means that the real risk is difficult to calculate and quantify, and is often underestimated. The 1859 Carrington super storm was the most spectacular geomagnetic storm in recent history but occurred in a world without interdependent networks and systems. If a similar storm were to occur today, the increased vulnerability could lead to unprecedented impacts.

## 2.5.3 Unexpected climate extremes

Two recent cyclones, a Category 2 storm that struck Santa Catarina province in Brazil in 2004 and Cyclone Gonu, which made landfall in Oman and the Persian Gulf in 2007, occurred in locations that had never in recorded history experienced storms of such magnitude (Figure 2.33). Contemporary populations have been unprepared for such extremes as the 2003 European heat wave or the 2010 Russian forest fires, which expose emerging or hidden vulnerabilities.

Global climate change may generate climate extremes for which there may be no historic precedent. Although it is still not possible to attribute the cause of individual events such as these to climate change, stochastic modelling can provide governments with insights into possible scenarios (ECA, 2009).

## 2.5.4 Interactions between physical and technological hazards

On 11 March 2011, Japan declared an 'atomic power emergency' when a devastating earthquake and tsunami damaged the Fukushima Daiichi Nuclear Power Station and caused a radioactive leak (Wald, 2011). This synchronous failure is posing major challenges to Japan, but its impacts are already being felt globally, in capital markets and in the nuclear energy industry.

Other such difficult-to-quantify risks are associated with major fires at industrial and petrochemical facilities. In addition to the effects of explosion and fire, such disasters may include the release of toxic gases. The red sludge from a burst bauxite storage reservoir in October 2010 near the Hungarian town of Ajka is one example of the consequences of poorly managed storage of highly toxic industrial and mining waste. Nine people were killed and more than 7,000 affected by the million cubic metres of spilled toxic sludge, and the full environmental and economic damage are not yet known (EM-DAT, 2011c).

Many similar chemical storage sites are also located in areas prone to other physical hazards. The remnants of the Soviet nuclear arms industry in Central Asia, for example, are located in an area prone to earthquakes, floods and landslides (Figure 2.34) (Sevcik, 2003;

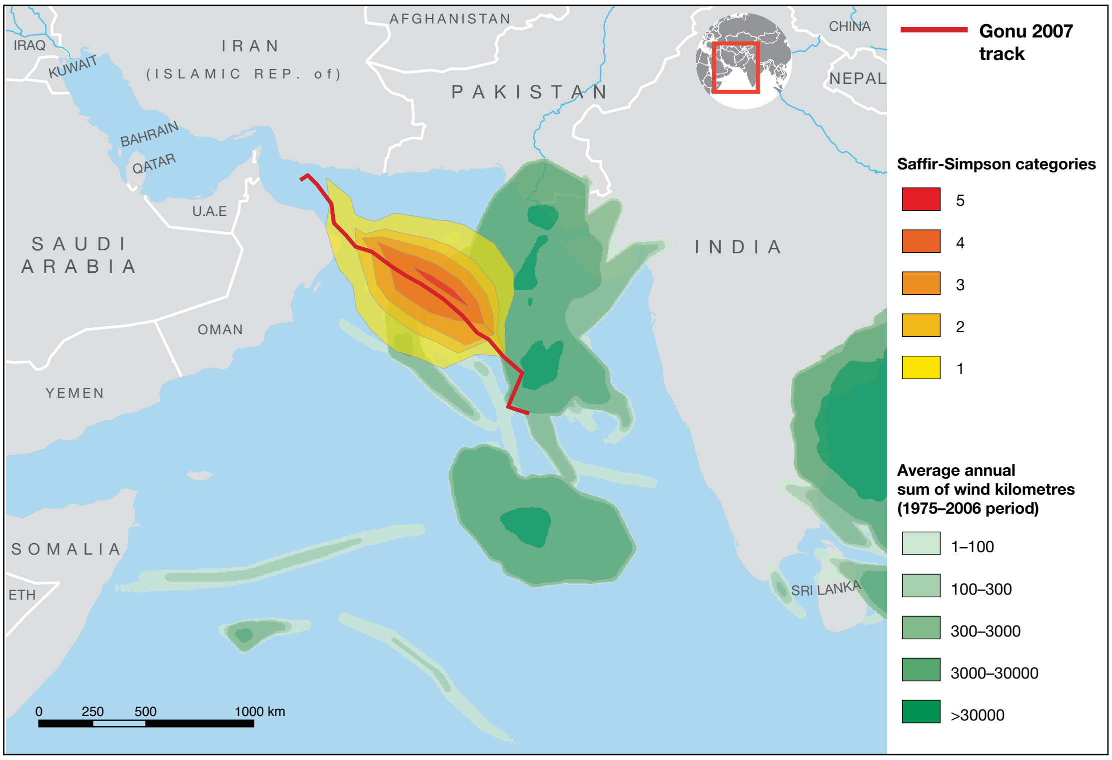
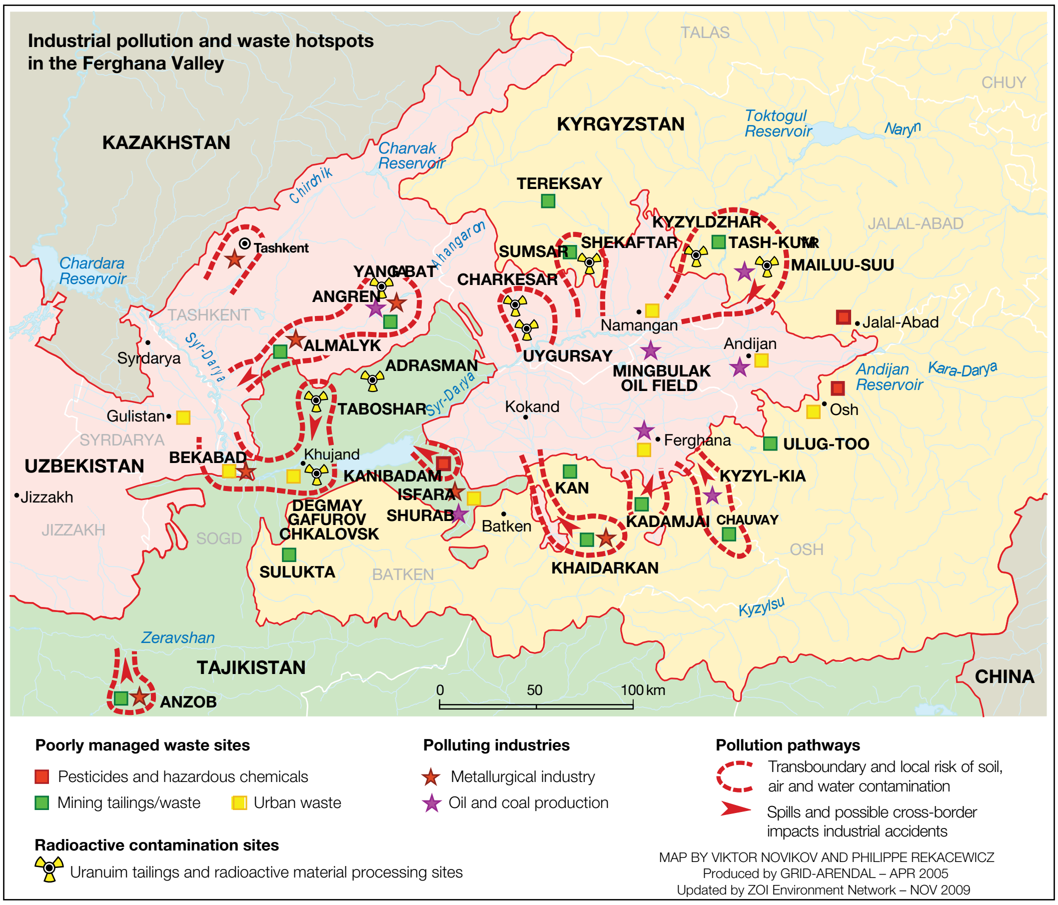



**Figure 2.33**
The track of Cyclone Gonu (2007)

Hobbs, 2010). Kyrgyzstan and Tajikistan are both subject to earthquakes, landslides and flooding that could magnify an already high risk of contamination (Sevcik, 2003; Hobbs, 2010). The compound risks posed by the proximity of nuclear tailings to natural hazards in Central Asia are particularly severe, but they are not unique. Mining and toxic-waste storage occurs in hazard-prone areas in many other countries, often without adequate risk identification or risk management. If such activities are initiated in countries with weak risk governance capacities, these compound risks will only increase.

**Figure 2.34**

Industrial pollution and waste hotspots in the Ferghana Valley, an area prone to earthquakes, landslides and flooding




*(Source: UNEP-GRID, 2011)*

## Notes

1 The low mortality in Sidr does not imply that the next severe cyclone to hit Bangladesh will have similar impacts. Although encouraging, one success story is not sufficient to prove that mortality risk has been definitively reduced.

2 Since the launch of GAR09, the number of tropical cyclones analysed has increased from 2,510 to more than 4,100, and an additional seven years of data have been included (1970–2009). For GAR09, cyclone risk was analysed only up to 300 km inland. Following expert review this limit has been removed. The algorithm for calculating average cyclone frequencies has also been improved and a new method for country level aggregation introduced. As a consequence tropical cyclone exposure has been calcualted differently in GAR11 compared with GAR09. The GAR11 flood analysis has also been improved and includes data from the hydroshed model for Canada, Mexico and the United States of America, which was not available for GAR09.

3 Norwegian Geotechnical Institute, Expert group meeting Earthquake Hazard and Risk Modelling Workshop, 12–13 October 2009, Oslo, Norway.

4 It is important to note that geographic regions may disguise strong inter-regional differences. For example, the fact that China and Pacific Islands such as Nauru and Vanuatu are part of East Asia and the Pacific does not mean that they are experiencing similar processes of risk construction. For World Bank income and geographic regions, see www.data.worldbank.org/country.

5 This is the number of countries affected by cyclones that make landfall. One cyclone can affect several countries, but many tropical cyclones never make landfall and are thus not included.

6 Small islands by definition often do not have 'remote rural areas' but still can have high mortality risk.
7 This analysis focuses on major river basin flooding (in watersheds with an area greater than 1,000 $km^2$). It does not include urban flooding, coastal flooding, flash floods or glacial lake outburst floods (GLOFs), or flooding on small islands. Nor does it take into account the damages caused by winds during floods, which can be substantial in some cases.
8 A completely new tropical cyclone dataset based on newly available data (from IBTrACS, NOAA) was used for this analysis (Peduzzi et al., 2011), improving upon on the analysis from GAR09.
9 The other high-income economies (OHIE) region is not included in this and the related tables and figures because of the limited number of countries modelled for floods and cyclones in this category.
10 Possibly due to climate change and warmer sea temperatures, but possibly also because of changes in recording instruments and methods (Landsea et al., 2006). With only short data series it is impossible to confirm if this is a longer-term trend.
11 Tropical cyclone exposure (approximately 100,000 people in 2000–2009) in the Russian Far East has been included in the EAP region.
12 In constant 2000 US$.
13 The analysis of tropical cyclone exposure does not include other high-income economy (OHIE) countries due to limited exposure, which is insufficient for robust modelling.
14 Expected impacts of climate change were studied considering three factors: expected reduction in agricultural productivity, rise in sea level, and scarcity of fresh water. Almost all countries with high or very high vulnerability, food insecurity and extreme trade limitations were expected to suffer severe reductions in agricultural productivity. All Small Island Developing States would be severely affected by sea-level rise and almost all African countries would be strongly affected by water scarcity, coastal flooding and other extreme weather-related events.
15 El Niño is a phenomenon in the equatorial Pacific Ocean characterized by a positive sea surface temperature departure from normal (for the 1971–2000 base period) greater than or equal in magnitude to 0.5 degrees Celsius, averaged over three consecutive months. La Niña is phenomenon in the same region characterized by a negative sea surface temperature departure from normal greater than or equal in magnitude to 0.5 degrees Celsius, averaged over three consecutive months (NOAA, 2003).
16 A statement released by the municipal authorities of Escazu highlights these issues (Segura et al., 2010).
17 Argentina, Bolivia, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, India (Orissa and Tamil Nadu), Indonesia, Iran (Islamic Republic of), Jordan, Mexico, Mozambique, Nepal, Peru, Panama, Sri Lanka, Syrian Arab Republic, Venezuela and Yemen.
18 SHELDUS uses different attributes to the other disaster loss databases analysed in GAR11, and contains data on mortality and economic losses at the county level in all 50 states in the United States of America, but does not record other attributes such as housing damage and destruction. Data for this case study were drawn from the Spatial Hazard Events and Losses Database for the United States, Version 8.0. Hazards and Vulnerability Research Institute (2010). Columbia, University of South Carolina, www.sheldus.org.
19 Small urban centres are defined as those with populations of 10,000 to 19,999; medium urban centres 20,000 to 99,999; large urban centres 100,000 to 999,999 and megacities greater than 1 million.