

## Chapter 2

# INTERNATIONAL PATTERNS OF RISK

In order to improve understanding of the relationship between development and disaster risk at the global level, UNDP has begun development of a Disaster Risk Index (DRI).

The pilot DRI, presented in this Report, enables the measurement and comparison of relative levels of physical exposure to hazard, vulnerability and risk between countries. It also enables the identification of vulnerability indicators that point to development processes contributing to the configuration of disaster risk.

One objective of the DRI is to demonstrate the ways in which development contributes to the configuration of risk and vulnerability. Another objective is to provide quantitative evidence to advocate for the reorientation of development policy and planning in a way that contributes to the management and reduction of disaster risk.

In its present form, the DRI has been developed with a global level of observation and a national level of resolution, allowing comparison between countries with respect to three hazard types (earthquakes, tropical cyclones and floods).

These three hazards are together associated with approximately 39 percent of deaths in large- and medium-scale natural disasters at the global level. A DRI covering droughts and famines, which account for 55 percent of global deaths in large- and medium-scale natural disasters, was also developed. However, the development of the drought DRI revealed a series of unresolved methodological and conceptual challenges, which imply that its results do not yet have the required degree of confidence. Nevertheless, the exploration of these challenges in itself provides important insights into drought risk and vulnerability.

Work was also undertaken to develop a multi-hazard DRI that combined the results of the individual indices on earthquakes, tropical cyclones, floods and droughts. Given the challenges in modelling drought risk mentioned above, and taking into account the fact that drought and famine contribute more than half of global disaster deaths, we have considered it prudent not to present the multi-hazard DRI at this stage.

The DRI is a mortality-calibrated index. In other words, it measures the risk of death in disaster. Disaster mortality is only one facet of overall disaster loss and often is not the most significant. The choice of mortality was guided principally by global data availability and it is recognised that as such, the DRI provides only a partial picture of risk. Mortality is the most accurate type of data available for making international comparisons of disaster loss. It serves to open an agenda of analysis on the links between disaster and development. There is much potential for future work to investigate other indicators of impact, such as livelihood sustainability.

The development of the DRI has been guided both by the use of a conceptual model that seeks to explain physical exposure, vulnerability and risk as well as by the availability of global datasets of a suitable quality. This first version of the DRI represents only a first approximation towards applying the conceptual model on the basis of available global data. It is expected that through continually reviewing the process based on greater data availability and further refinements to the conceptual model, it will be possible to improve the DRI in the future.

This chapter is split into three main sections.

**Section One** presents the Disaster Risk Index (DRI). This section first presents a methodological overview and then DRI findings for the three hazard types included in this first index: earthquakes, tropical cyclones and floods.

**Section Two** drills down into the geography of risk and illustrates — with examples from Central America, South Asia and Africa — the complexity of hazard, vulnerability and risk patterns at the sub-national level.

**Section Three** discusses four recommendations for the future development of the DRI. Firstly, the need

to improve data collection on disaster impact at all levels, but particularly at the sub-national level. Secondly, the need to progressively incorporate new variables into the index, through a learning process that will gradually improve its accuracy and usefulness. Thirdly, the need to measure the progress of policies targeted at disaster risk reduction, allowing the consideration of efforts made to reduce disaster risks as an indicator in the index. Fourthly, the need for the development of national level DRI — key to mainstreaming the overall recommendations of this Report into national development policy, planning and practice.

## 2.1 Global Risk Factors: The Disaster Risk Index

### 2.1.1 What is the DRI ?

The DRI enables the calculation of the average risk of death per country in large- and medium-scale disasters associated with earthquakes, tropical cyclones and floods, based on data from 1980 to 2000. It also enables the identification of a number of socio-economic and environmental variables that are correlated with risk to death and which may point to causal processes of disaster risk.

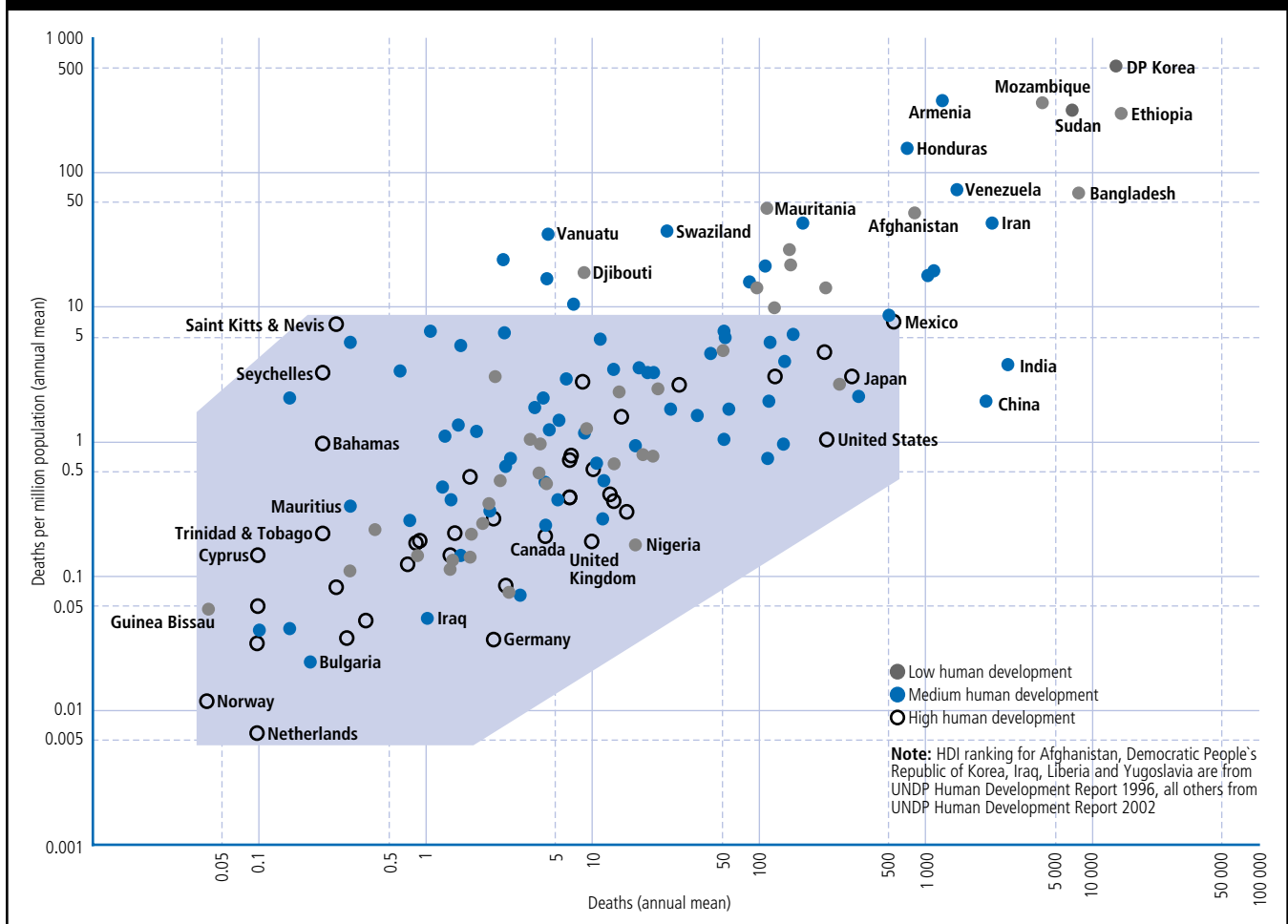
In the DRI, countries are indexed for each hazard type according to their degree of physical exposure, their degree of relative vulnerability and their degree of risk.

### 2.1.2 The conceptual model

Underlying the DRI is the concept that disaster risk is not caused by hazardous events per se, but rather is historically constructed through human activities and processes. As such the risk of death in a disaster is only partially dependent on the presence of physical phenomenon such as earthquakes, tropical cyclones and floods. In the DRI, risk refers exclusively to the risk of loss of life and excludes other facets of risk, such as risk to livelihood and to the economy. This is because of a lack of datasets available at the global scale with national resolution.

For an extreme physical event to be hazardous, by definition there has to be a subject to experience the hazard or the threat. For example, people, infrastructure and economic activities have to be located in an area where earthquakes occur. In the DRI, this relationship

FIGURE 2.1 DEVELOPMENT STATUS AND DISASTER DEATHS



Source: EM-DAT OFDA/CRED International Disaster Database

is expressed through the concept of *physical exposure*, referring to the number of people located in areas where hazardous events occur combined with the frequency of hazard events. Physical exposure is not an indicator of vulnerability, but is a condition *sine qua non* for disaster risk to exist. Without people exposed to hazardous events, there is no risk to human life.

Clearly however, greater physical exposure leads to greater loss of life. Assuming no change in other developmental conditions, a fivefold increase in the population living in a given flood plain would lead to a fivefold increase in mortality due to floods. Very high physical exposure in many countries reflects the concentration of population in hazard prone areas, itself a characteristic of the development process.

Physical exposure, however, is insufficient to explain risk. Countries with similar levels of physical exposure to a given hazard experience have widely differing levels of risk.

#### BOX 2.1 DEVELOPMENT STATUS AND DISASTER IMPACT

Figure 2.1 reveals that losses from natural disaster are tied to national development status.

While low and medium human development countries have similar loss patterns, some high human development countries occupy the bottom left-hand part of the graph. This indicates low numbers of deaths associated with natural disaster. No high human development country has recorded more than 10 deaths per million population as an annual average using data collected from 1980-2000, nor more than 600 deaths as an average in any one year. Both figures are exceeded by numerous medium and low human development countries.

This observation reinforces intuitive views about the disaster-development relationship, as discussed in Chapter 1. The aim of the DRI as presented in this chapter is to move beyond the surface view and begin a systematic examination of available data on disaster risk.

*Vulnerability* is the concept that explains why, with a given level of physical exposure, people are more or less at risk. In theory, vulnerability is modified by coping capacity and adaptive capacity. In the DRI,

coping and adaptation are assumed to have been active in shaping recorded risk. Vulnerability brings together all these elements of human process in a single concept.

In the DRI, vulnerability refers to the different variables that make people less able to absorb the impact and recover from a hazard event. These may be economic (such as lack of reserves or low asset levels); social (such as the absence of social support mechanisms or weak social organisation); technical (such as poorly constructed, unsafe housing); and environmental (such as the fragility of ecosystems).<sup>1</sup>

The way vulnerability is used in the DRI means that it *also* includes variables that may increase the severity, frequency, extension and unpredictability of a hazard. For example, deforestation may increase flood and landslide hazard in some contexts and destruction of coastal mangroves may increase cyclone hazard. Thus, those development activities that influence hazard as well as those that influence human vulnerability are represented in the DRI as vulnerability.<sup>2</sup>

Included in the *vulnerability* index of the DRI are also those factors that may decrease vulnerability, such as appropriate development and urban planning, and specific actions to mitigate disaster losses, such as disaster preparedness and early warning systems.

In the DRI, it is assumed that the factors that make people vulnerable to earthquakes are not necessarily the same as those that make people vulnerable to floods or cyclones. Each corresponds to particular configurations of development activities. Due to the hazard specificity of people's vulnerability, it is not conceptually possible to arrive at a global multi-hazard indicator of vulnerability. Rather the vulnerability indicators suggested by the DRI are always hazard specific.

### 2.1.3 The development of the DRI

The key steps involved in producing the DRI were:

#### *Calculation of physical exposure*

The DRI identified the areas exposed to each of the four hazard types (earthquakes, tropical cyclones, floods and droughts) and the population living in these areas to arrive at a calculation of *physical exposure* for each country. This is the average number of people exposed to a hazard event in a given year. Physical exposure for each hazard was mapped in a Geographical Information System. Physical exposure varies both

according to the number of people as well as to the frequency of hazard events. In the DRI, physical exposure is expressed both in absolute terms (the number of people exposed in a country) and in relative terms (the number exposed per million people).

#### *Calculation of relative vulnerability*

The risk of death in a natural disaster is a function of physical exposure to a hazardous event and vulnerability to the hazard. People are more or less vulnerable to a given hazard depending on a range of social, economic, cultural, political and physical variables. The DRI has used the number of people actually killed by each hazard type in each country as a proxy for *manifest risk*. In other words, the occurrence of past disasters manifests, by definition, the existence of conditions of physical exposure and vulnerability.

The DRI, therefore, was able to calculate the relative vulnerability of a country to a given hazard by dividing the number of people killed by the number exposed. When more people are killed with respect to the number exposed, the relative vulnerability to the hazard in question is higher.

#### *Calculation of vulnerability indicators*

The DRI then examined the manifest risk for each hazard type against a bundle of social, economic and environmental indicators through a statistical analysis using a multiple logarithmic regression model. A total of 26 variables selected through expert opinion were available as global datasets and analysed for each hazard type. This enabled the selection of those vulnerability indicators that were most associated with risk for each hazard type.

A detailed description of the data sets used and the operations performed on the data is provided in the Technical Annex.

### 2.1.4 Limitations to the DRI

In order to understand the results of the DRI, identify the possible uses of these results and above all to avoid the very real risk of misrepresentation and misuse of the results, it is important to critically and explicitly discuss a number of key limits with respect to the data used and the analysis presented.

#### *The DRI represents the risk of death*

Disasters affect people's lives and livelihoods in many ways. Depending on the type of hazard, houses may

be damaged or destroyed, crops may be lost and land may be eroded or washed away. Social infrastructure such as schools, hospitals and community centres may be destroyed, economic activities may be directly or indirectly affected, family members may suffer from illness or injury and be unable to work or study, and lives may be lost. Therefore, the risk of mortality is only one aspect of disaster risk. Many disasters cause enormous social and economic impact without serious mortality. This is particularly so for slow-onset disasters associated with drought.

The use of deaths as a proxy for manifest risk, therefore, strictly limits the analysis of disaster risk to human development. Deaths do not capture human development losses and can only point to comparative orders of magnitude in vulnerability and loss. An economic outcome of disaster risk should complement the current approach based on human losses. Not only are disaster risk trends in industrialised countries not addressed when using mortality calibrated models, but the different economic impacts among different types of hazards skew disaster risk trends within least developed countries.

In the DRI, mortality was chosen as a proxy indicator for disaster risk because reliable data on other aspects of disaster risk (people affected, economic impact) is not available in global level disaster databases. The DRI used the EM-DAT database (see Technical Annex), the only global disaster database in the public domain. While mortality is an indicator of broader risk to human development, the DRI only represents risk to loss of life and cannot be inferred to represent other physical, social and economic aspects of risk.

#### *The DRI examines risks associated with large- and medium-scale disasters*

Disaster risk can be represented as a continuum from, at one extreme, the risk from everyday hazards (such as contaminated water supplies, poor sanitation, house fires and dangerous working and living environments) to, at the other extreme, the risk associated with infrequent catastrophic hazard events, such as major earthquakes or cyclones that devastate entire countries and regions. In between these two extremes lie the risks associated with frequently occurring small-scale hazard events (such as highly localised landslides, flash floods and debris flows) and periodic medium-scale hazard events.

Publicly available global data on disaster impact is currently only available for large- and medium-scale disaster events, defined as those involving more than 10 deaths, 100 affected and/or a call for international assistance. As the DRI is based on this data, it does not represent risk associated with small-scale and everyday disasters. At the same time, a recent study undertaken for the ISDR Working Group 3 on Risk, Vulnerability and Impact Assessment, indicates that international reporting may not be capturing all the medium- scale disaster events that occur. Nevertheless, and taking into account these data limitations, we consider that for the purposes of an Index constructed with a global level of observation and a national level of resolution, the large- and medium-scale disasters captured in international databases represent a very good sample of overall disaster risk.

#### *The DRI represents risks associated with earthquakes, tropical cyclones and floods*

At the global level, and with respect to large- and medium-scale disasters, the three hazard types analysed in the DRI (plus drought, presented here as a work in progress) account for approximately 94 percent of total mortality. Nevertheless, in individual countries, other hazards may have an important local impact and are not considered in the DRI. For example: landslides, debris flows and fires.

At the same time, primary hazards may trigger a range of secondary hazard events. Earthquakes, for example, often provoke landslides and fires and tropical cyclones cause sea surges and flooding. The DRI only represents the *primary* hazard events as recorded in global disaster databases, even when in some cases the majority of loss may be associated with a range of different hazard types triggered by the primary event.

#### *The DRI represents disaster risk in the period 1980–2000*

The DRI has been calibrated using data from the period 1980–2000 because it was considered that access to information before that period was less reliable. This, however, weights the work in favour of countries that suffered catastrophic disaster events with large loss of life in the two decades under analysis and against countries that suffered such events in the 1970s, for example, but not since then.

At an early stage, volcanic eruptions were excluded from the DRI analysis because of the need to differentiate



locally between different types of volcanic hazard. Data for such a task exists and could be compiled into an international database.

### *The DRI tests vulnerability indicators from available global datasets*

The DRI has run statistical regression analysis comparing some 26 socio-economic and environmental variables with risk levels in order to identify possible indicators of vulnerability.

Clearly the variables that could be tested are those that were available in global datasets. This implies that there may be other variables that potentially might help build a better correlation with risk, but for which no global datasets were available at the time of production of the DRI. The choice of vulnerability indicators presented in the DRI, therefore, is limited by available data. It is hoped that in the future more direct indicators of national vulnerability might be available, for example, soil types or the proportion of earthquake resistant buildings per country for earthquake hazard.

The logarithmic base of the model can highlight long-term trends, but does not allow predictive casualties to be made. Small differences in the vulnerability indicator figures can mask major changes in disaster risk.

### *The DRI does not include indicators on disaster risk management and reduction*

In terms of assisting the advocacy purposes of the DRI, an ongoing aim is to generate a disaster risk reduction component. National change over time or comparison between countries operating alternative

risk management strategies can be used as an initial level of analysis of the comparative effectiveness of competing risk reduction strategies (including a do-nothing option). But a dedicated comparative index built up of components found to indicate risk reduction would be a clearer tool. Unfortunately, conceptual work remains to be done in identifying key indicators for multiple hazard types operating in a range of socio-political contexts.

## 2.2 Hazard Specific Risk Profiles

### 2.2.1 Earthquake hazard

A total of 158,551 deaths were associated with earthquakes around the world between 1980-2000 (see Figure 2.2).

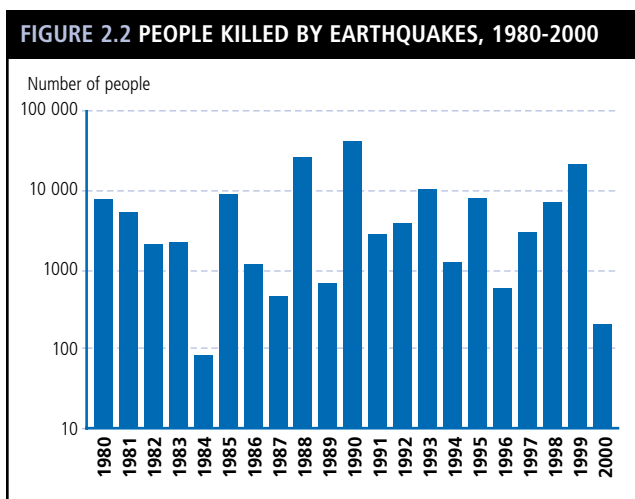
Iran has the highest toll of death for this period, with 47,267 people killed in earthquakes.

About 130 million people were found to be exposed on average every year to earthquake risk as the defined in this Report.

The left hand axis of Figure 2.3 shows the fifteen countries with the largest absolute populations exposed to earthquake hazard. Populous Asian states (Japan, Indonesia and the Philippines) top the list with the Americas (USA, Chile, Mexico), Turkey and India also included. The right hand axis displays the fifteen countries with the highest proportion of their populations exposed to earthquake hazard. Smaller island states (Vanuatu, Guam, Papua New Guinea) and Central American states (Nicaragua, Guatemala) top the list.

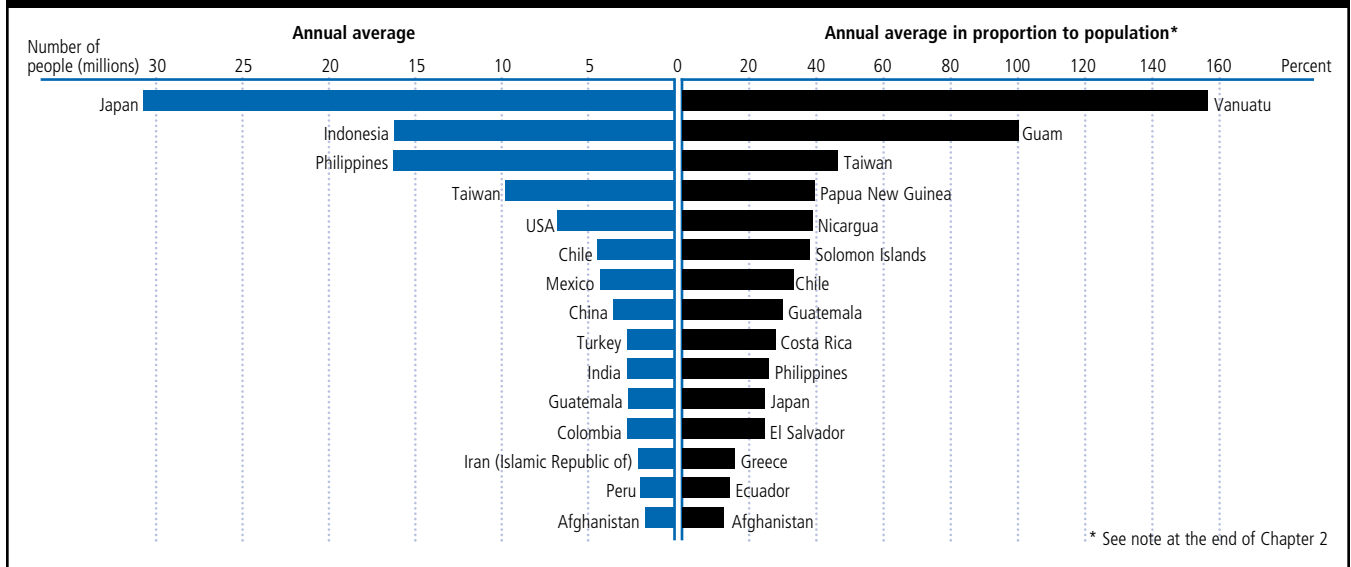
Comparing the size of exposed populations with the number of recorded deaths to earthquake hazard is used as a measure of relative vulnerability in Figure 2.4. Those states closest to the top left-hand corner of the graph show highest relative vulnerability.

The graph represents relative earthquake vulnerability between 1980 and 2000 only. Armenia stands out as being particularly vulnerable to earthquakes due to a single major catastrophic event that occurred during the reporting period. Similarly, earthquakes are rare in Guinea, however a significant event occurred in the reporting period. In contrast, Guatemala appears far less vulnerable because the catastrophic earthquake of



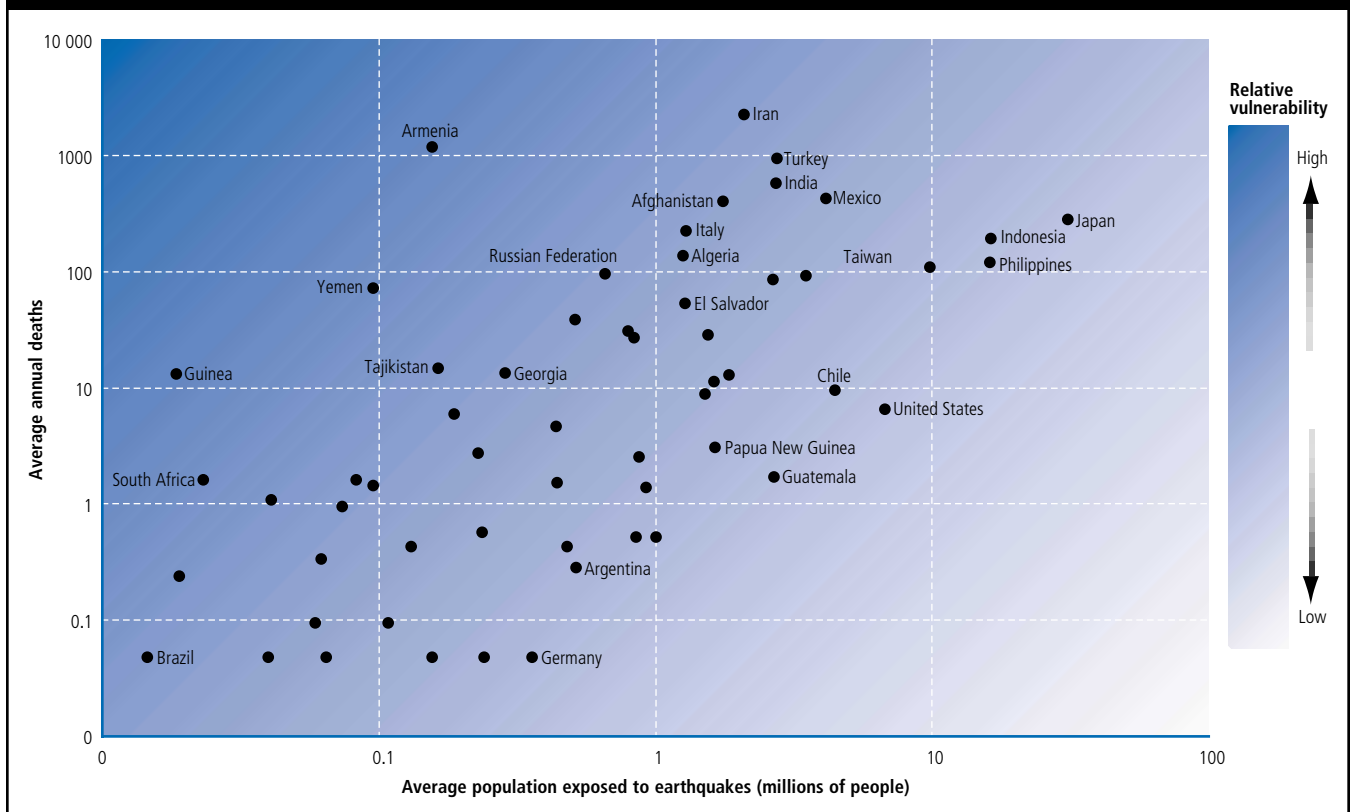
Source: The EM-DAT OFDA/CRED International Disaster Database

FIGURE 2.3 PHYSICAL EXPOSURE TO EARTHQUAKES, 1980–2000



Source: UNDP/BCPR; UNEP/GRID-Geneva

FIGURE 2.4 RELATIVE VULNERABILITY FOR EARTHQUAKES, 1980–2000



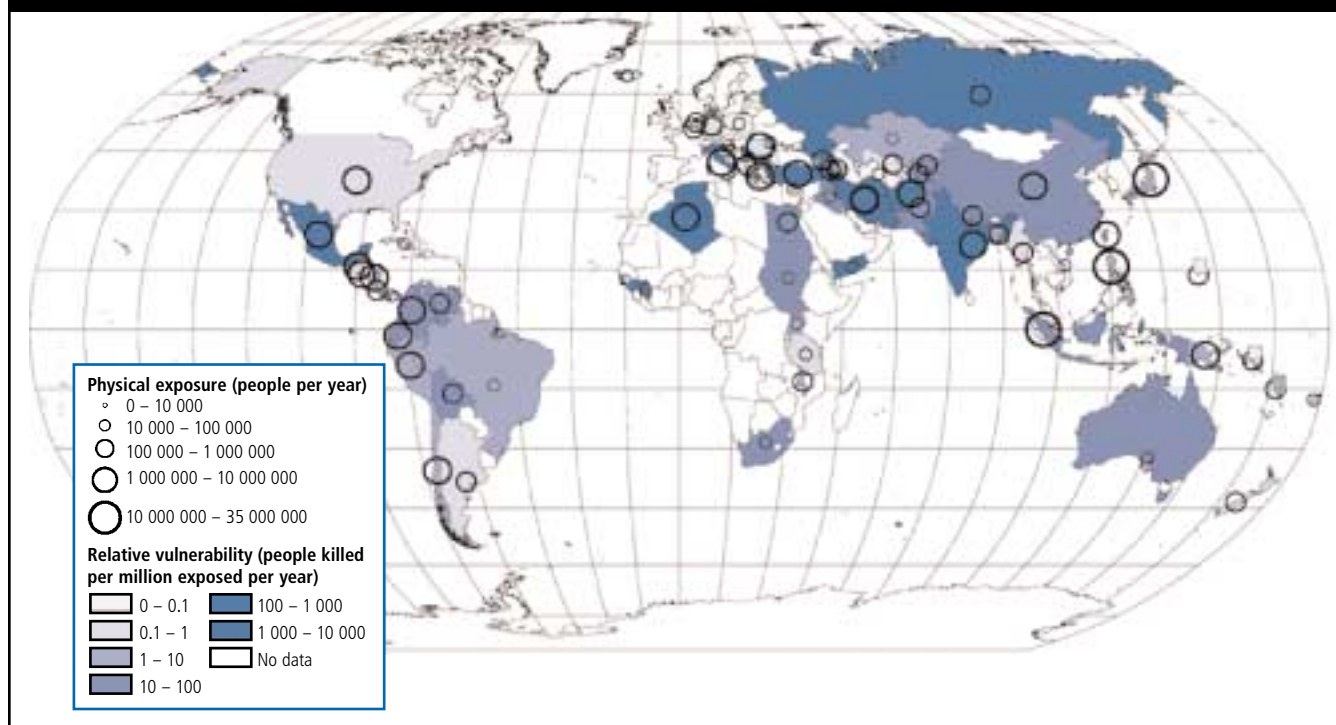
Source: The EM-DAT OFDA/CRED International Disaster Database and UNEP/GRID-Geneva

1976 occurred outside of the reporting period. China and Peru are other countries that experienced very high mortality in catastrophic earthquakes during the 1970s and therefore outside of the reporting period. The analysis, however, does show countries, such as the Islamic Republic of Iran, Afghanistan and India, which do experience frequent earthquakes suffering

proportionally far higher loss of life than others, such as Chile or the United States of America.

The tight fit of countries in Figure 2.4 along an axis from the bottom left to the top right-hand corner indicates intuitively a strong correlation between the number of deaths and physical exposure. In other words,

FIGURE 2.5 PHYSICAL EXPOSURE AND RELATIVE VULNERABILITY TO EARTHQUAKES, 1980–2000



Source: Université Catholique de Louvain: The EM-DAT The OFDA/CRED International Disaster Database (victims); Council of the National Seismic System (CNSS): Earthquake Catalog (earthquakes extent); CIESIN, IFPRI, WRI: Gridded Population of the World (GPW), Version 2 (population); Compilation and computation by UNEP/GRID-Geneva

the more people living in areas exposed to earthquake events, the higher the risk of death.

Regression analysis of vulnerability indicators showed that statistically, physical exposure and the rate of urban growth acted together in being associated with the risk of death to earthquake. In other words, the risk of dying in an earthquake was greater in countries with rapid urban growth.

Urban growth does not *explain* human vulnerability to earthquakes *per se*. Rather it is particular processes and factors of urban change that characterise rapidly urbanising countries that increase human vulnerability to earthquakes. These processes and factors will vary considerably from context to context. The earthquake disasters of Turkey in 1999 and Algeria in 2003 highlighted the lack of enforcement of building regulations as a key factor in generating physical vulnerability (see Box 3.1). A study of earthquake vulnerability in Lima, Peru showed that a process of deterioration and overcrowding of inner city rental housing was the key process associated with urban growth that was generating earthquake vulnerability.<sup>3</sup> In the 2001 Gujarat earthquake in India, it was non-earthquake resistant structures in both rural and urban housing that proved

to be a key vulnerability factor. In urban areas, the high density of dwellings increased fatalities.<sup>4</sup>

The fact that some countries with high urban growth rates have low relative vulnerability means that it is impossible to generalise. However, common to all the examples above is the fact that in many rapidly growing cities, earthquake risk considerations have not been factored into the building and planning process. In general, city governments have not been capable of regulating either building or settlement in a way that reduces risks. This is a key issue that will be explored in greater depth in Chapter 3.

A final representation of earthquake risk is shown in the World Map in Figure 2.5. Again, urban countries appear most at risk. (See the Appendix for data on individual countries.)

### 2.2.2 Tropical cyclone hazard

The term tropical cyclone used in this report includes tropical storms, hurricanes (alternatively termed typhoons, tropical cyclones or severe cyclonic storms), and super typhoons. Up to 119 million people were found to be exposed on average every year to tropical cyclone hazard and some people experienced an average



of more than four events every year. As a result, a total of 251,384 deaths have been associated with tropical cyclones worldwide, 1980-2000 (Figure 2.6). Bangladesh accounts for more than 60 percent of the registered deaths in this period while the Philippines show the highest frequency of tropical cyclones with reported deaths.

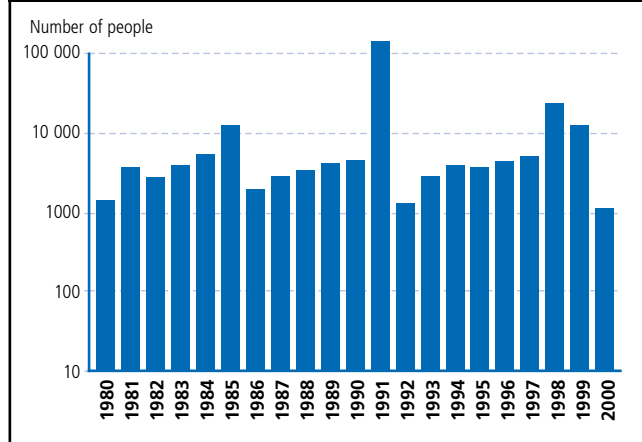
Hazard zones for tropical cyclones were based on data from the Carbon Dioxide Information Analysis (CDIAC) of the US government.

A total of 84 countries distributed over the tropics presented different levels of physical exposure to tropical cyclones (Figure 2.7). Those countries with the largest exposed populations have highly populated coastal areas and especially densely populated deltas (China, India, the Philippines, Japan, Bangladesh). Expressing exposure as a proportion of national population flagged island states and territories (Guam, the British Virgin Islands, Vanuatu, Mauritius) and the Philippines (a collection of islands).

Comparing the size of exposed populations with the number of recorded deaths to tropical cyclones is used as a measure of relative vulnerability to tropical cyclone death in Figure 2.8. Those states closest to the top left-hand corner of the graph show highest relative vulnerability.

A very large proportion of the population of Bangladesh is exposed to tropical cyclones, particularly the heavily

**FIGURE 2.6 PEOPLE KILLED BY TROPICAL CYCLONES, 1980-2000**



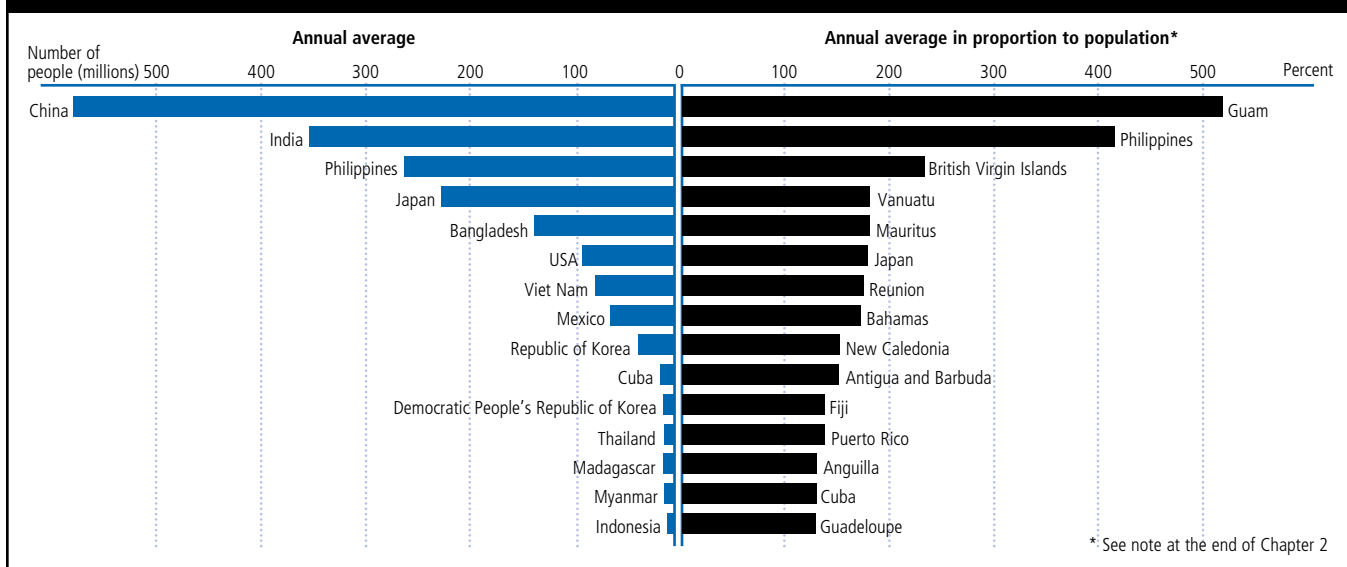
Source: The EM-DAT OFDA/CRED International Disaster Database

populated rural communities along the fertile delta at the confined head of the Bay of Bengal. The large number of recorded deaths shows that in this case high vulnerability accompanies high physical exposure.

Honduras and Nicaragua, while not among the countries with the highest physical exposure, appear as the most vulnerable countries in the period 1980-2000. This reflects the extraordinary magnitude and duration and the devastating human impact of Hurricane Mitch, which occurred in 1998.

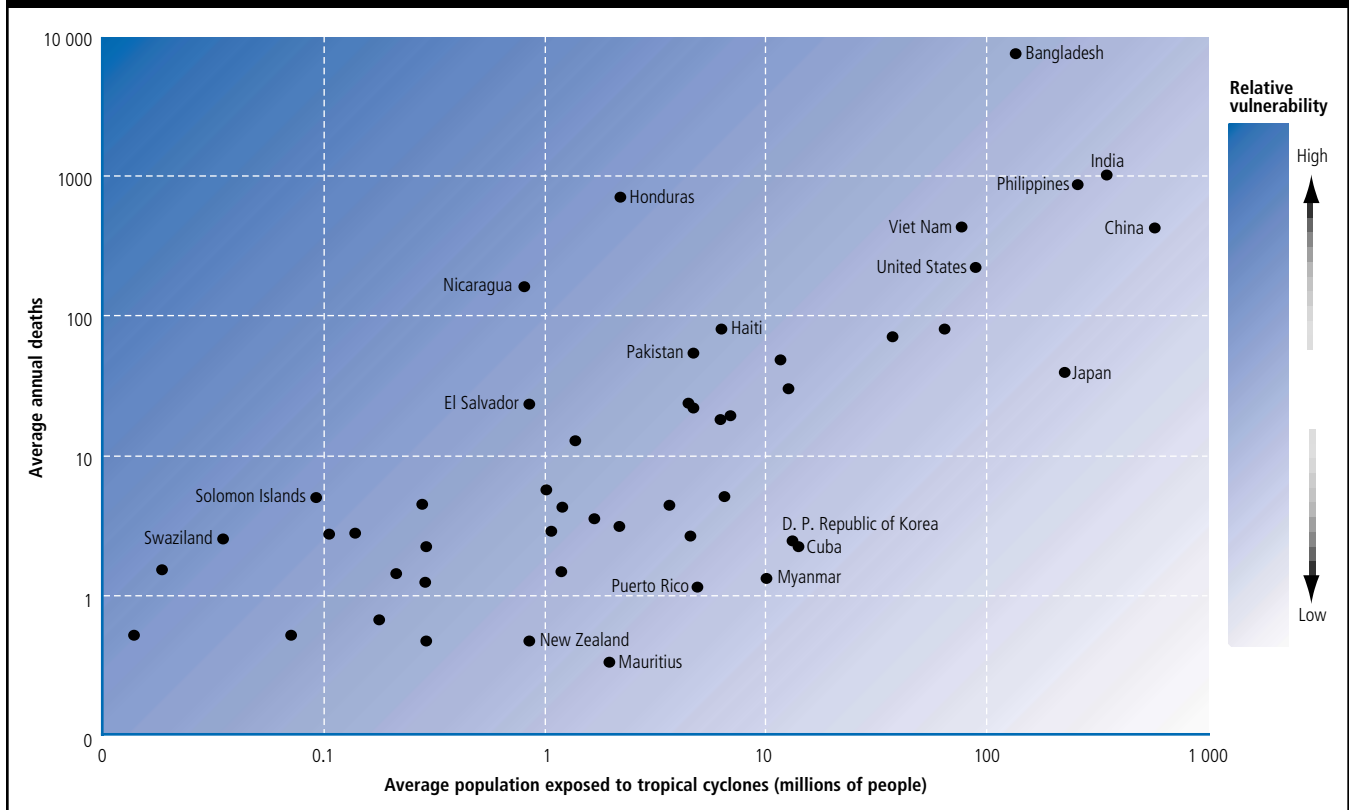
The complexity of the hazard events associated with tropical cyclones illustrates another of the limitations of the DRI model mentioned in section 2.1.2. Much

**FIGURE 2.7 PHYSICAL EXPOSURE TO TROPICAL CYCLONES, 1980-2000**



\* See note at the end of Chapter 2

Source: UNDP/BCPR; UNEP/GRID-Geneva

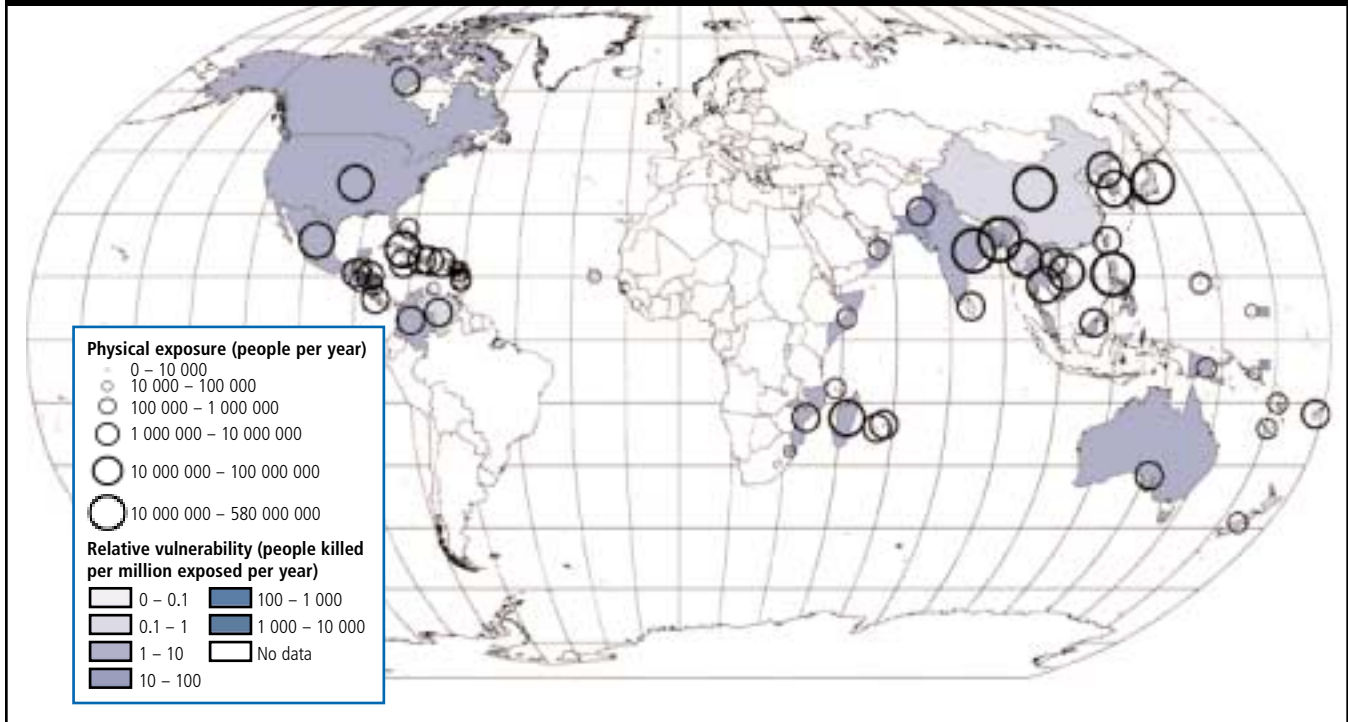
**FIGURE 2.8 RELATIVE VULNERABILITY FOR TROPICAL CYCLONES, 1980–2000**

Source: The EM-DAT OFDA/CRED International Disaster Database and UNEP/GRID-Geneva

**FIGURE 2.9 RELATIVE VULNERABILITY FOR TROPICAL CYCLONES IN SMALL ISLANDS, 1980–2000**

Source: The EM-DAT OFDA/CRED International Disaster Database and UNEP/GRID-Geneva

FIGURE 2.10 PHYSICAL EXPOSURE AND RELATIVE VULNERABILITY TO TROPICAL CYCLONES, 1980–2000



Source: Université Catholique de Louvain: The EM-DAT The OFDA/CRED International Disaster Database (victims); Carbon Dioxide Information Analysis Centre: A Global Geographic Information System Data Base of Storm Occurrence and Other Climatic Phenomena Affecting Coastal Zones (tropical cyclone frequency); CIESIN, IFPRI, WRI: Gridded Population of the World (GPW), Version 2 (population); Compilation and computation by UNEP/GRID-Geneva

of the impact of Hurricane Mitch in Honduras and Nicaragua was not due to hurricane force winds *per se*, but to the large number of floods, flash floods, landslides and debris flows triggered by the hurricane. The severity of these secondary hazard events was magnified by the effects of processes of environmental degradation that occurred over several decades. These were possibly aggravated in turn by the drought and fires associated with an ENSO (El Niño Southern Oscillation) event the previous year. All these hazard events coincided with a highly vulnerable population in both social and economic terms and weaknesses in early warning and disaster preparedness that led to large losses of life.

Figure 2.9 shows differences in relative vulnerability between Small Island Development States. Haiti is shown to have the highest relative vulnerability, perhaps linked to its small economy, degraded environment and weak institutions of governance. Cuba and Mauritius are the least vulnerable, despite both islands having relatively large proportions of their populations exposed to tropical cyclones. In both cases, though from contrasting political and policy orientations, resources have been made available for early warning, disaster preparedness and evacuation.

The positive results are evident.

Figure 2.9 also clearly illustrates the influence of human development status on risk. Haiti — the island state most at risk — has low human development, again contrasting with the higher human development countries of Cuba and Mauritius. This does not point to policy implications in itself, but does highlight the close link between development and disaster risk.

The regression analysis carried out for tropical cyclone risk showed a strong correlation between *physical exposure*, *percentage of arable land* and *Human Development Index* with observed risk. Countries with large, predominantly rural populations and with a low HDI rank will be most closely associated with tropical cyclone risk.

There are a number of reasons why this may be so. Rural housing in many countries will tend to be more vulnerable to high winds, flooding and landslides than urban housing and will generally be associated with higher mortality. Conversely, the weakness or non-existence of emergency and rescue services in rural areas of poor countries and lack of access to disaster preparedness and early warning are all other factors

that would help to explain mortality rates. The cyclone preparedness programme in Bangladesh is one of the few success stories in this area. By coupling cyclone shelters and community-based preparedness measures, the programme has managed to dramatically reduce vulnerability from the 1970s to the (still high) levels observed in the 1980–2000 reporting period. The relationship between rural livelihoods, vulnerability and disaster risk is a key issue for further discussion in Chapter 3.

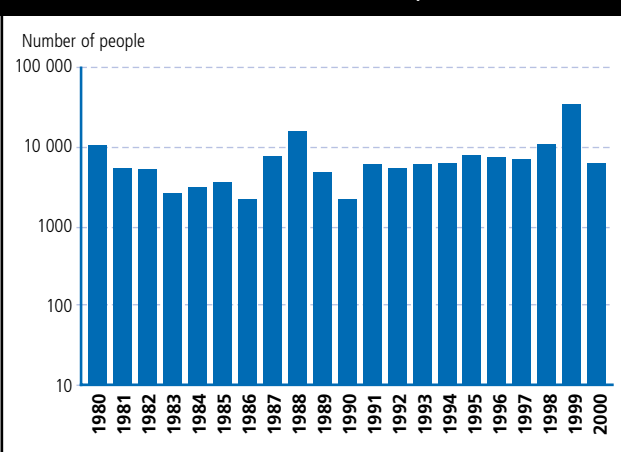
Figure 2.10 (see previous page) shows a World Map of physical exposure and relative vulnerability for tropical cyclones.

### 2.2.3 Flood hazard

About 196 million people in more than 90 countries were found to be exposed on average every year to catastrophic flooding. Some 170,010 deaths were associated with floods worldwide between 1980–2000 (see Figure 2.11).

The analysis of physical exposure to floods was weakened by the fact that no single global database was available. In addition, lack of information on duration and intensity of floods impeded the identification of different classes of flood hazard. In the absence of a worldwide floods database, floods registered on the EM-DAT database were used and mapped onto those watersheds where the flood occurred. The entire watershed was mapped as a flood prone area, despite

**FIGURE 2.11 PEOPLE KILLED BY FLOODS, 1980–2000**

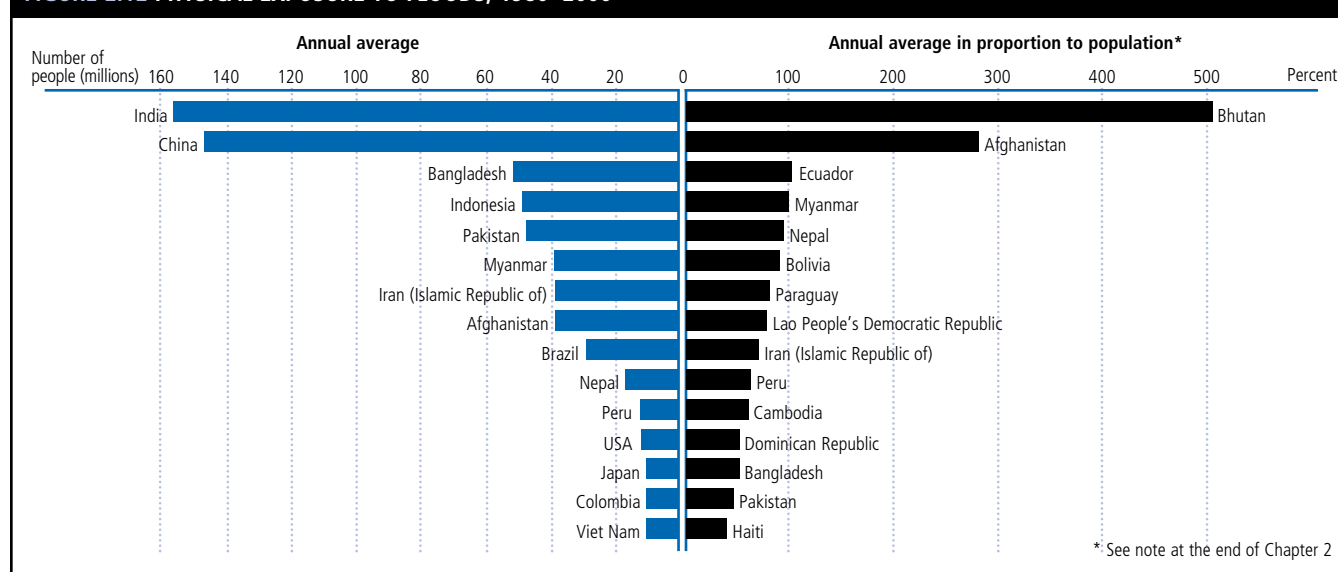


Source: The EM-DAT OFDA/CRED International Disaster Database

the fact that only a small area of the watershed was usually flooded. This means the number of people identified as being exposed to flooding in the DRI (Figure 2.12) is likely to be greater than numbers observed on the ground. As a consequence, losses calculated as a proportion of exposed populations (Figure 2.13) may appear smaller and the relative vulnerability lower than observed.

The geospatial analysis carried out for the calculation of human exposure identified 147 countries with populations exposed to floods. Figure 2.12 shows those states with the largest exposed populations. Populous South Asian countries (India, Bangladesh, Pakistan) and China figure strongly at the top of the list, as absolute population and population exposed as

**FIGURE 2.12 PHYSICAL EXPOSURE TO FLOODS, 1980–2000**



\* See note at the end of Chapter 2

Source: UNDP/BCPR; UNEP/GRID-Geneva

a proportion of national populations. This is tied to the large populations living in extensive river floodplains and low lying coasts in this world region. Less populous states with mountainous topography (Bhutan, Ecuador, Nepal), and Central American and Andean states are also flagged among those states as having large absolute and proportional populations exposed to flooding. While these countries are more mountainous than those in South Asia, they nevertheless contain many population centres located in river floodplains.

Comparing the size of exposed populations with the number of recorded deaths to flood events is used as a measure of relative vulnerability in Figure 2.13. Those states closest to the top left-hand corner of the graph show highest relative vulnerability.

As in the case of earthquake and tropical cyclone hazard, the calculation of human vulnerability to floods clearly illustrates some of the limitations to the DRI model that were outlined in 2.1.2.

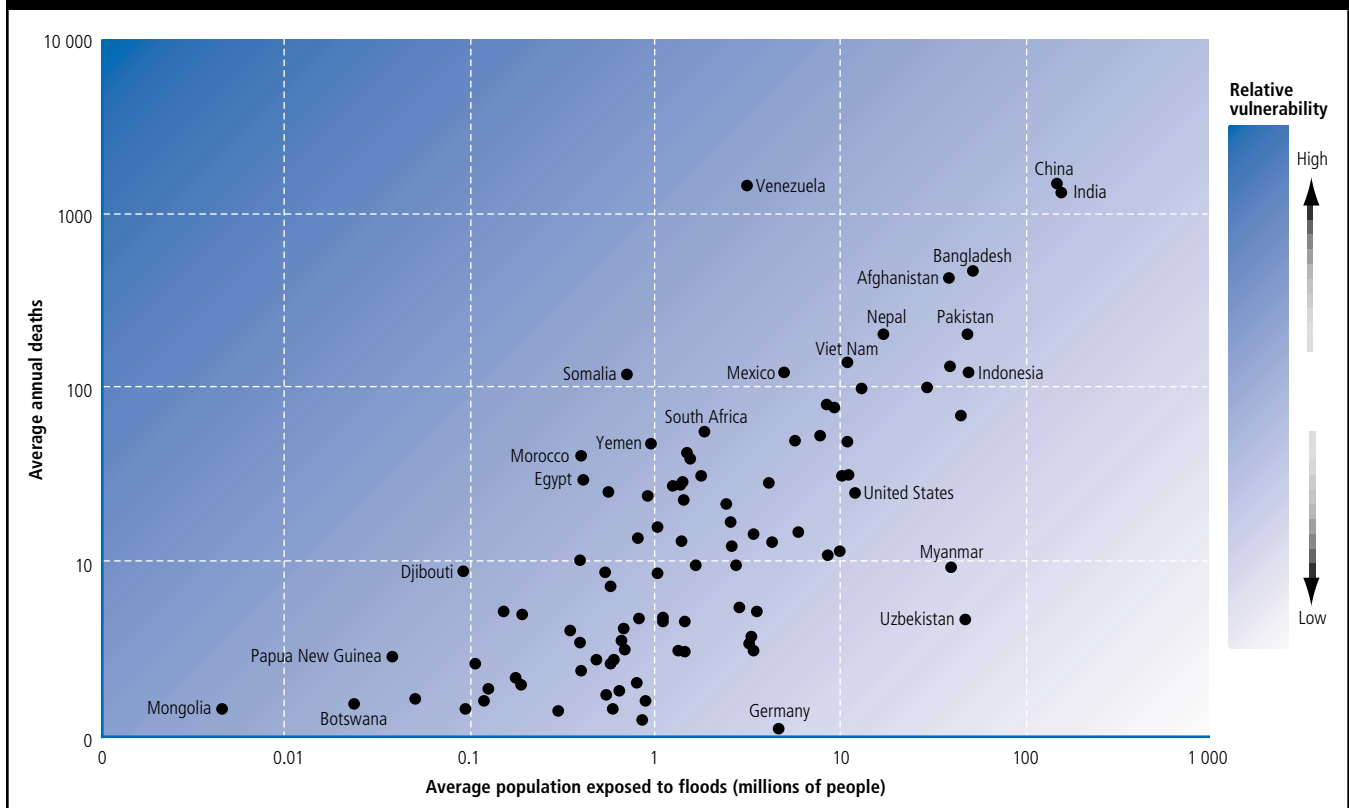
Venezuela appears to be the country with highest relative human vulnerability to flooding, based on

recorded lives lost to flood events. Again this is due to a single exceptional event occurring in 1999. At the same time, while the event was described generically as a flood in the EM-DAT database, a large proportion of the deaths were associated with debris flows in dense urban communities not located in floodplains.

At the same time, given the fact that whole watersheds were considered when calculating the population exposed, the ratio of killed-to-exposed people (relative vulnerability) does not have the same analytical power that it has for the other hazards, although this does not affect the DRI itself. Floods are made to appear less deadly than in reality. This may explain the positioning of Myanmar and Uzbekistan as countries with apparently low relative vulnerability. Care should be taken in drawing conclusions from this analysis, as it may be that exposed populations are exaggerated or deaths have not been picked up in the recording process.

Many flood events are highly localised in character and result in losses that are either below the threshold required to be registered in EM-DAT database or are simply not recorded internationally.

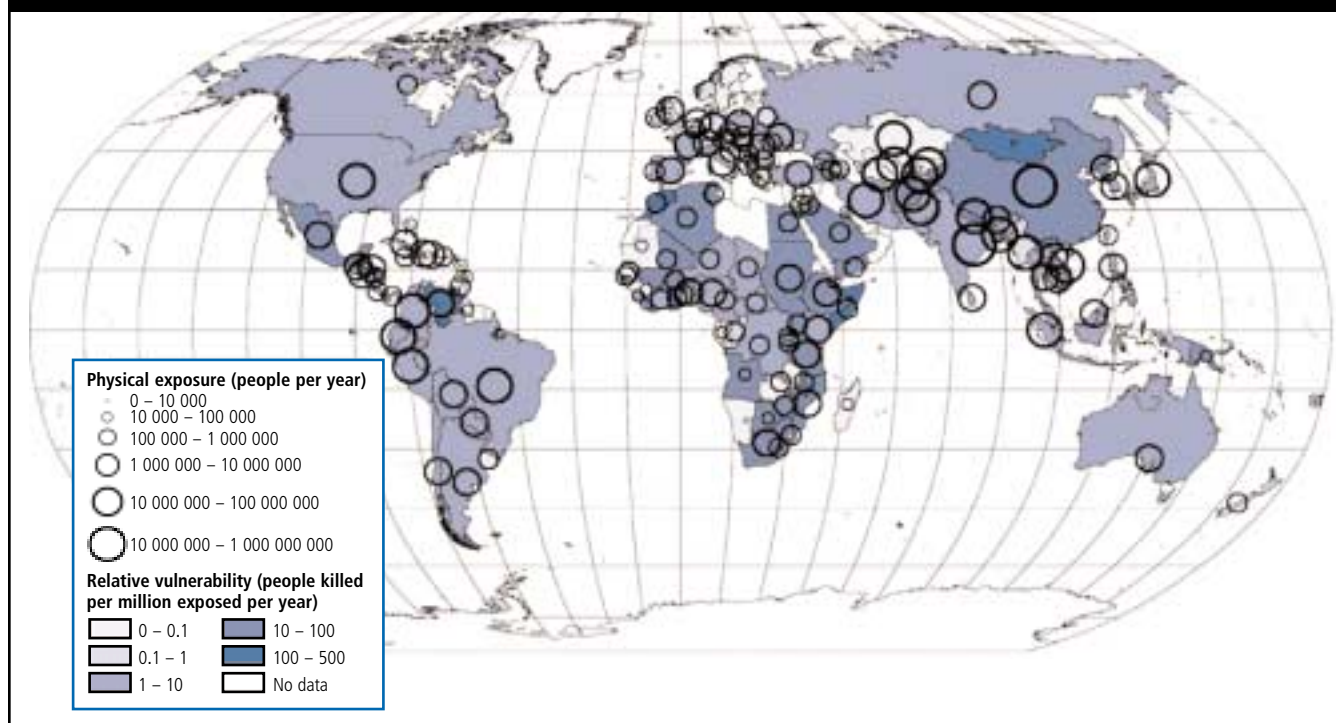
FIGURE 2.13 RELATIVE VULNERABILITY FOR FLOODS, 1980–2000



Source: The EM-DAT OFDA/CRED International Disaster Database and UNEP/GRID-Geneva



FIGURE 2.14 PHYSICAL EXPOSURE AND RELATIVE VULNERABILITY TO FLOODS, 1980–2000



Source: Université Catholique de Louvain: The EM-DAT The OFDA/CRED International Disaster Database (victims); U. S. Geological Survey: HYDRO1k Elevation Derivative Database (flood affected watersheds); CIESIN, IFPRI, WRI: Gridded Population of the World (GPW), Version 2 (population); Compilation and computation by UNEP/GRID-Geneva

The use of mortality as an indicator of vulnerability to floods could be supported by case specific information on losses to agricultural production, to housing and to social and economic infrastructure, which might be incurred without necessarily causing a large loss of life.

Taking into account and clarifying these different limitations, Figure 2.13 does show a range of countries, particularly in Africa and Asia, with higher human vulnerability to floods than countries such as Germany and the United States of America.

As in the cases of earthquakes and cyclones, there was a strong association with *physical exposure*. With floods this variable was tied to *GDP per capita*, which was inversely correlated with recorded deaths. There was a negative correlation between deaths from flooding and *local density of population*

Countries with low GDP per capita, low densities of population and high numbers of exposed people were most at risk from flood.

These indicators identify pathways into vulnerability to floods. The next stage of assessment would be to explore the detailed relationships that allow this to take place. This is partly the aim of Chapter 3.

Intuitively, one could expect mortality from floods to be high in countries with sparsely populated, poor rural areas, where disaster preparedness and early warning is non-existent and where health coverage is weak and not easily accessible. In such areas people would have less possibility to evacuate from flood prone areas and would be more vulnerable to death through flood related diseases.

Figure 2.14 presents a map of physical exposure and relative vulnerability to floods.

## 2.3 Unpacking Global Risks

In the first section of this chapter, the DRI was used to demonstrate the ways in which development constructs differential and heterogeneous risk patterns between countries at the global level. At a national level of observation and a local level of resolution, risk and vulnerability exhibit similar patterns of variance and heterogeneity, meaning that different regions and localities within a country are more risk-prone than others.

As was emphasised in Chapter 1 and will be explored in more detail in Chapter 3, risk is configured historically

## BOX 2.2 NATIONAL DISASTER DATABASES

This box presents three initiatives for national level data collection.

### The Latin America DesInventar

This methodology was initiated by the Network for Social Studies on Disaster Prevention in Latin America (LA RED) in 1994. It seeks to record all discrete events that have resulted in adverse effects on life, property and infrastructure triggered by natural and man-made phenomena and geo-referenced to the smallest available political-administrative unit in a given country — usually the District or Municipality. By collecting disaggregated data, DesInventar enables the recording of individual localised small-scale disasters as well as the impacts of large-scale hazard events at the local level.

National level DesInventar disaster databases, with up to 30 years of data, have been developed to date in 17 countries in the Americas. These are Argentina, Chile, Peru, Ecuador, Venezuela, Colombia, Panama, Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala, Mexico, Dominican Republic, Trinidad and Tobago, Jamaica and Guyana. Sub-national databases have been developed for the Departments of Antioquia and Valle del Cauca and for the city of Pereira in Colombia and for the State of Florida in the USA.

Local disasters with very limited direct impacts are included (e.g. the destruction of one house or a household affected by the loss of their harvest as a result of a frost), as well as those with more widespread impacts (e.g. earthquakes affecting metropolitan districts). These databases have been developed by national governments, international organisations, universities, scientific organisations and Non Governmental Organisations (NGOs). Data is obtained from the media and government agencies and existing databases. Once collected, data is verified nationally for consistency. Shared definitions are used for some

key hazards, while for others local specificity is more important. The challenge of uniformity between the databases remains, limiting the capacity for international comparisons.

### The Orissa Experience

In 2002, UNDP set about producing a database including an inventory of disaster events with a natural trigger for Orissa. The aim of the project was to develop a tool to help decision-makers prioritise expenditure in an objective manner. Orissa is to act as a pilot with the next stage, including replication in an additional four Indian states and integration into a national Government of India Integrated Disaster Resource Network. The methodology was modified from the experience of the Latin America DesInventar.

News media and government sources of information are used to build up the disaster events database. A historical database going back to 1970 has been collated and is updated weekly. Before data is entered, it has to be cleaned to enable a comparable analysis. For example, when a source measures disaster impacts in the number of families, this is recorded in the database as 'people impacted' by including six people for every family. Events are standardised so that similar events like cyclones and hurricanes are classified as cyclones, with whirlwind and tornado being recorded as gales. A new event 'boat capsize' was created.

Different data sources were given different data categories to enable reviews on structural differences in the reporting format used by the press (where there is much variation between individual reporting styles and events) and government sources (which are very comprehensive but formally structured). A particular constraint has been the unequal coverage of Orissa by data sources. The media, for example, does not cover Western Orissa as thoroughly as Coastal Orissa.

### MANDISA: South Africa

The programme for Monitoring, Mapping and Analysis of Disaster Incidents in South Africa (MANDISA) is a core activity for the Disaster Mitigation for Sustainable Livelihoods Programme of the University of Cape Town (DiMP). MANDISA was initiated as a pilot study in the CMA (Cape Town Metropolitan Area) in the Western Province of South Africa from 1990-1999. The methodology was inspired by DesInventar, but has been adapted for the South African context.

MANDISA focuses on South African-relevant losses including large urban 'non-drainage' floods, wildfires and extreme wind events, as well as highly frequent 'small' and 'medium' fires. Socio-economic and environmental risk factors that affect disaster impact are included where possible, allowing the potential for tracking the developmental conditions that prefigure disaster. While newspapers formed one source of information for tracking disaster events, the South African experience indicated that these provided limited insight into the highly recurrent 'small' events that occur in informal settlements reflecting only 649 of the 12,300 total incidents tracked through a thorough review of twelve different data sources, including incident reports from Fire Services, Social Services, the South African Red Cross Society and Disaster Management agencies.

MANDISA is viewed as an approach rather than a disaster tracking IT tool. This requires multi-agency cooperation, consultation and feedback, active sourcing of emergency and disaster information, strategic consolidation of information across agencies and robust geo-referencing. MANDISA is an internet-accessible database. This is intended to encourage local ownership as well as provide on-line information for schools, researchers, planners and disaster management personnel.

Source: Latin America DesInventar: <http://www.desinventar.org/desinventar.html>; Orissa: <http://www.undp.org.in/orissa/>; Mandisa: <http://www.egs.uct.ac.za/dimp/>

through the linked processes of economic development and environmental change, such as urbanisation and global climate change. Each risk scenario at the local level represents a unique configuration of hazards and vulnerabilities in the context of broader processes of development at the national and global levels. But ultimately, vulnerability and risk are manifested at the local level.

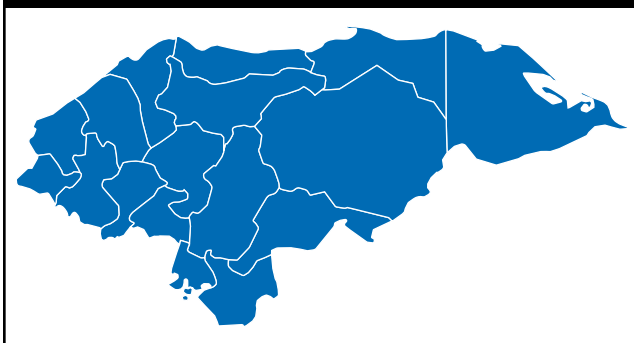
It is hoped and expected that the DRI is useful to illustrate global level risk and vulnerability patterns

and to advocate for development policies and practices that contribute to disaster risk reduction.

However, for this sea change in development culture to take root, national governments have to adopt appropriate development policies in the context of the more detailed and complex patterns of risk and vulnerability that exist within each country.

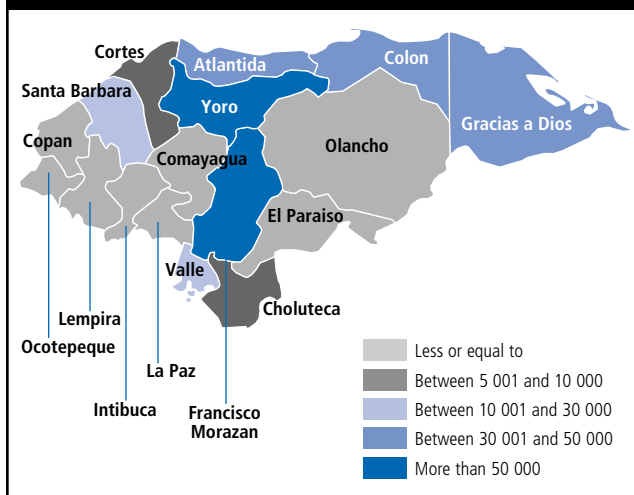
In this section of the Report, we will illustrate some of the complexities of risk at the sub-national level through a number of examples.

**FIGURE 2.15 NUMBER OF HOUSES DESTROYED BY HURRICANE MITCH IN HONDURAS (GLOBAL OBSERVATION AND NATIONAL RESOLUTION)**



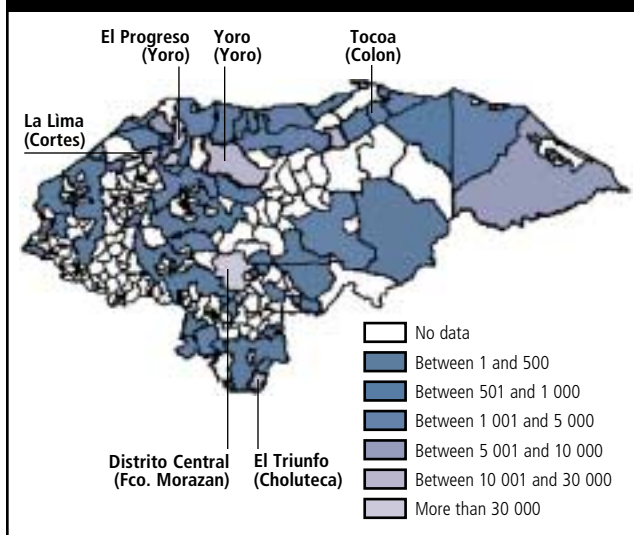
Source: COPECO-La Red, DesInventar-Mitch<sup>5</sup>

**FIGURE 2.16 NUMBER OF HOUSES DESTROYED BY HURRICANE MITCH IN HONDURAS (NATIONAL OBSERVATION AND DEPARTMENTAL RESOLUTION)**



Source: COPECO-La Red, DesInventar-Mitch<sup>5</sup>

**FIGURE 2.17 NUMBER OF HOUSES DESTROYED BY HURRICANE MITCH IN HONDURAS (NATIONAL OBSERVATION AND MUNICIPAL RESOLUTION)**



Source: COPECO-La Red, DesInventar-Mitch<sup>5</sup>

### 2.3.1 Risk patterns at the national and local levels

The DRI has been developed with a global level of observation and a national level of resolution. It allows the analysis of comparative risk levels between countries. This perspective can be complimented by viewing risk from a national level of observation and a local scale of resolution. When this is done, complex local risk patterns become apparent that are hidden at the global level.

#### *National disasters are composed of multiple local disasters*

Examined at the national level, large-scale disasters have a complex and heterogeneous impact on both territory and social groups. In this case, large-scale, national disasters may appear represented as a large number of small-scale disasters associated with a particular hazardous event. Box 2.3 explores this issue further with data from Hurricane Mitch in Honduras. The data was collected using the Latin America DesInventar methodology (See Box 2.2 on the previous page) by the National Commission for Contingencies (COPECO) of the Government of Honduras. In this case, what appears from the global level as a single, national scale disaster, takes on completely different characteristics seen with a national level of observation and a local level of resolution. This *bottom up* vision of the impact of Hurricane Mitch in Honduras clearly illustrates that risk and vulnerability patterns are locally configured.

#### BOX 2.3 MITCH: ONE DISASTER OR MANY?

The nested quality of disaster, where large-scale events identified at the global scale can also be interpreted as a collection of localised and small- or medium-scale events, is illustrated by the experience of Hurricane Mitch in Honduras, 1998.

Figure 2.15 represents a vision of Mitch from a global level of observation and a national level of resolution. Simply, a large number of houses were destroyed by the hurricane at the national level. Figure 2.16 moves to a national level of observation and a departmental level of resolution. At this level of resolution, widely differing impacts can already be observed between different departments. While a large number of departments had less than 5,000 houses destroyed, two departments had more than 50,000 houses destroyed. In Figure 2.17, the resolution is increased to the municipal level revealing yet another pattern of impact. While two municipalities suffered more than 30,000 destroyed houses (El Progreso in the Sula Valley and the central district of Tegucigalpa), a large number of municipalities in the country did not report destroyed houses at all.

Source: COPECO-La Red, DesInventar-Mitch<sup>5</sup>

**BOX 2.4 TRACKING RISK THROUGH TIME HIGHLIGHTS THE IMPORTANCE OF CONTEXT AND CULTURE**

The Orissa database points to epidemics as the greatest cause of deaths and fire as the greatest cause of property destruction in the state (see Figures 2.18 and 2.19). It is possible that epidemics will follow floods and cyclones so that the picture is a little more complicated than it might first appear. However, the recording of high death counts as losses to epidemics, does show the importance of indirect losses, compared to direct losses recorded from drowning or injury from a flood or cyclone. Epidemics following floods or cyclones and house fires are preventable. Their occurrence indicates high human vulnerability and a lack of adequate planning.

From the Orissa database it became evident that despite an underlying increasing trend in the number of reported fire events for the state, damage to property due to fire was declining (Figure 2.20). It is thought that this is because of increasing urbanisation, which marks a change from traditional and flammable construction materials towards a preference for houses constructed from concrete.

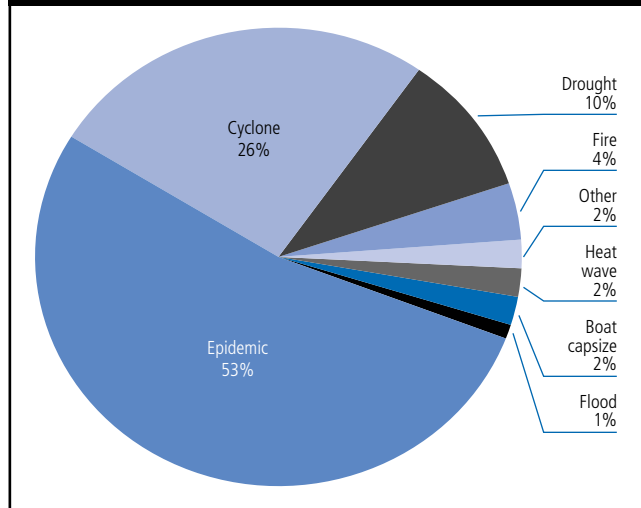
Some preliminary data also suggest a higher level of risk in some highly populated coastal areas. The concentration of people and risk into a small number of coastal districts shows the importance of sub-national studies for building up accurate pictures of risk that are hidden at the national or regional level.

Source: UNDP India, preliminary results of Orissa DesInventar database

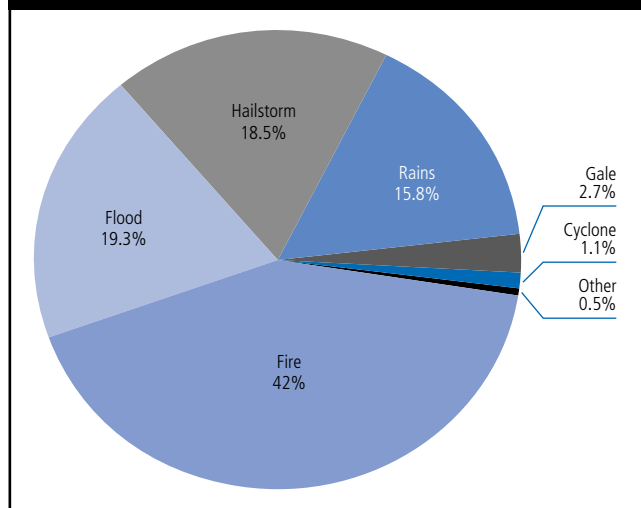
Each municipality in Honduras represented a particular configuration of hazards and vulnerabilities with respect to the housing sector, irrespective of the fact that the natural phenomenon itself (Hurricane Mitch) affected more or less the entire territory of Honduras. In other words, the disasters were associated with Mitch, but were related to a particular range of localised hazards and vulnerabilities, configured in the context of broader development processes at the global and national level.

Apart from the large-scale and medium-scale disasters that are represented in the DRI, the underlying local conditions of risk, hazard and vulnerability are manifested as frequently recurring small- and medium-scale disasters that are either individually too small to be included in global datasets, or else are not reported internationally.

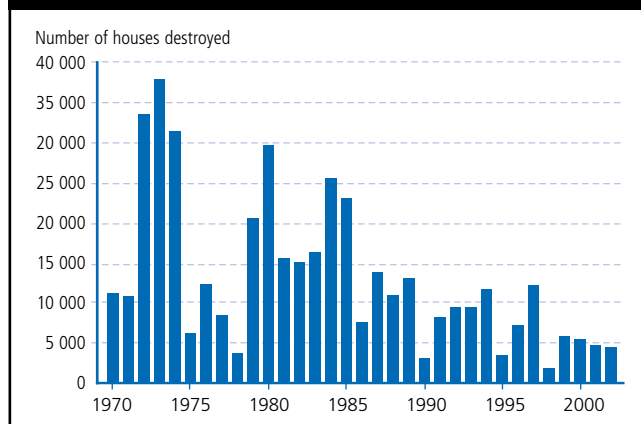
Such events represent a significant proportion of disaster loss in countries such as Panama, which is only rarely affected by major hurricanes and earthquakes. In Panama, the official national disaster database maintained by the National System for Civil Protection recorded 904 disaster events between 1996 and 2001.<sup>6</sup> These 904 events are associated with only 46 deaths, but involved considerable damage to livelihoods.

**FIGURE 2.18 NUMBER OF DEATHS REPORTED DUE TO DIFFERENT DISASTER EVENTS IN ORISSA, 1970–2002**

Source: UNDP India, preliminary results of Orissa DesInventar database

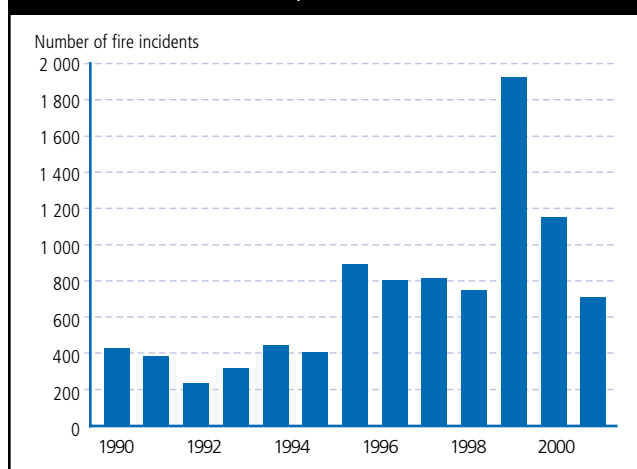
**FIGURE 2.19 NUMBER OF HOUSES DESTROYED DUE TO DIFFERENT DISASTER EVENTS IN ORISSA, 1970–2002**

Source: UNDP India, preliminary results of Orissa DesInventar database

**FIGURE 2.20 NUMBER OF HOUSES DESTROYED BY FIRE IN ORISSA, 1970–2002**

Source: UNDP India, preliminary results of Orissa DesInventar database



**FIGURE 2.21 NUMBER OF FIRE INCIDENTS FOR CAPE TOWN MUNICIPALITY, 1990 – 2002**

Source: MANDISA Project

For example, 40,531 hectares of crops were lost in these disasters. In the case of small landowners and subsistence farmers without insurance, the loss of a few hectares of crops can represent a catastrophic blow to livelihood sustainability.

Opening the DRI analysis to data feeding in from sub-national databases would introduce a broader spectrum of hazard types. As was mentioned in the section on the DRI, the losses associated with *primary* hazards, such as earthquakes, cyclones and floods, seen at the local level are linked to other secondary hazards events, including fires, landslides and liquefaction.

An examination of disaster losses in the Orissa DesInventar shows that more houses have been destroyed by fire and more deaths are lost in epidemics than through cyclones.

#### *Locally specific data can show the interaction of risk from an array of natural and anthropogenic hazards*

Locally specific data can help refine disaster risk reduction policy. The links between disease epidemics and disaster events, particularly floods and tropical cyclones, has long been a focus for research. The dynamics between disaster and disease continue to require a strengthening of our understanding. The importance of fires at the local level and in urban areas points to the need for further work on the relative importance of multiple hazards interacting with development at different levels. Deaths and injuries to road traffic accidents are likely to have a similarly significant local impact.<sup>7</sup>

House fires were not considered in the global DRI, which is oriented towards natural hazards. But this form of anthropogenic hazard is clearly important at the local level. This points to the opportunity for understanding risk processes that could come from exploring the links between development processes and risk to local anthropogenic hazards and larger scale natural hazards. How does exposure to small local events affect individual and collective vulnerability to large-scale hazards and vice versa? What are the implications for local development planning and risk reduction?

Providing a local lens allows for the large number of small events to be catalogued, re-shaping perceptions on risk as a priority concern for development policy. In the MANDISA project, it was originally anticipated, based on expert opinion, that the database would identify about 600 events for the period 1990-1999 in Cape Town, South Africa. In the end, 12,300 events were logged. Preliminary analyses from 1990-1999 have indicated that of the 12,300 incidents, 97 percent were fire-related. The most vulnerable houses were those in the informal housing sector. In an analysis of fire in the poor suburb of Gugulethu from 1990-1999, fires in the informal housing sector constituted 88.5 percent, with only 11.5 percent in the formal housing sector.

## **2.4 Future Directions in Natural Disaster Risk Modelling**

In this section of the Report, two exercises are presented that were undertaken within the DRI. Each pushes against the barriers imposed by data availability. The exploratory nature of these exercises limits the conclusions that can be drawn. But the processes involved are themselves illuminating, they point towards future directions in natural disaster risk modelling.

### **2.4.1 Can drought risk be modelled?**

Compared to the development of the DRI for earthquake, tropical cyclone and flood, modelling drought risk presented a series of additional challenges, which were only partly overcome. These include:

The difficulties in modelling drought hazard *per se*. A model of meteorological drought was used, but meteorological drought does not necessarily lead to agricultural or hydrological drought.



Compared to the other hazard types, deaths are a limited representation of manifest drought risk. Severe livelihood attrition may occur with only few recorded deaths, as was the case in Southern Africa in 2002. It is possible that many of the deaths labelled as drought disasters in the EM DAT database are due to other factors such as armed conflict.

Given these uncertainties regarding both the hazard model as well as the use of deaths as a risk indicator, the results should be considered only as illustrative.

To explore the possibilities of modelling drought, hazard data was examined using the same methods employed for earthquake, tropical cyclone and flood hazards. Methodological detail can be found in the Technical Annex, where particular challenges and some interpretation of results are offered.

A total of 832,544 deaths were associated with the occurrence of droughts worldwide, 1980–2000.<sup>8</sup> The drought conditions affecting sub-Saharan African countries from 1984 to 1985 were associated with the highest drought-related casualties for the period considered in the analysis. Ethiopia, Somalia and Mozambique recorded the most deaths.

Frequency and intensity were the main characteristics helping to delimit rapid onset events and only events crossing certain minimum thresholds were considered as disaster. For drought this is not the case and it is the duration of each drought that plays the most important role in characterising its hazard level. Droughts develop slowly and may last over a period of many years.

Given the length of time over which drought can be actively interacting with development processes, isolating deaths as a result of drought events is difficult. Deaths to drought are not direct, but rather the result of a complex interaction of drought and vulnerability as embedded in the economy. The link between drought and famine, for example, is full of intervening pressures.<sup>9</sup>

For the period 1980–2000, twenty countries are recorded in EM-DAT as having deaths associated with drought.

#### BOX 2.5 DEFINING AND MAPPING GLOBAL DROUGHT HAZARD

The methodology used to map exposure to meteorological droughts was developed and provided by the International Research Institute for Climate Prediction (IRI), Columbia University. Data was obtained from the US National Centres for Environmental Prediction (NCEP) and its Climate Prediction Centre accessed through the IRI Data Library (<http://iridl.ldeo.columbia.edu/>).

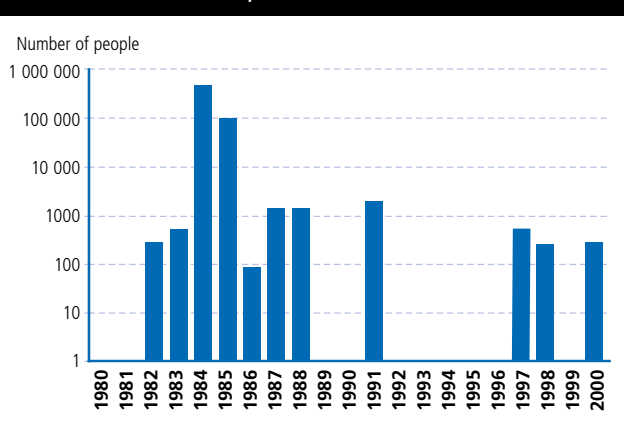
Meteorological drought was defined as a sustained period (three months or more) in which monthly precipitation at a given location is significantly below the long-term average (in this model, more than 23 years). By definition, desert regions are perpetually dry and therefore do not reflect the type of deficient precipitation we are considering. Three months of deficient precipitation in succession is generally considered the minimum duration required to define a drought. Many drought events persist for periods ranging from several months to several years.

The data used in the analysis consisted of monthly precipitation figures for the globe for the period 1979–2001. The dataset was based on a blend of surface station observations and precipitation estimates from satellite observations. Data was spatially organised in a 2.5 x 2.5 degree latitude/longitude grid.

The first step in assessing exposure to meteorological drought was to compute, for each calendar month, the median precipitation for all grid points between the latitudes of 60S and 70N over the base period 1979–2001. Next, for each grid point, the percent of the long-term median precipitation was computed for every month during the period January 1980 to December 2000. For a given month, grid points with a long-term median precipitation of less than 0.25 mm/day were excluded from the analysis. Such low median precipitation amounts can occur either during the dry season at a given location or in desert regions. In both cases our definition of drought does not apply. Finally, a drought event was defined as having occurred when the percent of median precipitation was at or below a given threshold for at least three consecutive months. The different thresholds considered were 50 percent, 75 percent and 90 percent of the long-term median precipitation with the lowest percentage indicative of the most severe drought according to this method. The total number of events during the period 1980–2000 were thus determined for each grid point and the results aggregated to country level.

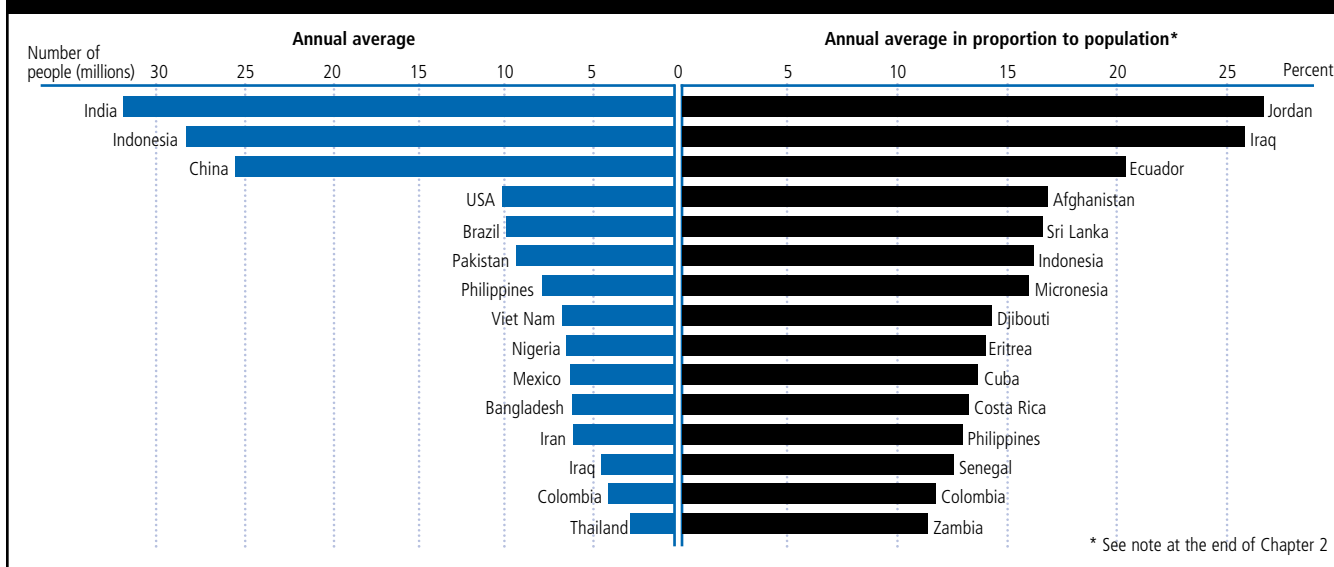
Data was from the US National Centres for Environmental Prediction (NCEP), Climate Prediction Centre (CPC), available through the IRI Data Library (<http://iridl.ldeo.columbia.edu/>).

**FIGURE 2.22 PEOPLE KILLED BY DROUGHT AND FAMINE, 1980–2000**



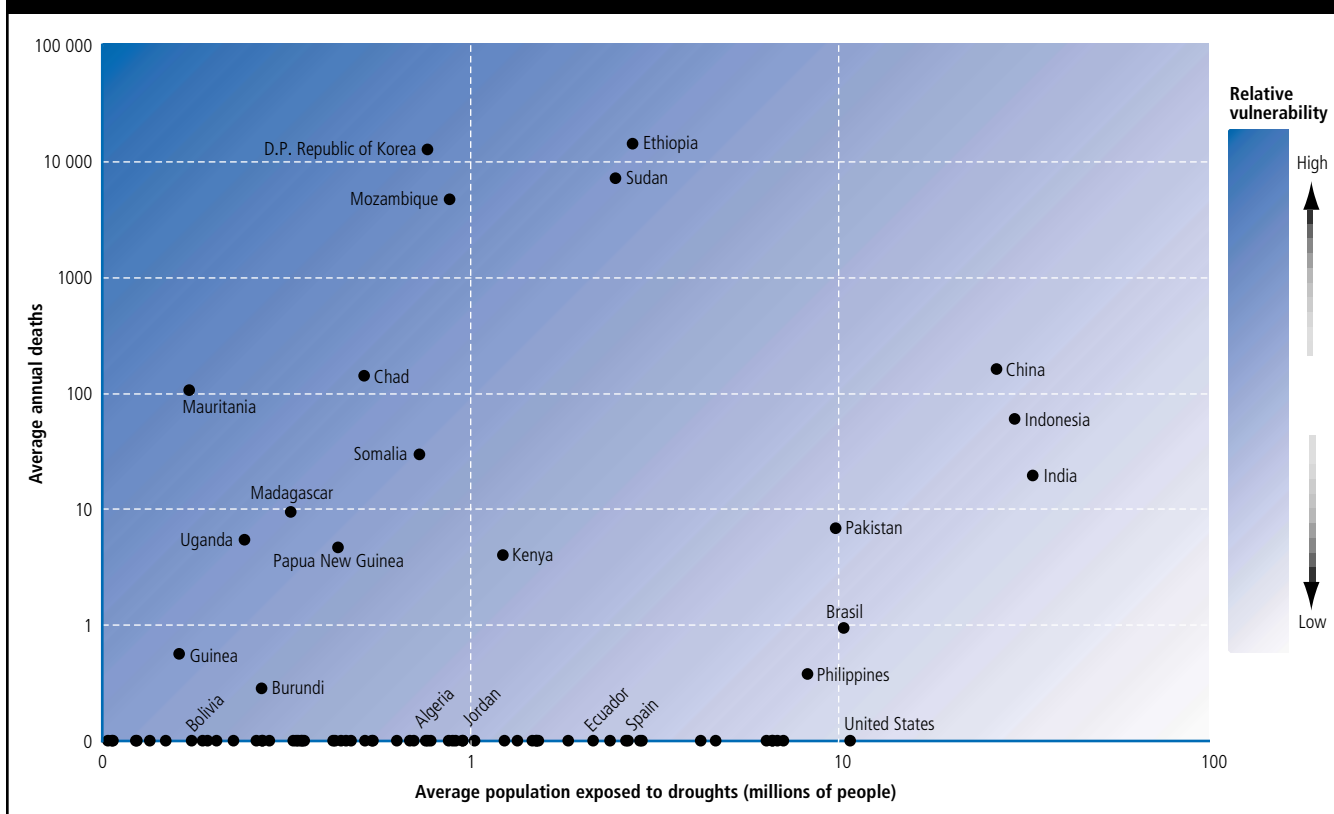
Source: The EM-DAT OFDA/CRED International Disaster Database

FIGURE 2.23 PHYSICAL EXPOSURE TO DROUGHTS, 1980–2000



Source: UNDP/BCPR; UNEP/GRID-Geneva

FIGURE 2.24 RELATIVE VULNERABILITY FOR DROUGHTS, 1980–2000



Source: The EM-DAT OFDA/CRED International Disaster Database and UNEP/GRID-Geneva

The periodic and country specific nature of drought is indicated in Figure 2.24 (see previous page), which presents annual deaths attributed to drought by EM-DAT.

A basic approach to the mapping of meteorological droughts was achieved by using a simple index that

applied a threshold-criteria to identify droughts. This took account of both shortfalls in precipitation and the duration of precipitation deficits. Box 2.5 (see previous page) describes the approach. The human exposure analysis, using a threshold of a 50 percent shortfall in precipitation over a three-

month period, was applied to 107 countries where data was available.

Using this approach, highly populated countries with large territories from Asia and the Americas are among those states with the largest exposed populations to meteorological droughts. When annual physical exposure is expressed per million inhabitants, less populated countries gain visibility.

Around 220 million people were found to be annually exposed to drought. An exploratory analysis of relative vulnerability was undertaken to investigate the relationship between drought (as defined as a 50 percent shortfall in rainfall over three months) and deaths attributed to drought at the international level. Figures 2.24 and 2.25 suggest that while few sub-Saharan African countries have large absolute or relative populations exposed to meteorological drought, seven of the 10 most vulnerable countries are located in sub-Saharan Africa.

Mozambique, despite being hit by flooding in 2000, presents a higher level of relative vulnerability to droughts. Ethiopia shows similar levels of vulnerability to drought and has recorded a higher number of drought-related casualties for the period of 1980-2000.

Most of the countries situated on the top left of the graphic (relatively more vulnerable) have suffered major armed conflicts<sup>10</sup> during the period under analysis. Ethiopia, Sudan, Mozambique, Chad, Uganda and Somalia suffered long armed conflicts for more than a decade during the period 1980-2000, often combined with other minor conflicts.<sup>11</sup> In addition, Mauritania and Papua New Guinea suffered more occasional conflicts (less than 1,000 deaths). North Korea, though not embroiled in a conflict, has been affected by its international isolation and this is reflected in very high relative vulnerability to drought. The role of political processes, and in particular armed conflict, in translating drought exposure into vulnerability and human loss of life is made all too clear by this analysis.

The national DRI model results contrast greatly with the other hazards studied in this Report. The socio-economic variables that had the greatest association with recorded drought deaths were the *percentage of population with access to improved water supply* and *physical exposure*.

Physical exposure is less important when associated with deaths to drought than when compared to earthquake, tropical cyclone and flood. This suggests that socio-economic factors play a greater role in generating drought risk than is the case with rapid-onset hazards. In fact, one of the conclusions of this DRI exercise is that it may be incorrect to label the deaths recorded as drought deaths at all. The deaths probably have much more to do with poor governance, conflict and internal displacement than with meteorological drought *per se*. While this implies that this DRI may not be a *drought* DRI, it does create great opportunities for risk reduction through development policy.

At the same time, however, the weak association between physical exposure and risk may also be due to the characteristics of the hazard model or to the use of deaths as an indicator of risk. If it were possible to model agricultural rather than meteorological drought and to use livelihood attrition rather than death as a proxy for risk, then the association between physical exposure and risk might be quite different.

It is important to note that the indirect connection between drought and mortality signifies that the selection of mortality as the outcome for which risks are evaluated affects the way drought losses should be interpreted. Drought impacts are widespread throughout economies with high dependence on primary sector activities. Their cumulative effect can be significant for people's livelihoods, even in situations where mortality attributable to the hazard event is not widespread. This may affect the placement of African countries in the rankings.

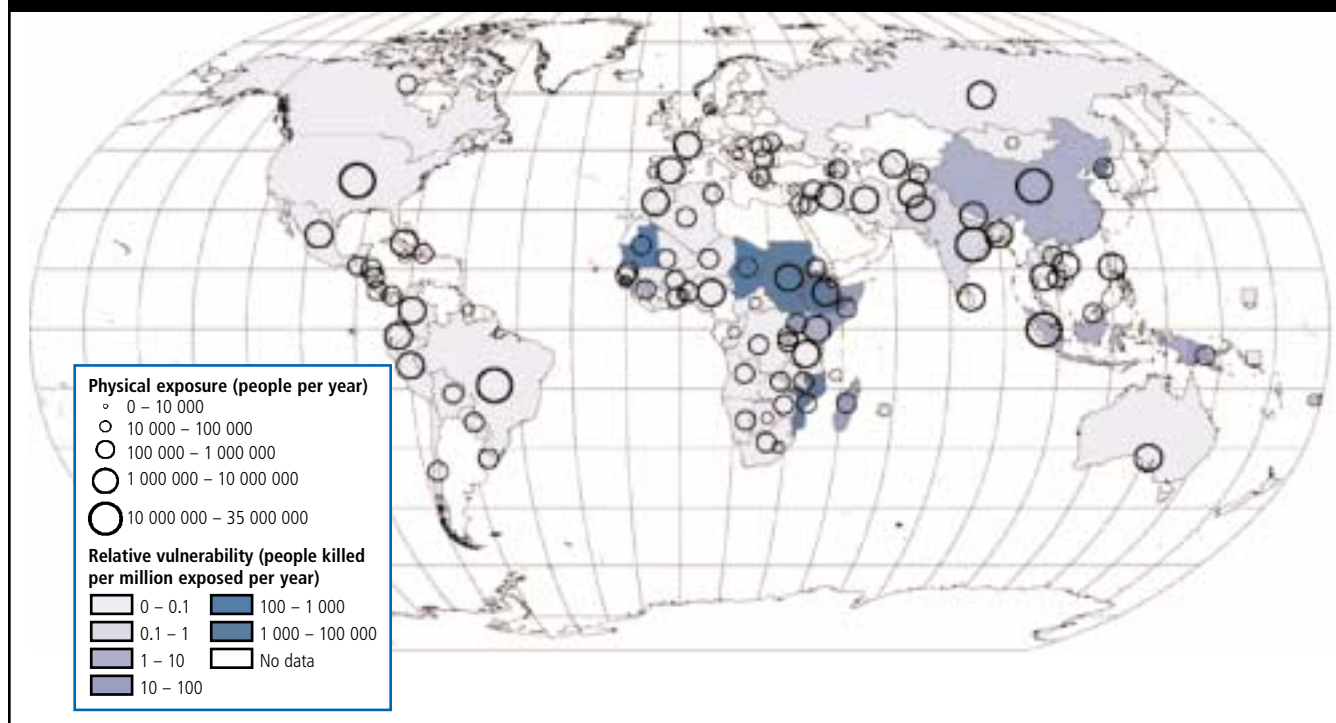
Relative vulnerability to drought and physical exposure are also presented as a world map in Figure 2.25 on the following page. Data for individual countries is in the Statistical Appendix.

#### 2.4.2 Towards a multi-hazard disaster risk model

Is it possible to build on the individual hazard indices for earthquake, tropical cyclone, flood and drought to form a multi-hazard DRI? In this section, initial steps towards the development of such a tool are presented. The Technical Annex records the methodology and results.

Developing a multi-hazard DRI model serves two purposes. First, it is an opportunity to break with the

FIGURE 2.25 PHYSICAL EXPOSURE AND RELATIVE VULNERABILITY TO DROUGHTS, 1980–2000



Source: Université Catholique de Louvain: The EM-DAT OFDA/CRED International Disaster Database (victims); International Research Institute for Climate Prediction (droughts extent); CIESIN, IFPRI, WRI: Gridded Population of the World (GPW), Version 2 (population); Compilation and computation by UNEP/GRID-Geneva

use of disaster impacts (deaths) to indicate disaster risk. The multi-hazard DRI models risk based on socio-economic variables associated with past disaster losses. This opens the way for a concrete analysis of the interaction of development processes with disaster risk. Individual social processes can be examined in relation to disaster risk. Through time it will be possible to track changes in development policy, changing socio-economic status and disaster risk. Second, in combining risk associated with four hazard types, the multi-hazard DRI is working towards providing a sharp tool for policy advocacy.

#### *From hazard to disaster risk*

The multi-hazard model is built from the socio-economic variables associated with individual hazards and identified in Sections 2.2 and 2.4.

The socio-economic variables used were: for earthquake, physical exposure and urban growth; for tropical cyclone, physical exposure, percentage of arable land and HDI score; for flood, physical exposure, GDP per capita and local density of population; for drought, physical exposure and percentage of population with access to improved water supply.

The potential for a multi-hazard DRI model is explored here by examining Figure 2.26, which shows differences

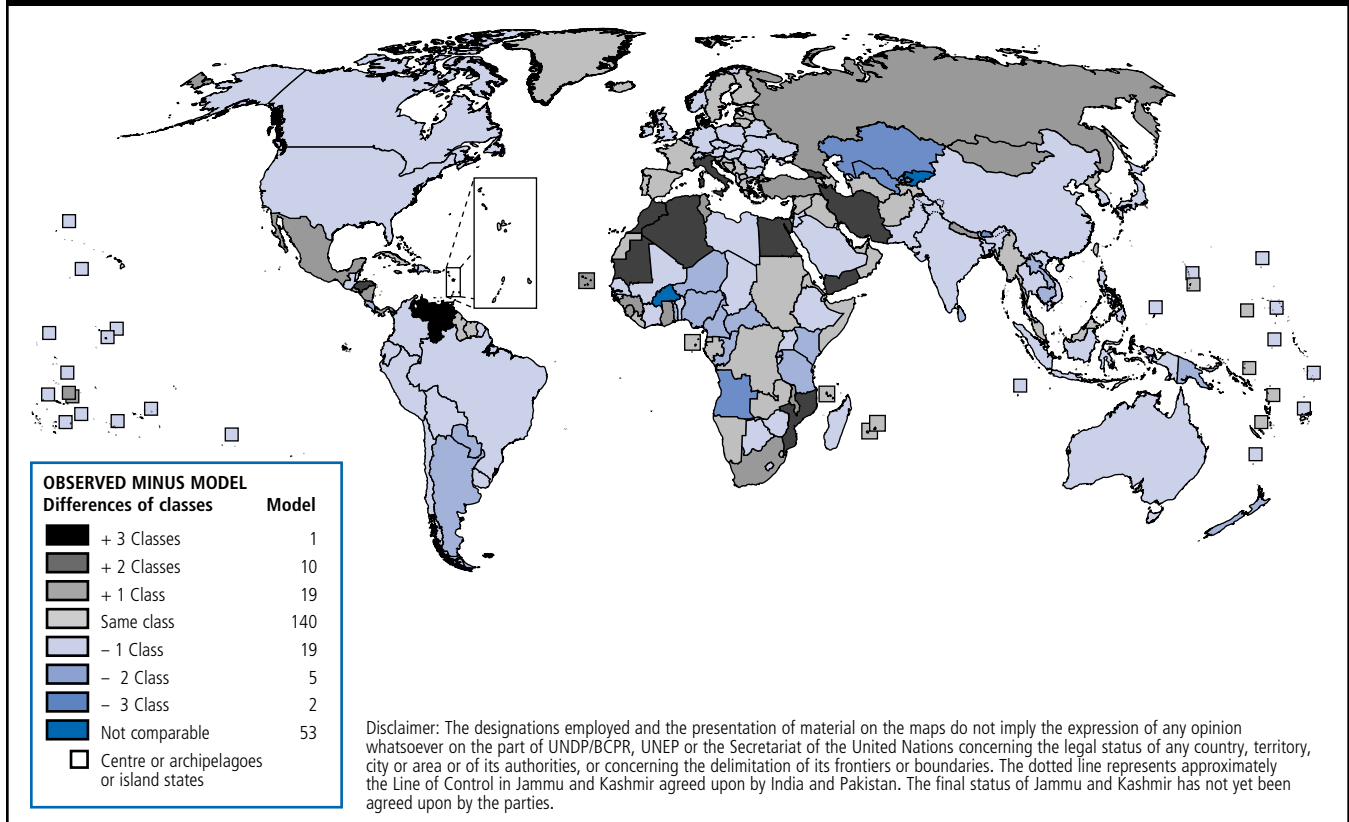
between recorded deaths from EM-DAT and deaths calculated using the DRI multi-hazard model.

Even at this early stage, a number of conclusions can be drawn from the process of developing the multi-hazard DRI model.

Cases where the model overestimates people killed suggest the need to refine differences between poverty, as represented by HDI or GDP per capita, and vulnerability. Countries falling into this group are low income, for example Burkina Faso and Bhutan, but have recorded less people killed than the model suggests. This finding brings new weight to discussions about the utility of indicators of poverty in vulnerability assessments and the importance of governance. Lower recorded deaths may also indicate that episodic hazards with long time intervals between events, particularly earthquakes in Bhutan, did not coincide with the 1980–2000 period used in analysis.

Cases where the model underestimates people killed point to the influence of catastrophic disasters. For example, in 1999 about 30,000 people were killed in Venezuela associated with flooding and secondary landslide events.<sup>12</sup> Building a framework for analysis that can cope with small-scale local disasters and

FIGURE 2.26 DIFFERENCES BETWEEN OBSERVED AND MODEL CLASSES



Source: Geoprocessing, analysis and infography UNEP/GRID-Geneva 2003

catastrophic events is a challenge that the DRI model is working to address.

In 196 out of 249 countries, it was possible to compare the recorded and model deaths. Fifty-three countries were left out because of the absence of data. The drought hazard data was available, but with a low confidence on the ability of the vulnerability variables to capture driving pressures such as governance, armed conflict and HIV/AIDS, it was decided not to pursue analysis.

## 2.5 Improving Disaster Indicators

### 2.5.1 Improving Disaster Data

The DRI and other risk information systems use a deductive methodology<sup>13</sup> in which data on disaster impact is used as an indicator of *manifest risk*.

As was mentioned in Section 2.2, a key constraint is that reliable global data is limited to mortality. And this is only for large-scale and a part of the medium-scale disasters that occur. One opportunity for improving risk information, therefore, lies in improving

the quality, coverage and accuracy of disaster data. Perhaps most required is more accurate data on losses and associated socio-economic variables with global coverage and sub-national resolution.

The Working Group 3 on Risk, Vulnerability and Impact Assessment of the Inter-Agency Task Force of the ISDR has recommended the development of a multi-tiered system of disaster reporting. In this system, disaggregated disaster data collected at the local level is progressively aggregated into national and global disaster datasets, using a unique global disaster identifier to link sub-national, national and global datasets.

The development of such a multi-tiered system of disaster reporting is a complex and challenging undertaking.

The collection of disaster data at the national level for all scales of development planning is a basic need if disaster risk is to be integrated into development planning. Only with this information can policies have the precision needed to tackle the variations in vulnerability and hazard that exist at the local level.



**BOX 2.6 TOWARDS A MULTI-TIERED SYSTEM OF DISASTER REPORTING**

The achievement of complete global coverage of national disaster datasets, using an appropriate comparable methodology, would be a major asset to risk analysis. Given the relatively significant coverage of national level disaster datasets in Latin America and the Caribbean, this requires promoting the compilation of national datasets in other regions such as Asia, the Pacific and Africa. Global coverage of national datasets is essential to underpin a range of upcoming initiatives, such as assessing the probable impact of climate change. A first step would be to survey additional national databases, especially to find out what more may be available at the national level and to bring those resources into the larger global effort

The consolidation of a system for creating a unique global disaster identifier for each disaster event is another important step in improving global disaster data. Right now, for example, a number of different institutions are involved in developing the Global Identifier (GLIDE) concept, originally proposed by the Asian Disaster Reduction Center (ADRC). GLIDE has been further developed by the Centre for Research on the Epidemiology of Disasters (CRED), the UN Office for the Coordination of Humanitarian Affairs (OCHA) and other partners in order to ease the linking of national and international datasets. GLIDE also permits disaster data to be annotated with reports, articles, photos and other material — a concept that is already being put into practice through the Relief Web project.

The adoption of a unique disaster identifier, based on GLIDE, in national datasets would allow the aggregation of disaster effects in different local administrative areas by disaster event. At the same time, it would allow the communication of medium-scale disaster events from national to international datasets, enriching global datasets like EM-DAT and enabling the integration of national and international reporting and data capture systems. In turn, this requires assistance with database integration and on-line access to participating countries and institutions. Other important steps include:

- The development of common reporting standards and protocols for capturing and exchanging data in both national and global databases with a view to increasing correlation and convergence.
- The development and promotion of methods and standards for capturing economic losses that are currently not adequately reported in either national or international disaster databases.
- The development of national capacities to compile and maintain disaster databases according to the common standards and protocols mentioned above. This requires the identification of national institutions able to undertake these tasks on a regular, predictable and sustainable basis. Previous experience with the development of national databases indicates that academic institutions may be the most appropriate to compile historical disaster inventories, while disaster management organisations may be appropriate to maintain and update disaster datasets on a day-to-day basis.

Source: Report of Working Group 3 of the Inter-Agency Task Force of the ISDR, October 2002<sup>14</sup>

National disaster databases have relatively good coverage in Latin America and the Caribbean, but far less so in other regions. While detailed assessments of the economic impact of particular large-scale disasters are

**BOX 2.7 GLIDE – THE UNIQUE GLOBAL DISASTER IDENTIFIER**

The GLIDE concept was developed by the Asian Disaster Reduction Center (ADRC) in association with the UN Office for the Coordination of Humanitarian Affairs (OCHA) Relief Web project, the Food and Agriculture Organization (FAO), the USAID Office of US Foreign Disaster Assistance (USAID-OFDA), the Centre for Research on the Epidemiology of Disasters (CRED) and other partners.

GLIDE was introduced in 2002 and makes the system of building an international database of national and sub-national disaster events much easier and more transparent.

Before the introduction of GLIDE in 2002, numerous organisations operated their own disaster databases. This meant searching the database of each organisation individually for every disaster. Sometimes different organisations would use different names for the same disaster, making searching more difficult. With no direct links between organisations, verifying data was also difficult.

Source: <http://www.glidenumber.net/>

carried out by The Economic Commission for Latin America and the Caribbean (ECLAC) and others, regular reporting of economic loss in disaster events is uneven and unreliable. Problems of data compatibility and definitions abound.

Nevertheless, the potential for improving risk information, and in turn for informing development policy and planning, is so great that it is clear that this is an area in which major investments are both justified and required.

The current project of the Government of India and UNDP to develop a fully on-line system of disaster reporting at the state and national level is another example of innovative ongoing initiatives that start to address this challenge.

**2.5.2 Enhancing the DRI**

A constraint on the DRI was the availability of reliable global datasets based on hazard patterns and the socio-economic and environmental variables tested as vulnerability indicators. However, new datasets are constantly becoming available. Since the pilot DRI was completed, a number of new and potentially important datasets have become available which could be used to enhance and improve the accuracy and usefulness of the DRI model and expand it to additional hazard types.

It will be possible, therefore to generate further iterations of the DRI in the future with improved and enhanced datasets and on the basis of expert critique of the results and models used. Gradually, the DRI

should be able to produce a far more fine-tuned simulation of reality than was possible when this first pilot version was produced.

There are a number of other ongoing initiatives to develop indicators and indices on disaster risk and related themes. Of particular relevance to the mapping of disaster risk presented in this Report are two projects:

- In 2001, the World Bank, in association with Columbia University and the ProVention Consortium, commenced a Global Disaster Risk Hotspots research programme.<sup>15</sup>
- In 2002, the Inter-American Development Bank and Universidad Nacional de Colombia embarked on an Indicators for Disaster Risk Management in the Americas project.<sup>16</sup>

Both projects aim to develop decision-making tools to identify areas of high risk and causal factors underpinning risk with a view to help the targeting of national and international development investments. An overview produced for the Working Group 3 of the Inter-Agency Task Force of the ISDR is included as an Appendix.

Clearly, enormous potential exists for sharing data and feedback among the different methodologies and models used, as has already occurred in the development of the pilot DRI. Synergies between the different initiatives should be actively promoted and encouraged

### 2.5.3 Developing a disaster risk reduction indicator

The indicator of relative vulnerability for each hazard type developed in the DRI, presents a value which encompasses not only the different factors that increase the risk of mortality in a country, but also the factors that may decrease mortality. These latter factors include efforts being made in many countries to enhance disaster preparedness and mitigation and in some cases to manage and reduce disaster risks.

The importance of exposing capacities hidden in non-disaster situations is an overall challenge in promoting effective disaster risk reduction across the globe. The case studies included in Chapter 3 of this Report point to the range of actions being undertaken at the

local and national levels to reduce disaster risk within the development process.

The pilot DRI did not include considerations of the relative capacity of countries in disaster risk management in the process of identifying and testing vulnerability indicators. In other words, the low relative vulnerability of a country to a given hazard may be due to the application of effective risk management measures. However, this cannot be captured by the DRI.

Potentially, if global datasets were to exist that measured in different ways countries' capacity to manage and reduce disaster risk, these could also be used as indicators within the DRI. This would enhance the advocacy role of the DRI by demonstrating how appropriate policy and planning interventions can reduce vulnerability to hazard.

The development of disaster risk reduction indicators is still at an early stage of development. The ISDR

#### BOX 2.8 THE ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN

The Economic Commission for Latin America and the Caribbean (ECLAC) has led the way in developing methodologies for calculating the economic impact of natural disasters. The division of impacts into direct, indirect and secondary losses presented in Chapter 1 were first developed by ECLAC.

In 2003, ECLAC published a *Handbook for Estimating the Socio-Economic and Environmental Effects of Disasters*. This is a tool for quantifying damages, identifying the most affected regions and those requiring priority attention during the reconstruction phase. It reckons that the total amount of accumulated damages to disaster in the region is probably more than US\$ 65 billion. These losses primarily affect smaller, less developed countries, particularly in the Andes, Central America and the Caribbean.

Based on thirty years experience measuring the main disasters in the region, the ECLAC methodology for measuring damages and losses was first published in 1991. The revised methodology makes it possible to quantify economic, social and environmental effects.

ECLAC recently completed a study of the socio-economic impact of the January 2003 earthquake in Mexico's Colima state. The earthquake, which measured 7.8 on the Richter scale, affected the Mexican states of Colima, Jalisco and Michoacán. It caused 28 deaths and injured many more and caused considerable damage. Using the revised ECLAC methodology, an assessment of impacts in Colima state set the total amount of damages at about US\$ 90 million, or 3 percent of its GDP in 2002, one of the highest losses to a natural disaster in Mexico in recent years.

After the flooding in Argentina's Santa Fe province in April 2003, the regional government requested an evaluation from ECLAC, which was carried out jointly with the UNDP. The final report estimates that losses reached US\$ 1 billion.

Source: <http://www.eclac.cl/analisis/TIN53.htm#6>

**BOX 2.9 A FRAMEWORK TO GUIDE AND MONITOR DISASTER RISK REDUCTION**

Monitoring progress towards development and disaster risk reduction goals is made more transparent when measured by shared criteria.

The UN International Strategy for Disaster Reduction (ISDR) and UNDP have proposed a framework of five thematic areas each opening up to reveal a cluster of disaster risk management concerns with potential benchmarking tools. The Framework was presented by ISDR in 2002 in *Living with Risk: A Global Review of Disaster Reduction Initiatives*.

The thematic areas that drive the proposed framework are: governance, risk identification, knowledge management, risk management and preparedness, and emergency management. There are a host of suggested benchmarking tools to measure standards of practice. These include elements of policy and planning, legislation, codes and their enforcement, availability and use of disaster risk and impact assessments, education and training, the existence of social security and financial instruments for risk burden sharing, and the coverage of community-based preparedness.

This is an ambitious agenda covering a huge variety of organisational practices and technical specialisms. It will require international support. One possibility is to tie indicators in with the MDGs and other sub-national development targets. This will prevent unnecessary duplication of effort. Similarly, the Framework will need to specify which actors or partnerships of actors have responsibility for undertaking or completing individual tasks. To succeed as a vehicle for changing practices, the framework will need to be accepted by multiple stakeholders from civil society, the private sector and government agencies. To do this, these groups' participation in the planning process is paramount.

From 25 August 2003 to 26 September 2003, the Framework was presented for open scrutiny in an on-line conference. The need for tools to help enhance the transparency of the process of building disaster risk reduction into development planning was reinforced, as was the need for a flexible set of benchmarks that are robust, yet sensitive to local context.

Source: Source: <http://www.glidenumber.net/>

Secretariat and UNDP are currently working to develop a core set of indicators as a proposal to further develop a methodology against which to guide and monitor disaster risk reduction and are the result of an expert consultation. As a starting point to this process, the Secretariat has prepared a core set of principles and goals.<sup>17</sup>

#### 2.5.4 The development of national level DRIs

As we have emphasised, the purpose of the global DRI is to illustrate relative patterns of vulnerability and risk between countries. Its goal is to provide evidence of the contribution of development to the configuration of disaster risk and to advocate for a change in development policy and planning. It is also of use to international organisations that may wish to

set priorities according to a quantitative measure of relative risk between countries at the global level.

However, if disaster risks are to be managed and reduced, change in development policy and planning is required at the national level. In order to inform such change, the development of national level risk indicators and indices is required.

The development of DRI, with a national level of observation and a local level of resolution, that would enable the identification and explanation of relative risk and vulnerability, have enormous potential to support national development planning.

There are two main criteria for selecting in which countries to develop national level DRI. The global DRI analysis points towards those countries where risk to a given hazard is greater and where a national level DRI would be most useful. Indeed, all countries would not need to be covered for all hazards if they were not affected, or had a low level of risk.

A second consideration is data availability. As we have discussed above, national disaster data currently exists only for a small number of countries, mainly in Latin America and the Caribbean, and this would be a limiting factor on the development of national DRI. In contrast, in many countries at the national level there are relevant datasets that can be used to identify and test a far larger and better attuned variety of socio-economic and environmental vulnerability indicators than is possible at the global level. Building up national level databases of local conditions of vulnerability, to complement those national databases of local occurrences and impacts of disaster discussed above, would provide a strong foundation for fine-tuning the global assessments of disaster risk at the national level.

Recognising the weight of small and medium disaster events in total disaster losses has critical implications for our understanding of how risk is generated and accumulates at the local and national levels. A similar conclusion is presented in the *Human Development Report, 2003*. Here, the mapping of sub-national data for conflict with human development index scores makes clear the spatial bounding of exposure to conflict in Indonesia, Colombia, Nepal and Sri Lanka.<sup>18</sup> Variance in levels of exposure to conflict and differing development status at the local level are revealed by a

sub-national resolution and supported by sub-national level HD indicators.

This again points to the need for a multi-layered, nested approach to collecting data on disasters and linking risk analysis with development policy.

The global scale of observation is most useful for highlighting national priorities for action to confront failures of development and disaster risk management. Hurricane Mitch in Honduras was clearly such a case. Developing targeted risk reduction programmes below the international scale requires a local focus based on local disaster data gathering. Building the picture up from the local to the global again can indicate those countries that have experienced comparative success or failure in tackling development and disaster management weaknesses.

**Note on physical exposure:** physical exposure represents the number of people exposed per year to a particular hazard. This means that for some cases, this figure can be higher than the population of the country when a hazard is affecting a large part of the population and more than once per year. For example, in the Philippines, the population is hit by 5.5 cyclones per year. On average therefore, the physical exposure is much larger than the population.

1. One of the first and most complete definitions of vulnerability was developed by Gustavo Wilches-Chaux. See Wilches-Chaux, Gustavo, "La Vulnerabilidad Global in Maskrey," Andrew (Ed), 1993, *Los Desastres no Son Naturales*, LA RED, Bogota, Colombia.
2. See Lavell, Allan in Fernandez, Maria Augusta, 1999, *Cities at Risk: Environmental Degradation, Urban Risk and Disasters*, LA RED/USAID, Quito, Ecuador.
3. Maskrey, Andrew and Romero Gilberto. 1986. *Urbanizacion y Vulnerabilidad Sismica en Lima Metropolitana*, PREDES, Lima.
4. Salazar, A. (2002) Normal Life after Disasters? 8 years of housing lessons, from Marathwada to Gujarat, Architecture + Design, New Delhi, Jan/Feb.

5. <http://www.desinventar.org/sp/proyectos/lared/comparacion/index.html>
6. <http://www.sinapro.gob.pa/estadisticas.htm>
7. *IFRC World Disasters Report 1998*.
8. Famine deaths are also included in this figure.
9. Dreze and Sen 1998. *Hunger and Public Action*, Oxford University Press; Oxford.
10. **Major conflict:** At least 1000 battle-related deaths.
11. **Minor conflict:** At least 25 battle-related deaths per year and fewer than 1000 battle-related deaths during the course of the conflict.
12. EM-DAT: The OFDA/CRED International Disaster Database, Universite Catholique de Louvain, Brussels, Belgium.
13. A discussion of deductive and inductive models for risk modelling is presented in Maskrey, Andrew, 1998, *Navegando entre Brumas: La Aplicacion de los Sistemas de Informacion Geografica al Analisis de Riesgos*, LA RED, Bogota.
14. [http://www.unisdr.org/task-force/eng/about\\_isdr/tf-meeting-6th-eng.htm](http://www.unisdr.org/task-force/eng/about_isdr/tf-meeting-6th-eng.htm)
15. For more information and contact details, see appendix on international initiatives at modeling risk.
16. Indicators for Disaster Risk Management in the Americas. This project was initiated in August 2002 and involves the Instituto de Estudios Ambientales (IDEA), Universidad Nacional de Colombia and the Inter-American Development Bank (IDB). It is Component II of a technical cooperation entitled an Information and Indicators Programme for Disaster Risk Management in Latin America and the Caribbean. This indicators programme is developing an assessment methodology to measure key elements of countries' vulnerability and the performance of different risk management tools. The purpose of the project is to improve decision-makers' access to appropriate data and methodologies needed to meet the challenges of reducing and managing their risk to natural hazards in the region. Testing of the indicators methodology will be done in approximately 10 countries and include: (i) The definition of vulnerability and performance indicators for disaster risk management and their conceptual foundation. (ii) The design of the data/information collection method (iii) The testing of the indicators methodology in selected countries. The project will also finance a regional technical workshop with policy makers and experts from the region to evaluate the assessment methodology and disseminate results. For information regarding the indicators programme and its conceptual framework see: Cardona 2003, <http://idea.unalmz.edu.co/>
17. See ISDR Secretariat 2002.
18. *UNDP Human Development Report 2003*, p. 48.