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 main-streaming 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.

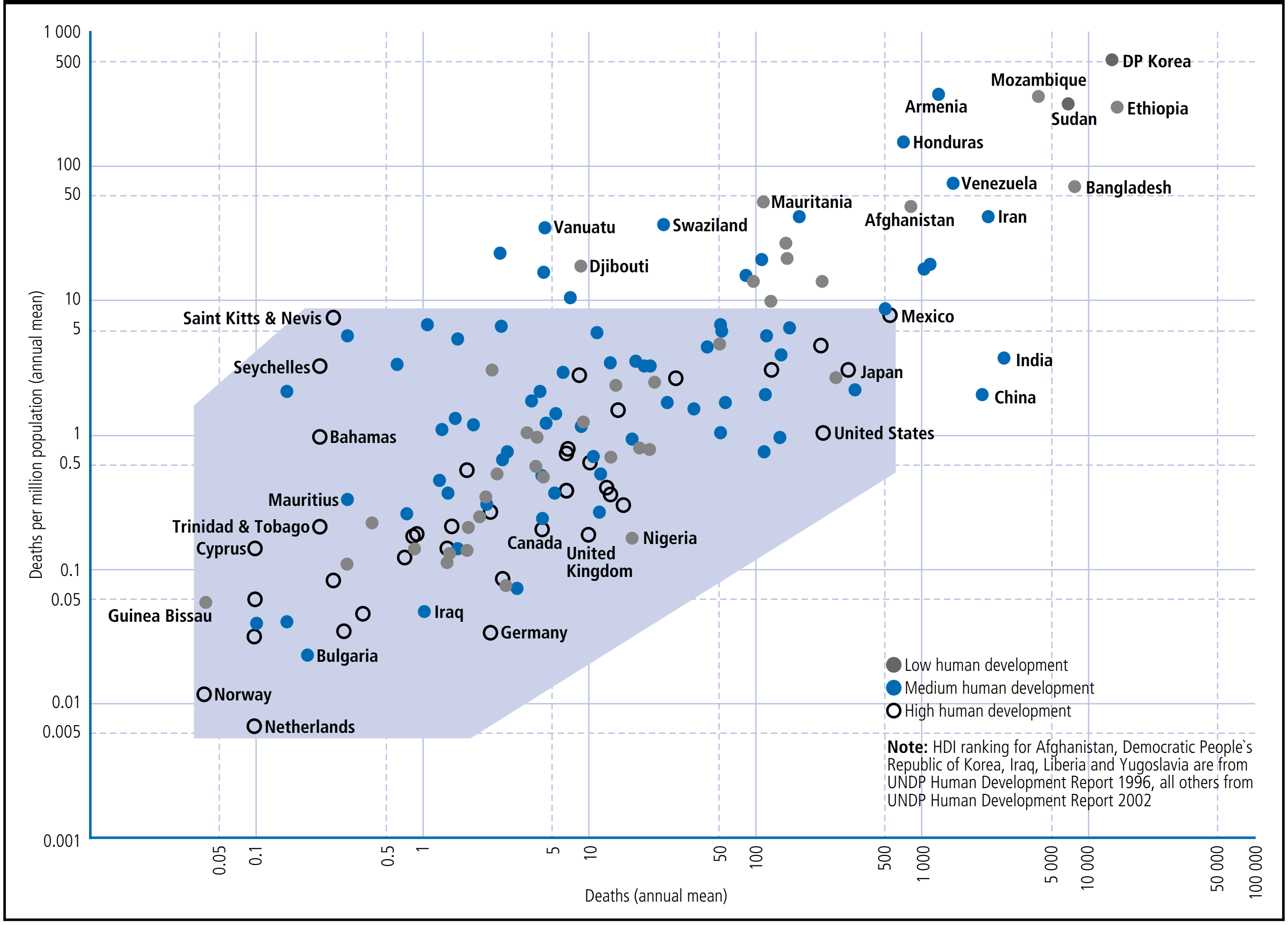
In the DRI, countries are indexed for each hazard type according to their degree of physical exposure, their degree of relative vulnerability and their degree of risk.

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).[1]

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.[2]

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.

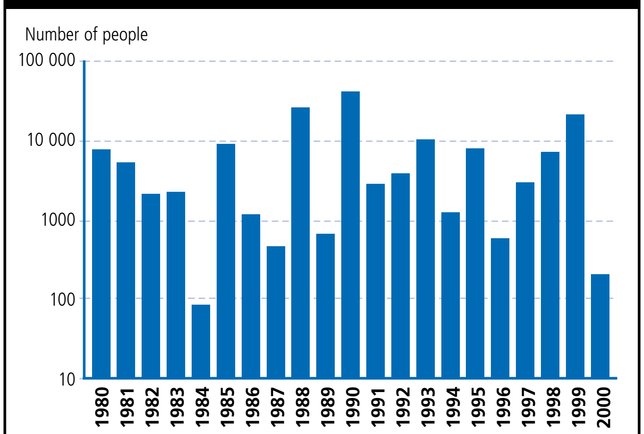
Clearly the variables that could be tested are those that were available in global datasets. This implies that there may be other variables that potentially might help build a better correlation with risk, but for which no global datasets were available at the time of production of the DRI. The choice 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.

FIGURE 2.2 PEOPLE KILLED BY EARTHQUAKES, 1980-2000



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

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