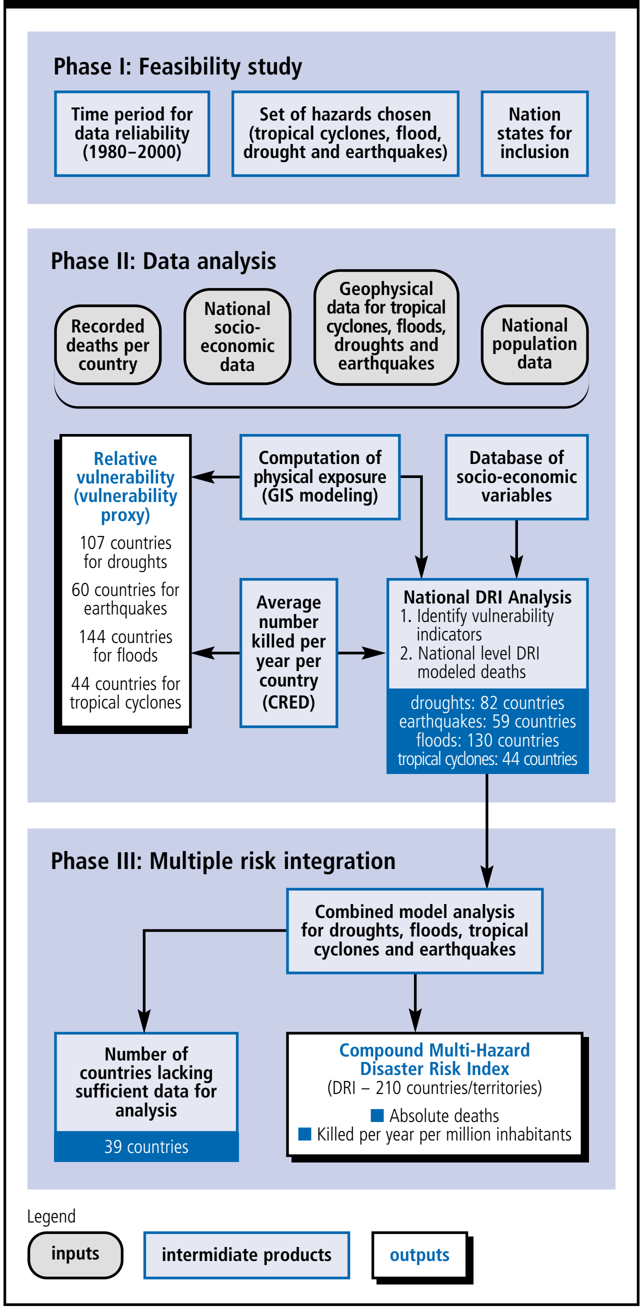
Physical Exposure: Elements at risk, an inventory of those people or artefacts that are exposed to the hazard.[2]

In the DRI: Physical exposure refers to the number of people located in areas where hazardous events occur combined with the frequency of hazard events.

Human Vulnerability: A human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard.

In the DRI: Human vulnerability refers to the different variables that make people more or less able to absorb the impact and recover from a hazard event. The way vulnerability is used in the DRI means that it *also* includes anthropogenic variables that may increase the severity, frequency, extension and unpredictability of a hazard.

FIGURE T.1 FLOW CHART OF THE GLOBAL RISK AND VULNERABILITY TREND PER YEAR (GRAVITY) PROJECT



Natural Disaster: A serious disruption triggered by a natural hazard causing human, material, economic or environmental losses, which exceed the ability of those affected to cope.

In the DRI: Disasters are a function of physical exposure and vulnerability.

Risk: The probability of harmful consequences or expected loss (of lives, people injured, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Risk is conventionally expressed by the equation Risk = Hazard + Vulnerability.

In the DRI: Risk refers exclusively to loss of life and is considered as a function of physical exposure and vulnerability.

T.2 Sourcing Data

T.2.1 EM-DAT Database

The DRI exercise is calibrated against the mortality data in the EM-DAT global disaster database. It is important to be clear about the data collection and management methods employed by EM-DAT.

The Centre for Research on the Epidemiology of Disasters (CRED) maintains the EM-DAT database at the University of Louvain in Belgium. Events that conform to a consistent definition of a disaster are included in the database. Such events meet at least one of the following criteria: 10 or more people reported killed; 100 people reported affected; a call for international assistance; and/or a declaration of a state of emergency. Information on losses comes from secondary sources (government reports, the International Federation of the Red Cross and Red Crescent Societies (IFRC) and other disaster relief agencies, Reuters, reinsurance company assessments) and is cross-checked where possible. These criteria exclude smaller loss events which are not considered disasters.

One important quality of EM-DAT is its management by an independent academic institution that encourages public access and scrutiny of the dataset. Great care is taken to verify disaster reports and emphasis is placed on the higher confidence that can be placed on the accuracy of deaths over those injured, made homeless or affected by disaster, although information is also made available for these categories.

Two other global disaster databases are maintained by the Munich Re Group and Swiss Reinsurance Company, but are not publicly available. A study by CRED (commissioned by the ProVention Consortium[3]) carried out a comparison of EM-DAT, Swiss Re and Munich Re natural disasters databases for four countries (Honduras, Mozambique, India and Viet Nam) between 1985 and 1999. Although the report stated that all three databases furnish the world community with 'acceptable levels of data on disasters',[4] it discovered significant variations among these datasets in both the events recorded and losses reported.

These differences were explained by differences in recording practice: what date each event is given, differences in classificatory methodology for each hazard type (a problem if one hazard triggers another) and the multiple entry of a single disaster event. As a result, the study found considerable differences between the datasets in the number of people affected (66 percent) and to a lesser extent the number of deaths (37 percent) and physical damage (35 percent). This is not surprising, since the definition of people affected varies enormously from disaster to disaster and from reporting source to reporting source. It is the most difficult impact variable to quantify and for this reason has not been used in the DRI work. The report also showed that the differences between the databases reduced significantly with time. This reflects EM-DAT's practice of reviewing its databases to incorporate updated information as it becomes available, even years after an event. A main weakness with global disaster data is the lack of standardised methodologies and definitions. This weakness is being addressed through the development of a unique global identifier for disaster reporting, the GLIDE system discussed in Chapter 2.

As mentioned above, EM-DAT explicitly excludes events where the loss is below defined threshold levels. A study undertaken on behalf of the ISDR Working Group 3 on Risk, Vulnerability and Impact Assessment, compared national disaster databases developed using the DesInventar methodology with the EM-DAT databases in four countries (Colombia, Chile, Panama and Jamaica). In all four countries, small-scale disasters with losses below the EM-DAT threshold represented a variable proportion of total disaster loss. Additionally, the national databases contained data on a number of medium-scale disasters that were above the EM-DAT threshold, but which were not captured by international reporting. It is impossible to arrive at a firm conclusion from a four-country study regarding what percentage of total disaster loss is not captured by international reporting, and in any case this will vary from country to country. Again, the adoption of a unique identifier such as GLIDE in both national and global databases like EM-DAT should progressively improve the consistency of disaster reporting.

Given that the DRI is calibrated against mortality data from EM-DAT, under- or over-reporting of this variable in EM-DAT would affect the DRI results. However, the DRI takes into account the varied reporting for individual disasters by basing its analysis on average losses over a 20-year period (1980-2000). The EM-DAT database provides a very good sample of total disaster loss in this period with a national level of resolution.

This period provides a reasonable length of time to account for fluctuation in the occurrence of most hazard types and also coincides with the most reliable period of data collected in EM-DAT. Figure T.2 shows the total number of disasters recorded by EM-DAT from 1900 to 2000. The upward trend at first suggests an exponential increase in disaster frequency. However, improvement in disaster reporting is a substantial

FIGURE T.2 DISASTERS RECORDED BY EM-DAT

Source: EM-DAT: The OFDA/CRED International Disaster Database contributing factor.[5] While one cannot rule out that the number of hydrometeorological hazard events may have increased, the upward trend in reported disasters is more likely to be tied to improvements in telecommunication technology and the increasingly global coverage of different information networks. This makes the reporting and recording of disaster losses more possible today than in the past.

T.2.2 Choice of hazard types

The decision to limit the DRI to earthquake, tropical cyclone, flood and drought was based on two factors. First, the dominance of these hazard types in being associated with lives lost to disaster in past records (94.43 percent). Secondly, the availability of usable geophysical and hydrometeorological data to model each hazard's comparative extent and potential severity of impact. Data had to be available at the global level but detailed enough to map risk within each country.

During a preliminary investigation, volcanic eruptions were also considered. They were finally excluded because of the complexity of modelling the spatial extent of volcanic hazard events. Other types of hazards that may lead to disasters and influence the process of human development, such as technological and biological hazards, are not covered by the DRI, nor are natural hazards with more prominence at the local scale such as landslides. These could be included in the future when global datasets of events with national resolution come into use.

T.2.3 Choice of country cases

The DRI exercise aims to include all sovereign states in its analysis. This is compromised in two ways. First, there are varying levels of data availability. The decision here was to include all states from the outset, but discount those with inadequate data from detailed analysis. This partly accounts for the uneven number of states entered into the hazard-specific analyses. Secondly, a number of territories are classified as dependent territories or overseas departments. Such dependencies are often small islands or enclaves geographically distant from, but politically and administratively tied to, sovereign states such as France, the United Kingdom, USA or China. Overseas territories and sovereign states often exhibit very different socio-economic and environmental characteristics and hazard profiles. Where possible such territories have been analysed in their own right.

T.2.4 Outline formula and method for estimating risk and vulnerability

The formula used for modelling risk combines its three components. Risk is a function of hazard occurrence probability, the element at risk (population) and vulnerability. The equation below was made for modelling disaster risk.

0 (hazard) x population x vulnerability = 0 (risk)

The three factors used to construct this statistical explanation of risk were multiplied with each other. This meant that if the hazard was null, then the risk was null. The risk was also null if nobody lived in an area exposed to hazard (population = 0). The same situation held if the population was invulnerable (vulnerability = 0, induce a risk = 0).

From this, a simplified equation of risk[a] was constructed:

EQUATION 1 RISK

EQ1 $$R = H \cdot Pop \cdot Vul$$

Where
- R is the risk (number of killed people.
- H is the hazard, which depends on the frequency and strength of a given hazard
- Pop is the population living in a given exposed area
- Vul is the vulnerability and depends on the socio-politial-economical context of this population

Hazard multiplied by the population was used to calculate physical exposure.

EQUATION 2 RISK EVALUATION USING PHYSICAL EXPOSURE

EQ2 $$R = PhExp \cdot Vul$$

Where
- PhExp is the physical exposure, i.e. the frequency and severity multiplied by exposed population

Physical exposure was obtained by modelling the area affected by each recorded event. Event frequency was computed by counting the number of events for the given area, divided by the number of years of observation (in order to achieve an average frequency per year). Using the area affected, the number of people in the exposed population was extracted using a Geographical

a. The model uses a logarithmic regression, the equation is similar but with exponent to each of the parameters.

EQUATION 3 ESTIMATION OF THE TOTAL RISK

EQ3 $$Risk_{Tot} = \sum(Risk_{Flood} + Risk_{Earthquake} + Risk_{Volcano} + Risk_{Cyclone} + ...Risk_n)$$ [b]

Information System (GIS). The population affected multiplied by the frequency of a hazard event for a specified magnitude provided the measure for physical exposure.

Socio-economic variables that could be statistically associated with risk were identified by replacing the risk in the equation with deaths reported in EM-DAT. A statistical analysis was then run to identify links between socio-economic and environmental variables, physical exposure and observed deaths.

The magnitude of events was taken into account by drawing a threshold above which an event is included. In the case of earthquakes, the threshold was placed at 5.5 on the Richter scale. Then the magnitude was partially taken into account by approaching the size of the area affected in relation to the magnitude, for the computation of physical exposure. Estimating event magnitude for use in global assessments is an area where there is great scope for improvement.

Scores for aggregated hazard deaths were calculated at the national level. Expected losses due to natural hazards were equal to the sum of all types of risk faced by a population in a given area. This is summarised in Equation 3 above.

The multi-hazard risk for a country required calculating an estimate of the probability of the occurrence and severity of each hazard, the number of persons affected by it, and the identification of the population's vulnerability and coping capacities. This is very ambitious and not achievable with present data constraints. However the aim is to provide an approach built on existing data that will be refined in subsequent runs of the DRI.

T.3 Choice of Indicators

T.3.1 Spatial and temporal scales

The DRI exercise was performed on a country-by-country basis for the 249 countries defined in the GEO reports.[6]

The socio-economic variables used in the analysis of risk needed to be available to cover the 21-year period under analysis. This period was from 1980 to 2000. The starting date was set at 1980 because access to information (especially on victims) was not considered reliable or comparable before this year. The variables introduced in Equation 2 were aggregate figures (sum or average) of the available data for that period, with the following major exceptions:

- Earthquake frequencies were calculated over a 36-year period, due to the longer return period of this type of disaster. The starting date for the first global coverage on earthquakes measurement is 1964.
- Cyclones frequencies were based on annual probabilities provided by the Carbon Dioxide Information Analysis Center (CDIAC).[7]
- HDI was available for the following years: 1980, 1985, 1990, 1995 and 2000. However, algorithms were applied for computation of every year between 1980 and 2000.
- Population by grid cell (for physical exposure calculations) was available for 1990 and 1995.
- The Corruption Perception Index (CPI) was available for 1995 to 2000.

T.3.2 Risk indicators

Risk can be expressed in different ways (for example by the number of people killed, percentage killed or percentage killed as compared to the exposed population). Each measure has advantages and inconveniences (see Table T.1 on the following page).

The DRI work used two indicators for each hazard type: the number of killed and killed per population. The third indicator is used to indicate relative vulnerability. Exposed populations to different hazards should not be compared as stated in the Report without standardisation.

T.3.3 Vulnerability indicators

Table T.2 (see following page) hows those socio-economic and environmental variables chosen to represent eight separate categories of vulnerability.

b. In the case of countries marginally affected by a hazard type, the risk was replaced by zero if the model could not be computed for this hazard.