Visions of Risk

A Review of International Indicators of Disaster Risk and its Management

PHOTO: GUSTAVO WILCHES-CHAUX

A Report for the
ISDR Inter-Agency Task force on Disaster Reduction
Working Group 3:
Risk, Vulnerability and Disaster Impact Assessment

December 2004

Visions of Risk: A Review of International Indicators of Disaster Risk and its Management

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Mark Pelling
King's College, University of London

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Foreword by

Sálvano Briceño
Director, ISDR secretariat

The limited availability and access to information on vulnerability, hazard and disaster impacts often prove a hindrance to the work of decision makers and disaster risk practitioners. Poor quality data and efficient tools such as indexes and comprehensive databases can undermine their efforts to reduce risk and vulnerability to disasters worldwide. Measuring progress without clear indicators is almost impossible.

Coordinated by the UN Development Programme (UNDP), *Vision of Risks: A Review of Global Indicators of Disaster Risk and its Management* reviews three important initiatives which represent the first comprehensive global and regional assessments of disaster risk: the Disaster Risk Indexing project (DRI) of the UNDP in partnership with in partnership with the UN Environment Programme-Global Resource Information Database (UNEP-GRID); the Hotspots indexing project implemented by Columbia University, the ProVention Consortium (under the umbrella of the World Bank), and the Americas programme of IDEA in partnership with the Inter-American Development Bank (IADB).

In 2000, the Inter-Agency Task Force on Disaster Reduction (IATF/DR) identified risk, vulnerability and disaster impact assessment as a priority for its work. Accordingly, the Task Force established a Working Group under the leadership of UNDP's Bureau of Crisis Prevention and Recovery whose goal is to contribute to sustainable reduction in disaster risk by incorporating approaches, methods and tools for risk, vulnerability and impact assessment in risk reduction processes. The Working Group played a key role in advancing the subject, identifying present and future challenges to be addressed.

The recommendations of *Vision of Risks: A Review of Global Indicators of Disaster Risk and its Management* will make a valuable contribution to the discussions at the World Conference on Disaster Reduction (Kobe, 18-22 January 2005) within the context of governance and institutional and policy frameworks for risk reduction. The report will also support the establishment of a comprehensive framework through which to identify the performance of national disaster risk management systems and to develop, with the authorities in participating countries, appropriate risk management solutions.

Preface by

Andrew Maskrey
Chair, ISDR/IATF Working Group 3 on
Risk, Vulnerability and Disaster Impact Assessment

Managing disaster risks presents different challenges than managing disasters. In disaster situations, the damages are all too evident and the needs all too clear. The risk factors that led to the disaster, on the other hand, are very often hidden – largely invisible to policy-makers and the general public, and even to disaster and development professionals. It is only after these risk factors and the latent risks have become manifest that the call to action is made. By then it is too late, however. The damage has been done.

Risk management offers an alternative to disaster management. Risk management seeks to address the root causes of disasters, reducing the exposure and vulnerability of people and economic assets in order to reduce losses. Cost effective risk management requires being able to identify where hazards are most likely to strike, who or what will be exposed, and what vulnerabilities will lead to those assets being damaged or destroyed. Risk management, therefore, depends not on identifying the consequences of disasters but rather the causes. These causes need to be made visible and real so that the risks can be perceived, understood and reduced.

Since 2000 a Working Group on Risk, Vulnerability and Disaster Impact Assessment has been working to improve the evidence base for global disaster risk management. This group, Working Group 3 of the Inter-Agency Task Force of the International Strategy for Disaster Reduction, brought together experts from the United Nations and other international organizations, the private sector and academia.

Cooperation among the participants assisted with coordination among three major efforts to assess worldwide disaster risks and risk factors. The first of these was a global report issued by UNDP in 2004 called *Reducing Disaster Risk: A Challenge for Development*. A second, *Natural Disaster Hotspots: A Global Risk Analysis*, is due to be published in early 2005 as collaboration between Columbia University and the World Bank under the umbrella of the ProVention Consortium. The third, *Indicators for Disaster Risk Management in the Americas*, a collaboration between the Inter-American Development Bank and the National University of Colombia, Manizales, has produced initial results for twelve countries in Latin America and the Caribbean.

Together these three efforts constitute a major effort to apply consistent theory, complementary methods, and the best available data to assess vulnerability and risk levels, identify risk factors, and suggest where investments in risk reduction are most needed. The following report compares and contrasts the three initiatives.

As chair of Working Group 3, I hope that this comparative analysis assists in understanding the similarities and complementarities between the analyses described below. Collectively they have established a foundation upon which future efforts can be built. Understanding what has been done, and what remains to be done, to advance the field of risk identification and therefore of risk management is an important contribution to that end.

The present report is also a contribution to a new initiative being prepared under the auspices of the ProVention Consortium: the Disaster Risk Assessment Programme (DRiskMAP). The main objective of Disaster RiskMAP will be to improve the evidence base for disaster risk management and thus enable the application and prioritisation of effective disaster risk reduction strategies at the national, regional and global scales. The program will add synergy to, and improve coordination between, a number of ongoing international initiatives, providing an active network where international organisations and UN agencies, international financial institutions and donors, governments, regional organizations, research institutes, the private sector and NGOs can share knowledge, information, expertise and resources. A number of key organisations, including UNDP, World Bank, IADB, Columbia University, CRED, OCHA Relief Web, ADRC and LA RED, have pledged support towards this next step in taking forward the DRiskMAP idea to establish an active program and network. The World Conference on Disaster Reduction in Kobe, Japan offers an important next point of departure to engage wider interest, support and, above all, broad participation in this collaborative initiative.

The drafting of this report was commissioned to Dr. Mark Pelling, geographer from Kings College, London. The original idea for the study emerged at a meeting of Working Group 3 in hosted by the Inter-American Development Bank in Washington D.C. in March 2004 and where the initial results from all three initiatives were presented in a comparative framework. Further opportunities for comparing methodologies and findings occurred at the presentation of the Hotspots Project in Oslo in September 2004, hosted by the Norwegian Geotechnical Institute and at the presentation of the Indicators for Disaster Risk Management of the Americas Project in Manizales in November 2004, hosted by the National University of Colombia.

On behalf of the ISDR Inter Agency Task Force I would like to particularly thank the following people and institutions who have made invaluable contributions to the present report: Maxx Dilley, Silvia Mosquera and colleagues from the International Institute for Global Climate Prediction (IRI) at Columbia University; Omar Dario Cardona and colleagues from the Instituto de Estudios Ambientales (IDEA) of the Universidad Nacional de Colombia; Pascal Peduzzi and colleagues from UNEP-GRID, Geneva; Caroline Clarke and Kari Keipi of the Inter-American Development Bank; Margaret Arnold of the Hazard Management Unit of the World Bank; Oddvar Kjekstad of the Norwegian Geotechnical Institute; Mohammed Abchir of the ISDR Secretariat and David Peppiatt of the Secretariat of the ProVention Consortium. We are particularly grateful to Gustavo Wilches-Chaux for the cover photograph.

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Abbreviations

DDI	Disaster Deficit Index
DRI	Disaster Risk Index
LDI	Local Disaster Index
PVI	Prevalent Vulnerability Index
RMI	Risk Management Index
MCE	Maximum Considered Event
BCPR	Bureaux for Crisis Prevention and Recovery
CIESIN	Center for International Earth Science Information Network
DFID	UK Department for International Development
EM-DAT	The OFDA/CRED International Disaster Database
GDP	Gross Domestic Product
GIS	Geographical Information System
GLIDE	Global Identifier Number
GRID	Global Resource Information Database
GPW	Gridded Population of the World
GSHAP	Global Seismic Hazard Program
IDEA	Instituto de Estudios Ambientales, Universidad Nacional de Colombia - Sede Manizales
IDB	Inter American Development Bank
IRI	International Resources Institute
ISDR	International Strategy for Disaster Reduction
PAHO	Pan American Health Organisation
SIDS	Small Island Developing States
UN-HABITAT	UN Human Settlements Programme
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WG3	Working Group Three of the ISDR

Contents

Figures and Tables

Executive Summary

This report reviews the performance and future possibilities for disaster risk indexing drawing on three international indexing initiatives. These initiatives provide the first comprehensive global and regional assessments of disaster risk. They point towards the ways in which indexing can contribute to enhanced transparency and effectiveness in development planning and disaster management.

The three projects under review are the Disaster Risk Indexing project (DRI) of the UNDP in partnership with UNEP-GRID; the Hotspots indexing project implemented by Columbia University and the World Bank, under the umbrella of the ProVention Consortium, and the Americas programme of IDEA in partnership with the InterAmerican Development Bank (IDB). Each project was based on a conceptual framework that included particular understanding of the factors contributing to human vulnerability and disaster risk. Co-operation between the project teams was facilitated by Working Group Three (WG3) of the ISDR, chaired by UNDP. This Report has been commissioned as an activity of WG3 and presents a comparative review of the outputs and methods of each project.

The executive summary presents a review of the results of the indexing projects, a comparison of project methodologies, opportunities for verification and complementarity between the indexing programmes, and recommendations for further work.

Disaster Risk Revealed

The projects present the first global overviews of disaster risk. Findings include:

- 75 per cent of the world's population live in areas that have been affected at least once by earthquake, tropical cyclone, flood or drought between 1980 and 2000. The geographical inequality of disaster risk is demonstrated in the finding that while only 11 per cent of the people exposed to natural hazards live in countries classified by UNDP as low human development, these countries account for more than 53 per cent of total deaths to disaster (DRI).

- 160 countries have more than one quarter of their total population in areas at relatively high mortality risk from one or more hazards. More than 90 countries have in excess of ten per cent of their total population residing in areas at relatively high risk from two or more hazards. In 35 countries at least five per cent of the population are relatively highly at risk from three or more hazard types (Hotspots).

Together, the projects provide the first structured analysis of loss from individual hazard types at global and regional scales. The DRI and Hotspots offer a global picture built up from sub-national and national data. In the case of flood hazard for example:

- About one third of the world's land area is exposed to flooding. Flood prone places contain a high proportion of the world's economic assets and population, e.g., 82 per cent of world population resides in flood exposed places (Hotspots).

- Those countries with the largest absolute numbers of people exposed to flooding include India, China, Bangladesh, Indonesia and Pakistan. When population exposed is calculated as a proportion of national population smaller states were indicated as having most exposure to flooding; Bhutan, Afghanistan, Ecuador, Myanmar and Nepal top the list. In both cases Asian states contain the greatest human exposure to flooding (DRI).

The DRI provides the first global view of human vulnerability, with national resolution. Two global indicators of vulnerability were developed.

- The Relative Vulnerability index compared national data for populations exposed with recorded mortality. In the case of floods, for the period 1980-2002 Venezuela exhibited the greatest vulnerability, reflecting the high mortality triggered by flooding in 1999. This is attributed to a single large flood event, which contained a number of landslide events.

- Key socio-economic indicators for national level human vulnerability were identified for individual hazard types. In the case of flood hazard disaster risk was associated with countries having high proportions of their population exposed to floods, and vulnerability from:
    - low GDP per capita, and
    - low density of population.

  This suggests that investments in reducing mortality to flooding might be best directed to poor, rural populations with high flood exposure. This is the first time such policy advice has been produced through a statistical analysis at the global level and for multiple hazard types, that can work alongside expert judgement.

Hotspots developed three indices of disaster risk and mapped global disaster risk with sub-national resolution for individual hazard types.

- Risk of mortality, risk of economic loss and risk of economic loss as a proportion of GDP were mapped by Hotspots. Flood risk is widely distributed across the globe with Asia showing the greatest area at risk. When risks of mortality and economic loss to flooding are compared, the geography of highest risk shifts from the global South - places in Central and South America and sub-Saharan Africa (relatively high mortality risk) to the global North - Europe, North America and the Middle East (relatively high economic risk).

Global multi-hazard disaster risk indexes were built by combining assessments of vulnerability for individual hazards.

- Hotspots mapped sub-national multi-hazard risk for economic loss and mortality. Risks associated with six hazards were calculated: floods, cyclones, drought, earthquake, landslides and volcanoes. A large number of populous regions recorded risk by both mortality and economic loss including: Central America, the Caribbean, Mediterranean states, the Himalayas, and Pacific rim states in Asia and the Americas. Sub-Saharan Africa shows high risk of mortality.

- A multi-hazard DRI based on mortality was developed from the combination of socio-economic vulnerability indicators identified for each hazard type. Risks associated with four hazards were initially calculated: earthquake, flood, cyclone and drought. Countries were grouped into five classes of disaster risk indicated by mortality. Calculated national multi-hazard mortality had a close fit when compared with recorded national multi-hazard mortality.

Changing focus from the global to the national level, the Americas programme has produced four indexes that describe individual components of national disaster risk and applied them to 12 countries in the Americas.

- The Disaster Deficit Index calculated national financial capacity to respond to disasters with 50, 100 and 500 year return periods. A 50 year return period event exceeded the financial capacity to recover of Chile, Peru, the Dominican Republic and El Salvador, while absolute economic loss was greatest for Chile and Mexico.

- The Local Disaster Index described the national accumulation of disaster risk from locally and nationally recognised events. Examples of countries registering high mortality during locally and nationally recognised disasters were Colombia and Ecuador, with Guatemala and the Dominican Republic showing high numbers of people affected. The spatial concentration of losses can indicate uneven geographies of development and disaster risk, this was observed in Ecuador, Peru, Chile and Colombia.

- The Prevalent Vulnerability Index calculated socio-economic vulnerability at the national level. Countries with high socio-economic vulnerability included Jamaica, Guatemala and El Salvador.

- The Risk Management Index measured disaster risk management performance using the self-evaluation of national experts following a common rubric. National actors in Chile and Costa Rica evaluated their performance as very high in disaster risk reduction. Experts in Argentina and Ecuador ranked low their national performances particularly in the areas of risk governance and financial protection.

The Indexing Projects

Here the aims, scope and conceptual characteristics of the indexing programmes, and possible future directions based on the work reported in this document are identified.

Aims and Scope

The DRI focused on indexing vulnerability and the development processes that contributed to vulnerability. Vulnerability was calculated using mortality as the outcome of interest. The DRI is global in scope with a national level resolution. It is targeted at national and international policy-makers.

Hotspots aimed to map natural disaster 'hotspots', areas at relatively high risk from one or more natural hazards. Three separate risk indexes were developed, with mortality, economic loss and economic loss as a proportion of GDP as the outcomes of interest. The index is global in coverage and presented through a series of maps with sub-national resolution. The index results were primarily targeted at the international community but are also relevant for national and sub-national planning.

The Americas programme built a suite of four indexes. Two measured particular aspects of vulnerability at the national level: The Disaster Deficit Index (DDI) examined financial exposure and gaps in capacity to finance disaster losses, and the Prevalent Vulnerability Index (PVI) measured socio-economic vulnerability. The Risk Management Index (RMI), together with the DDI, is the first international effort to assess institutional performance in disaster risk reduction. These indexes used an intrinsic understanding of vulnerability – in contrast with the DRI and Hotspots where vulnerability was measured in relation to specified individual or multiple hazard types. The fourth index, the Local Disaster Index (LDI) assessed accumulated national risk from disaster events that had been noted locally. The four indexes were applied in 12 countries in the Americas. Targeted at national decision-makers, they are also of interest to international agencies supporting risk management in the Americas.

The three indexing programmes shared a common theory of disaster causality – that losses in disasters are caused by three sets of factors: exposure to hazard, the frequency or severity of hazard and the vulnerability of exposed elements. Beyond this, the DRI and Hotspots also shared a deductive approach, building indexes from historical data. The Americas programme took an inductive approach modelling disaster risk from a range of input variables.

DRI and Hotspots indexes also utilise common datasets and have collaborated in the generation of GIS hazard maps. Both indexes incorporate data on medium and large scale disaster losses reported in the EM-DAT disaster database. Despite these similarities the DRI and Hotspots have developed different methodologies fitting their contrasting aims. An important difference is that the DRI socio-economic vulnerability and disaster risk is calibrated to disaster mortality, whereas in Hotspots EM-DAT data on mortality and economic loss are used as a source of vulnerability weights for calculating grid-cell-level disaster risk. The LDI of the Americas programme used national data, including locally recorded disaster losses from the DesInventar database and local records of large disasters, some of which may also be recorded in EM-DAT.

Theoretical and methodological similarities between the indexes offer scope for verification of results and the possibility of future consolidation and complementarity.

Future Potential

Scope for further development can be found in each of the indexing programmes. In the DRI work contributing to the identification of socioeconomic indicators for hazard specific and multi-hazard disaster risk would be most useful. In Hotspots there is potential for developing a more detailed analysis of results which at present are presented with a sub-national resolution at the global scale. Opportunities for grouping data to make comparisons of disaster risk, for example between urban agglomerations or small island states could be explored. The next step for the Americas programme is to apply its suit of indexes in the assessment of the remaining countries in Latin America and the Caribbean, and beyond.

Scope for methodological integration of the indexes is limited by the contrasting deductive and inductive approaches. However, differences in methodology create opportunities for the independent verification of outcomes, and for potential complementarity.

Five avenues for verification have been identified, which might form the starting point of any future collaboration:

i) Comparison at the national level between mortality risk indexes of the DRI and Hotspots.

ii) Comparison between the PVI, RMI (and possibly the DDI) of the Americas programme and the socio-economic vulnerability method of the DRI.

iii) Comparison between local hazard exposure data mapped into GIS by the DRI and Hotspots where methodologies or data differed, for example in flood hazard.

iv) Comparison between the national disaster losses as represented by the Americas programme LDI and the multi-hazard risk indexes of the DRI and Hotspots as part of an analysis of the influence of the DesInventar and EM-DAT databases, as well as the project methodologies on national disaster risk indexes.

v) Comparison of the vulnerability levels calculated by Hotspots for 28 country region/wealth groups, with the national vulnerability ranks calculated by DRI, to verify the lack of bias introduced by the Hotspots aggregation methodology.

Further work might examine complementarily between the indexes. Work could examine:

i) Complementarity between the deductive approach of the DRI and Hotspots global sale indexes and the Americas programme indexes built inductively.

ii) Complementarity between the hazard specific assessments of vulnerability developed in the DRI and Hotspots and the intrinsic view of vulnerability built in the PVI of the Americas programme.

iii) Complementarity between the characterisation of risk management performance of the Americas programme RMI and DDI with the characterisation of risk used in the DRI and Hotspots.

Together, the indexes presented in this report represent an important step toward the development of knowledge based disaster risk management. In the medium- to long-term these indexes could usefully help the development of:

i) International benchmarks and national targets for disaster risk and disaster risk management performance.

ii) Coupled assessments of disaster risk and risk management performance that marry cross-country indexes with in-depth assessments of national and sub-national disaster loss and disaster risk management performance.

Recommendations

1. Establish a co-ordinated international disaster risk management assessment programme

The programme could be global or regional in scope. It would draw on experts from a range of national agencies and centres of excellence. Core elements of a possible programme agenda are presented below as Recommendations 1 - 4.

2. Review index methodologies for verification, consolidation and expansion

Facilitate a comparison of the results of DRI, Hotspots and Americas programmes. This would serve as a mechanism for the verification of findings, for exploring the advantages and disadvantages of consolidation amongst the indexes and for examining prospects for extending the scope of the indexes. In particular potential for developing benchmarking tools should be explored.

3. Launch a programme of country-level assessments of disaster risk and risk management performance.

Apply a consolidated suite of national and sub-national versions of the indexes of disaster risk and risk management performance following the outcome of work conducted as part of Recommendation 2. National and sub-national assessments should aim to provide a minimum of standardised data with which to build common indices of risk and risk management performance. This should contribute to the improvement of in-country capacity for risk management policy making, and to enable cross-country comparisons.

The programme would build on the international and national human resources already developed under the individual indexing programmes.

4. Disseminate Effectively.

Dissemination of the findings of a co-ordinated disaster risk indexing programme should be targeted at the development as well as the disaster risk communities and professions.

The following recommendations complement the core activities of a co-ordinated international disaster risk management assessment programme and are targeted at general efforts to improve disaster risk and risk management indicators and indexing.

5. Encourage stakeholder participation

Where possible, the application of indexes should be complemented by a discursive mode where policy makers can contribute to the review of key variables and index components. Opportunities for collaboration with local vulnerability and capacity assessment initiatives, and the complementarity of results, should be explored.

6. Improvements in data

Improvements are underway to enhance the comprehensiveness and global accessibility of data on hazard, disaster impact and socio-economic variables influencing vulnerability. More work is needed.

7. Build an integrated framework for the collection of disaster impact data

The GLIDE[1] initiative provides an existing resource for connecting sub-national and national data on disaster. The initiative should be supported.

[1] http://www.unisdr.org/task-force/eng/about_isdr/tf-meeting-6th-eng.htm and www.glidenumber.net

Chapter 1. Introduction

The impact of natural disasters on development is growing. In September 2004 alone in the Caribbean, three hurricanes in succession led to over 1,800 deaths in Haiti[1]. High mortality in Haiti contrasted with high economic losses in the southern US showing how development status shapes the manner in which a natural hazard event can become a 'natural' disaster.

It is increasingly argued that reducing disaster loss requires disaster risk reduction strategies. A key barrier in the promotion of disaster risk reduction strategy, that is linked to appropriate development policy, arises from a lack of a common assessment methodology to observe and characterise disaster risk and disaster risk management. Such tools can provide transparency in decision-making for risk reduction and a means of tracking national progress in disaster risk management. It is this challenge that the three indicators reviewed in this Report have risen to meet. The challenge is great: limited availability and access to data on vulnerability, hazard and disaster impact constrain what is possible. But the three indicator programmes reviewed here have made considerable headway and point the way for establishing a comprehensive framework through which to profile risk and the performance of national disaster risk management systems and to develop, with the authorities in participating countries, appropriate risk management solutions. An ongoing assessment using indicators can help provide continuity, encouraging action to improve disaster risk management even in periods of relative calm. Helping to identify the strengths and vulnerabilities of a country and its disaster risk management system helps to orient national resources and international cooperation in building and strengthening robust national systems.

In this chapter each of the indicator programmes are introduced in turn, as well as the facilitating function of Working Group Three of the ISDR. This is followed by discussion on the more general nature of indicators and their contribution in development and disaster risk reduction management. Finally the structure for the Report is presented.

1.1 The Indicator Programmes

The three indicator programmes are the results of partnerships between scientific institutes and funding agencies.

- DRI by UNEP/GRID-Geneva and UNDP[2].
- Hotspots by Columbia University, the World Bank and numerous collaborating partners[3].
- The Americas programme by the Instituto de Estudios Ambientales, Universidad Nacional de Colombia - Sede Manizales and the InterAmerican Development Bank[4].

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[1] http://www.reliefweb.int/w/rwb.nsf/UNID/F4CB15DD9D4C9A7F85256F20006583FA?OpenDocument
[2] See http://www.undp.org/bcpr/disred/rdr.htm and http://gridca.grid.unep.ch/undp/
[3] http://www.proventionconsortium.org/projects/identification.htm
[4] http://idea.unalmzl.edu.co/

Each programme has specific goals, which direct the character of each indicator, its conceptualisation and methodological development. The DRI programme aims to identify the relationship between national development pathways and national level disaster risk. Hotspots' primary goal is to map at a sub-national scale those places exposed to multiple hazard risk. The Americas programme aims to look inside countries at their national levels of vulnerability and disaster risk management performance. Each programme has a conceptual framework and methodology to ensure cross-country comparison.

The simultaneous arrival of three independently conceptualised and developed disaster risk indicator programmes provides a unique opportunity for comparison and collaboration. This Report hopes to contribute by highlighting the comparative advantages of each indicator methodology, and to look for ways of developing each inicator individually and as part of a collective effort.

1.2 Working Group Three

Working Group Three (WG3) of the ISDR[5], chaired by UNDP-BCPR provided a forum for programme researchers to compare methodologies, share knowledge and prevent duplication of effort. This Report is a product of WG3, and as such is a summary of WG3 supported activity in this area, aiming to contribute to the progress of disaster risk indicators and indexing during the 2005 UN World Conference on Disaster Reduction and beyond.

WG3 is intended to have a limited lifespan and was tasked with supporting ways for bringing disaster risk reduction into development planning. WG3 aims to:

1. support co-operation in global and regional risk analysis by facilitating the sharing of information and ideas;
2. review the coverage, quality and accuracy of local, national and international reporting on disaster impacts;
3. support the development of local tools for vulnerability and risk assessment.

Progress in meeting the first objective is reported on here.

Progress towards the second objective is being achieved through support for the co-ordinated reporting of disaster loss data and the bringing together of data and reporting procedures on locally, nationally and internationally significant disaster events as enabled through the GLIDE initiative. Established in May 2004[6], GLIDE provides a common referencing system for recording disaster events. Its archive is public and can be accessed through the internet[7]. The resource can be used to compile disaster loss data and to search for individual events. In parallel to the GLIDE initiative, new possibilities for the involvement of Re-Insurance companies in the supply of non-commercially sensitive disaster loss and risk data may open new avenues for assessing disaster risk.

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[5] http://www.unisdr.org/eng/task%20force/tf-working-groups3-eng.htm
[6] http://www.unisdr.org/task-force/eng/ebout_isdr/tf-meting-6th-eng.htm
[7] http://www.glidenumber.net

Progress towards the third objective is being led by UN-HABITAT, which has sought to bring together good practice for local vulnerability and risk assessment. The leadership of UN-HABITAT reflects the growing significance of urban settlements as sites of disaster risk and loss.

1.3 What are Indicators and indexes?

Indicators and indexes both seek to represent a complex reality or abstract concept with summary values. They are useful tools for showing decision-makers where they are, which way they are going and how far they are from where they want to be. A good indicator or index should alert decision-makers to a problem before it gets too difficult to fix.

The distinction between an indicator and an index can be fuzzy. In this Report, an index is used specifically to refer to a numerical summary value providing information on the relative status of a unit of interest. The DRI has produced a multi-hazard mortality disaster risk index to compare risk status between countries, Hotspots has calculated mortality, economic loss and economic loss as a proportion of GDP disaster risk indexes applied to grid-cells. The objective of the Americas programme has never been to reduce reality to a single value and is rather conceived of as an indicators program. Its four indexes each applied to 12 countries include two compound indexes built through the aggregation of data on component sub-indicators. The status of these sub-indicators are themselves valuable results.

The character of an index comes from the particular elements and values chosen as important for measurement, the subjects and units (individuals, countries, etc) of analysis, the methodology used to generate the index from input data and the specific data sources used. Indexing approaches can be characterised as inductive or deductive. Inductive approaches model risk through weighting and combining different hazard, vulnerability and risk reduction variables. Deductive approaches are based on the modelling of historical patterns of materialised risk (Cardona, 2003). In this Report the Americas programme is an example of an inductive approach, the DRI and Hotspots programmes both follow deductive approaches. Inductive approaches are challenged by the absence of a universally accepted procedure for assigning values and weights to different inputs. Deductive approaches find it difficult to accurately reflect risk when disasters occur infrequently or where historical data is not available. The two approaches can support one another, for example with deductive indexes being used to validate results from inductive models.

Cardona (2003, drawing on PAHO (2001)) identifies seven criteria for assessing the quality of indexing and indicator methodologies:

1. Validity: the effectiveness with which it measures its target.
2. Reliability: the replicability of results.
3. Specificity: the indicator or index should only measure the phenomenon it intends to.
4. Measurability: input data should be available and easily obtained.

5. Comparability: outputs should be available for comparison between units and over time.
6. Cost-effectiveness: that the results justify their investment in time and money.
7. Redundancy: that each input variable should measure a discrete phenomenon.

Once indicators and indexes have been developed it is important to evaluate their use. The utility of an indicator or index is not only a product of its internal logic and robustness, but also of its ability to communicate a message. The message given should be simple and intuitive. This reduces the scope for contrary interpretations of index values from contrasting political, lay or expert judgements. For constructing disaster risk and risk management indicators and indexes, different definitions of acceptable levels of risk (those adopted in building codes for example) may be used but must be made explicit. Summing and weighting procedures invariably contain a degree of subjectivity. These and the identification of cut-off points for judging acceptability must all be carefully disclosed. Neither indicators nor indexes are politically or culturally neutral artefacts, as has been observed, 'we measure what we value, and value what we measure'[8]. It is at the stage of policy, as well as technical, discourse that notions of disaster risk acceptability should be considered. Thus, to the measures of indicator and index quality identified above, legitimacy might be added.

Even a combination of indicators and indexes should be seen as only one methodology among a broader array of tools for making visible disaster risk and risk management performance. Individual indexes can not capture all the relevant pressures and processes acting to produce disaster risk as it is experienced in the world. As with any indicator, reality is reduced down to those elements that have been judged to be the most essential in describing or understanding the phenomenon, in this case disaster risk and its management. It is for this reason that the three indexing/indicator programmes reviewed in this Report offer such a rich opportunity for improving our understanding of disaster risk and development. Each programme seeks to measure disaster risk from a particular conceptual framework so that the combined knowledge is greater than could be possible with a single approach.

1.4 Disaster Risk Indicators and Indexing in Context

Some of those risk modelling tools most closely related to the disaster indicators discussed in this Report have been developed by the insurance industry. This includes the development of models for hazard return periods and probable maximum loss. These tools use data on past disaster impacts to project future risk of loss as well as using weighted variables to develop loss models. The methodologies are largely applied only to assets with insured (or potential future insurance) value. This excludes many of the assets of low-income people and countries at risk. Competition within the insurance sector has meant public access to the methods and results of actuarial tools is restricted.

A broad range of disaster risk evaluation tools, including indicators and indexes, fall under the umbrella title of 'risk assessment tools', which the ISDR define as those tools

[8] UN (2001) Indicators of Sustainable Development: Guidelines and Methodologies, page 7, accessed from http://www.un.org/esa/sustdev/natlinfo/indicators/indisd-mg2001.pdf

which seek to: 'determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend'.[9]

Many tools have been developed to identify and map hazards and human vulnerability[10]. Local hazard assessments draw on hydrometeorological or geophysical data and models to evaluate and predict hazard exposure and are most useful for building construction and infrastructure planning. The different approaches used in assessing individual hazard types has made multi-hazard assessments difficult, but initiatives such as the World Meteorological Organisation's Comprehensive Risk Assessment for Natural Hazards have made progress. Multi-hazard assessment is increasingly using GIS technology to overlay hazard specific maps. Differences in local methodology have also hampered the development of global hazard assessments. Progress in this has been a major contribution of the Hotpsots and DRI indicator programmes.

The assessment and mapping of human vulnerability is less developed than hazard assessment work. Vulnerability assessments vary in the balance of social, economic and political characteristics included and in the extent to which environmental and ecological assets are included. For this reason, and because of the dynamic nature of human vulnerability, the aggregation of vulnerability assessment data has proven difficult. Food security and vulnerability to drought impacts have proven particularly difficult to assess. The World Food Programme and Food and Agriculture Organisation have been active in developing vulnerability assessment tools for drought and food insecurity. These tools are often integrated into early warning information systems. The assessment of disaster impacts has also made rapid headway in recent years. The Economic Commission for Latin America and the Caribbean has a well established framework for calculating the direct, indirect and secondary economic impacts of disasters[11]. Finally, a burgeoning number of vulnerability and capacity assessment methodologies have been developed that employ participatory methodologies at the local level to facilitate self-assessment by people at risk and hope to contribute towards local action to access resources to ameliorate aspects of vulnerability or hazard.

National indexes and indicators enable cross-country comparisons and can work alongside sub-national disaster risk and vulnerability assessment tools. The advantage of national indexes and indicators is that they can reduce complicated data into a few pieces of information that can be used to compare progress over time or between units of analysis. National indexes can provide a preliminary stage in the development of international benchmarks and national targets to track policy progress.

In-depth national and sub-national studies of disaster loss complement the cross-country indexes. The depth of such studies can extend beyond the specific inputs required for indexes, and they can evaluate disaster risk and risk reduction performance into more

[9] ISDR (2004) Living With Risk, page 63
[10] see Twigg (2004) for a review.
[11] http://www.eclac.cl

detailed and specific dimensions. When these other studies of disaster loss are current, if conditions change on the ground it may be that these country studies will identify the changes first, pointing towards potential modifications in the range of input variables used to calculate indexes. In turn, indexes generate a pointed focus for policy-makers and can galvanise and track action on a specific area of policy over time. Where indexes can act as benchmarking tools to track policy progress between counties and at the national level studies are needed for benchmarking within countries.

1.5 The Structure of the Report

Following this first introductory chapter, Chapter Two presents an overview of the aims and methods used by each index programme. Chapter Three presents a sample of the results produced by the three indexes. A comparison of methods is made in Chapter Four. Recommendations for future indexing work are then offered. Finally, detail on the construction and sourcing of input data is presented in the Appendices.

Chapter 2. The Indexing and Indicators Programmes

In this section the conceptual framework and core methodology of each of the indicator programmes is presented in turn.

2.1 The DRI programme

The DRI aims to demonstrate the ways in which development influences disaster risk and vulnerability. While expert judgement can be used to identify such linkages, the DRI represents the first effort to produce a statistical methodology. The DRI has global coverage and a national scale of resolution. Some 22 tributarians states are also included[1]. The DRI is applied in full to earthquake, tropical cyclone and flooding. Preliminary analysis is also undertaken for volcano, landslide and drought. The starting point for the DRI is to obtain or produce hazard maps for earthquake, cyclone and flooding (and also drought) which are then overlain by population maps in a GIS system to identify national human exposure to each hazard type.

The DRI produces two measures of human vulnerability. The first, Relative Vulnerability, is calculated by dividing the number of people killed by the number of people exposed to a particular hazard type. Higher relative mortality equates to higher relative vulnerability. The simplicity of the model means that no country is excluded for showing outlier characteristics.

The second measure of vulnerability aims to identify those socio-economic variables that best explain recorded mortality to individual hazard types. A step-wise multiple-regression is used with disaster mortality from EM-DAT as the dependent variable. Independent variables include physical exposure and a list of 24 socio-economic variables selected by an expert group to represent: economic status, type of economic activities, environmental quality, demography, health and sanitation, education and human development[2]. Those independent variables that best explain the variation in the dependent variable are chosen to describe the global characteristics of vulnerability for each hazard type. The time-period of mortality data availability (21 years for flooding and cyclones) is extended for earthquakes (36 years) to compensate for the low frequency of this hazard type thus allowing a longer time-period for the registering of mortality within EM-DAT. Volcanic hazard requires a longer time span, for which reliable loss data is not available, leading to the dropping of volcanic hazard from the DRI index.

A DRI multi-hazard index combines values for hazard specific socio-economic variables. Hazard specific models based on identified global vulnerability variables are run at the national level. For each hazard this allows the calculation of expected mortality for each

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[1] For example, Montserrat and Bermuda were treated independently rather than as part of the United Kingdom. Tributarians states will also be included when the term ‘country’ is used in discussions of the DRI method and results.

[2] The choice of categories for relevant variables was directed by the DRI’s conceptual framework, which directed choice towards characteristics of development that have been associated with vulnerability. Appendix 3 presents the list of variables used.

country and territory based on the values of the globally selected vulnerability variables. The multiple-hazard risk index for each country is made by adding modelled deaths from individual hazard types. The modelling process through which this is done required data entries for all countries. To reduce the number of countries with no data a value of 'no data' was replaced by zero risk of deaths. Countries are excluded if they have less than 2 per cent of their population affected and less than 1,000 people affected per year. Overall, 39 countries have been excluded from the model. Reasons for individual countries to be excluded are: countries marginally affected by a hazard, countries known to be exposed but with no loss data, and countries where the distribution of risk could not be explained by the model (for example, for drought in Sudan, where food insecurity and famine is more an outcome of armed conflict than of meteorological drought as defined in the model). A final stage in the modelling process is to run a Boolean process to allocate one of five statistically defined categories of multi-hazard risk to each country. This is preferable to giving each country a raw numerical multi-hazard risk value. In order to examine the fit between modelled mortality and mortality recorded in EM-DAT data from both sources are categorised into five country-risk classes and a cluster analysis performed to assess the closeness of fit.

2.2 Hotspots

Hotspots aims to identify those places where risks of disaster-related mortality and economic losses are highest, based on the exposure of people and GDP to major hazards and historical loss rates. Hotspots operates at the global level with a sub-national scale of resolution[3]. For Hotspots, which uses GIS grid cells as a unit of analysis, one challenge is where to draw the line in including lightly populated or economically unproductive areas in the analysis. A decision was made to exclude grid cells with les than 5 people per km² and with no significant agricultural production. This reduces the number of grid cells in the global analysis from 8.7 million to 4.1 million, significantly reducing processing time and preventing these low risk cells[4] from biasing results. Earthquakes, volcanoes, landslides, floods, drought and cyclones are included in the analysis. Hazard severity is indicated by event frequency or probability. Exposure for each grid cell faced with hazard is calculated based on the population and economic assets of that cell. It is assumed that all those people and economic assets within a grid cell are equally exposed to hazard.

Two sets of vulnerability coefficients have been calculated, one based on historical disaster mortality rates per hazard event, the other on historical rates of economic losses. Both vulnerability measures follow the same logic: 28 mortality and economic loss coefficients are calculated for each hazard. For both mortality and economic losses there is one loss rate for each of 7 regions[5], and 4 country wealth classes (high, upper-middle, lower-middle and low), defined according to standard classifications of the World Bank. For each hazard, historical mortality or economic losses per event for all countries in

[3] The units of analysis are some 4.1 million 2.5 by 2.5 minute grid cells. With areas ranging from 21km² at the equator to 11km² at the poles, these cells cover most of the inhabited land area of the globe.
[4] With a minimal number of people or assets exposed to hazard, calculated disaster risk would always appear low for these grid cells.
[5] Africa, East Asia and the Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, North America, South Asia,

each region/wealth class are aggregated to obtain a loss rate for the hazard for the region/wealth class.

These rates, or weights, are aggregated for each of the 28 region/wealth classes rather than calculated for each country individually because there is an insufficient number of hazard/loss events and, therefore, loss data, to calculate them for most individual countries. In an earthquake-prone country for example, unless an earthquake occurred during the period covered by EM-DAT, the loss rate would be zero. Furthermore, only approximately 30 per cent of the events recorded in EM-DAT include data on economic losses. Calculating the loss rates across groups of similar countries creates a larger pool of events across which to calculate them. Nonetheless, the historical loss data used to calculate the rates is thin for some hazard-region-wealth class combinations. A vigorous effort to improve the global database on disaster losses is currently underway to address this deficiency in future analyses.

Once calculated, these loss rates, or vulnerability coefficients, are used to weight hazard exposure of population or GDP for each grid cell to obtain risk. For each grid cell, the weight from the corresponding region/wealth class in which the grid cell is located is used.

A multi-hazard Hotspots index aggregates single hazard Hotspot values. A challenge for Hotspots is the lack of commensurability between measures of hazardousness for different hazard types. For example: frequency is used to measure severity for droughts and probability values for landslides. Aggregating these measures of severity would simply inflate the relative hazard values of those hazard types measured on a larger scale (e.g. on a frequency of 0 to infinity compared to a probability of 0 to 1). To allow aggregation a uniform adjustment is made to all values within a given region-wealth class so that the total mortality or economic loss for the class equals the mortality or economic loss recorded in EM-DAT for that hazard type.

The Hotspots results are presented as relative risk values. The risk values for each of the 4.1 million grid cells are sorted into 10 equally sized deciles for each hazard, and for all hazards combined. The top 30 per cent of the values are considered relatively high risk, the middle 30 per cent as relatively medium risk and the lowest 40 per cent as relatively low risk.

2.3 The Americas programme

The principal aim of the Americas indexing programme is to aid national decision-makers in assessing disaster risk and risk management performance. The system of indicators presents a benchmarking of each country in different periods from 1980 to 2000 and the basis for consistent cross-national comparisons. Four independent indexes have been developed, each represents disaster risk or disaster risk management in different ways and is targeted at specific audiences. Each index has a number of variables that are associated with it and empirically measured:

1. The *Disaster Deficit Index* (DDI) measures a country's financial exposure to disaster loss, and the financial resources available for recovery.
2. The *Local Disaster Index* (LDI) represents the proneness of a country to locally significant disaster events, and their cumulative impact. Spatial variability and sub-national dispersion of disaster risk is also indicated.
3. The *Prevalent Vulnerability Index* (PVI) represents prevailing conditions of national level human vulnerability.
4. The *Risk Management Index* (RMI) measures a county's performance in disaster risk management.

The suite of indexes was applied in 12 countries in Latin America and the Caribbean (Mexico, El Salvador, Costa Rica, Guatemala, Jamaica, Trinidad and Tobago, Dominican Republic, Colombia, Ecuador, Peru, Chile and Argentina). The sub-indexes have national scales of resolution.

The DDI is a function of the expected losses received by the state and the capacity of the state to generate reconstruction funds from private, government and international sources when hit by a maximum considered disaster event (MCE). MCEs with return periods of 50, 100 and 500 years related to rapid-onset hazards are considered. Vulnerability is formally included as part of the derivation of the DDI. It is used to represent the proportion of an asset that is calculated to be lost in an event of a given intensity (the MCE). A DDI value greater than 1.0 indicates a lack of financial capacity to cover the costs of disaster impact. In a parallel presentation of this index MCE losses are also be expressed as a proportion of annual national current account budgets.

The LDI includes four hazard types (landslides and debris flows, seismo-tectonic, floods and storms, and other events[6]) based on the categorisation of hazard used in the data source for this index: the DesInventar database managed by La Red[7]. Values of local disaster magnitude and geographical distribution are calculated from three sub-indexes: mortality, people affected and physical loss (housing and crops) applied to sub-national regions or municipalities. Local data is combined to build the national LDI. A high LDI indicates high regularity in the magnitude and geographical distribution of disaster events recognised in the local reports and media across the country.

The PVI is a composite index of national level inherent vulnerability. It is derived from the aggregation of measures collected at the national level for three dimensions of human vulnerability: exposure and physical susceptibility, socio-economic fragility and lack of resilience. The PVI measures inherent, or intrinsic vulnerability – no specific hazard type or scale of impact is required, neither is any disaster response capacity considered. Each dimension of vulnerability is calculated from eight quantitative components, which are weighted and aggregated to provide a final index value.

The RMI is also a composite index. Four dimensions of disaster risk management are included in its calculation: risk identification, risk reduction, disaster management and

[6] other events include biological and technological phenomena
[7] http://www.desinventar.org/desinventar.html

governance and financial protection. Each dimension has six qualitative components to be valued at the national level by expert judgement. The components are weighted and aggregated to arrive at the final index value. A sensitivity analysis is used to test for the influence on the results of the chosen weightings.

Chapter 3. Global Disaster Risk and its Management

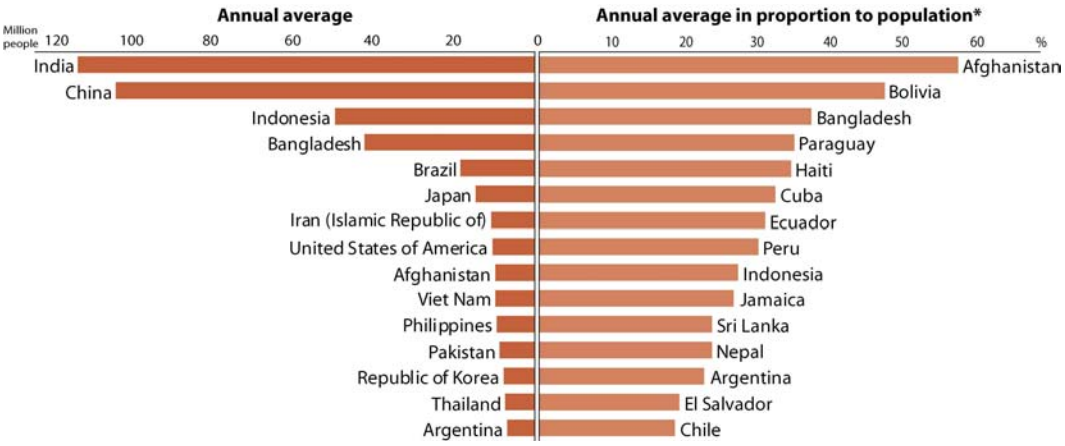
In this section, examples from the results of the three programmes are presented in turn. The intention is to demonstrate progress made in the field as a whole. It should be noted that each programme focussed on a particular range of individual hazard types so that results are not straightforwardly comparable[1]. Outcomes of the programmes are presented through examples taken from flood hazard, chosen because of its global distribution[2].

3.1 The DRI programme

DRI vision of hazard

The DRI shows the high absolute numbers of people exposed to flooding in Asia – especially India and China. When population exposed is presented as a proportion of national population (to indicate a measure of national vulnerability) smaller countries become more important than the large, populous states (see Figure 1).

Figure 1: Physical exposure to floods, 1980-2000



Source: UNDP/BCPR; UNEP/GRID-Geneva (in UNDP, 2004)

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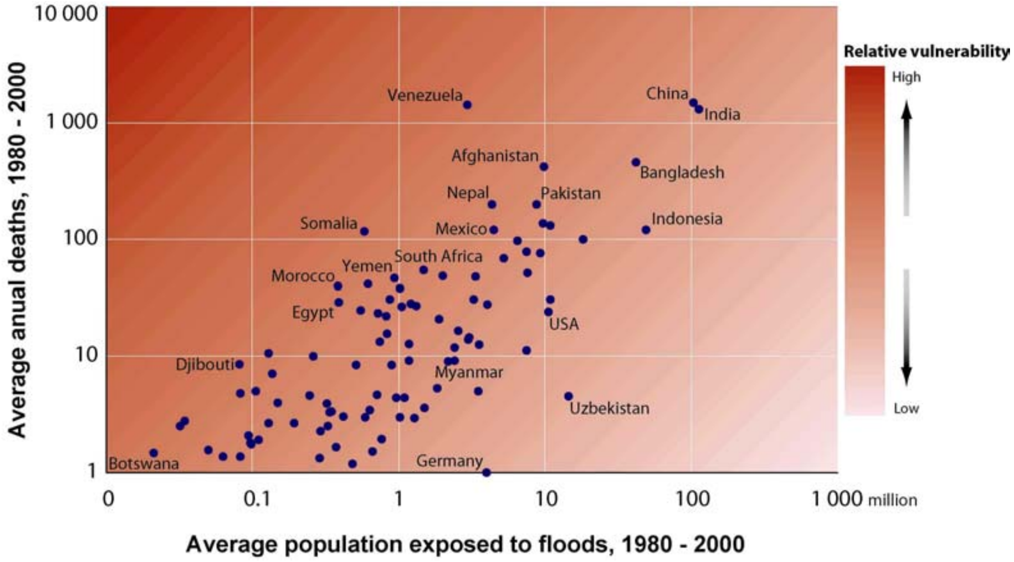
[1] The DRI analysed earthquake, tropical cyclone and flooding. Drought was also included in the multi-hazard DRI. In addition the Hotspots analysis included volcanic hazard and extended their coverage of cyclones to a global assessment.

[2] Mortality 1980-2000 associated with major hazard types in the EM-DAT database: drought, 832,544; tropical cyclone, 251,384; flooding 170,010; earthquakes, 158,551.

Relative Vulnerability
Relative Vulnerability was presented as an index value, or graphically as in Figure 2.

Figure 2: Relative vulnerability for flooding, 1980-2000



Source: EM-DAT OFDA/CRED and UNEP/GRID-Geneva (in UNDP, 2004)

Relative Vulnerability is highest in the top left-hand corner of Figure 2. The high relative vulnerability displayed by Venezuela is a result of the large number of deaths associated with catastrophic flooding in 1999, in this case landslides were an immediate cause of many of the deaths.

Social and economic indicators of vulnerability
The DRI analysis identified the following variables for flood risk in addition to physical exposure:

- low GDP per capita
- low density of population

In other words, according to the DRI, the risk of dying in a flood was greatest in countries with high physical exposure to flooding, small national economies and low densities of population[3]. This may reflect the greater difficulty of preparing for floods in low density rural societies where large scale public works such as river and sea defences that require collective labour or large financial investments are not easily delivered and the difficulty in providing adequate emergency assistance and recovery support for low density and widespread rural populations such as those hit by flooding in Mozambique 2000[4].

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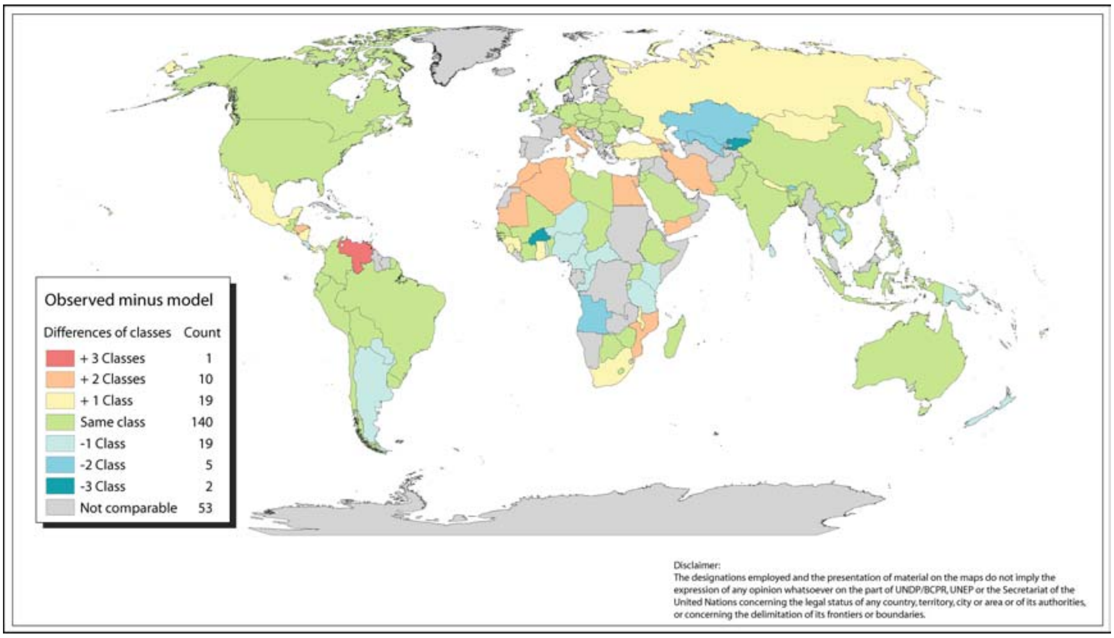
[3] Vulnerability and hazard exposure variables were identified through a correlation with mortality data from EM-DAT.
[4] Christie, F and Hanlon, J (2001) Mozambique and the Great Flood of 2000, James Currey, Oxford

The multi-hazard DRI
Figure 3 presents a comparison of the calculated DRI multi-hazard model with recorded data on disaster mortality from EM-DAT

Figure 3: Differences between multi-hazard DRI and observed disaster mortality



Source: UNDP/BCPR, UNEP/GRID-Geneva (in UNDP, 2004)

Figure 3 shows a close fit between calculated mortality risk and observed mortality, suggesting the combination of statistically chosen socio-economic vulnerability variables and physical exposure to hazard do indeed explain a large amount of global disaster risk. This conclusion is made from the 196 out of 249 countries where data were available to make this comparison[5]. Of the 196 countries, 140 showed a close fit between calculated mortality risk and observed mortality. In 26 countries the multi-hazard DRI overestimated mortality, in 30 countries the multi-hazard DRI underestimated mortality.

3.2 Hotspots

Hotspots vision of hazard
Hotspots showed widespread exposure to flood hazard across the globe. About one third of the world's land area, including 82 per cent of the world's population, was exposed to flooding from 1985 to 2003. The most flood-prone areas encompass about 9 per cent of land area and more than 38 per cent of world population (2 billion people) and include the Philippines, Indonesia, southeast Asia, the Korean peninsula, China, Bangladesh, northeast India, eastern Africa, Europe, coastal South America, Central America and the Midwest of the USA[6].

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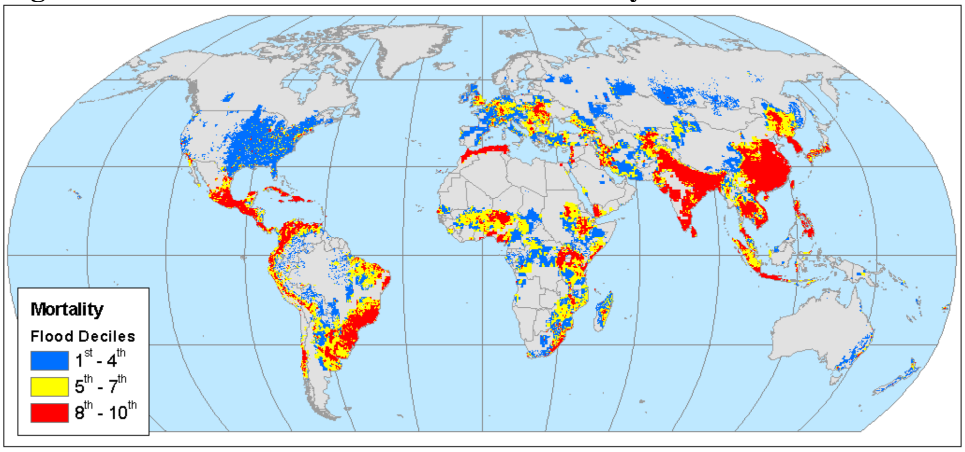
[5] Data was not available for one or more variables for 55 countries leading to their exclusion from the analysis.
[6] A second measure of exposure was developed by Hotspots that incorporated a measure of population density. This has the effect of increasing the measure of exposure for most regions, with the exception of less densely populated areas along the Gulf Coast of the USA.

Hotspots also showed that flood prone areas include highly productive agricultural land, showing the complex linking of opportunity (increased soil fertility) and hazard that is characteristic of flood-prone areas. Areas with high hazard exposure often have higher than average densities of population, GDP activity and transportation infrastructure[7].

Indexes of sub-national flood-related mortality and economic loss risk

Hotspots produced relative risk maps for mortality, economic loss and economic loss as a proportion of GDP. In Figures 4, 5 and 6 relative risk is shown as high (red), medium (yellow) or low (blue). Broadly, South and Southeast Asia register high risk of both mortality and economic loss from flooding. In addition, Central and South America and sub-Saharan Africa show high mortality risk from flooding. Europe, North America and the Caucuses show high risk from flooding measured through absolute economic loss.

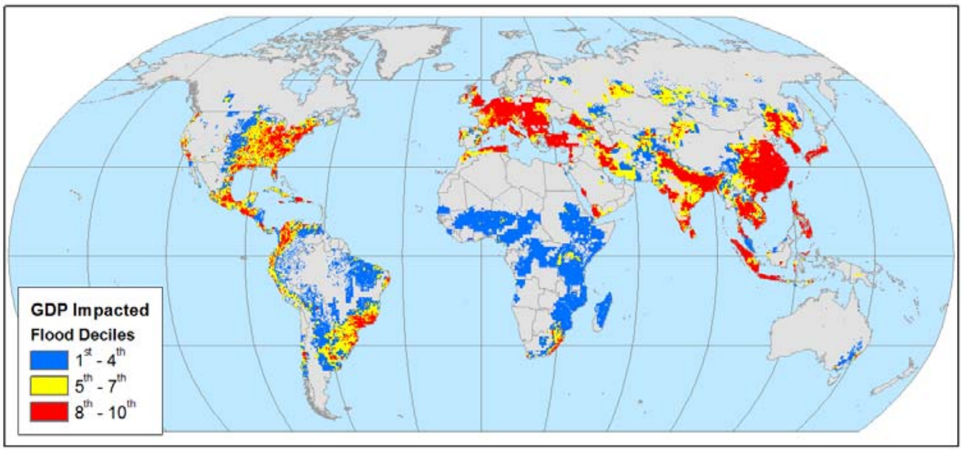
Figure 4: Global distribution of flood mortality risk



Source: Dilley et al (2004)

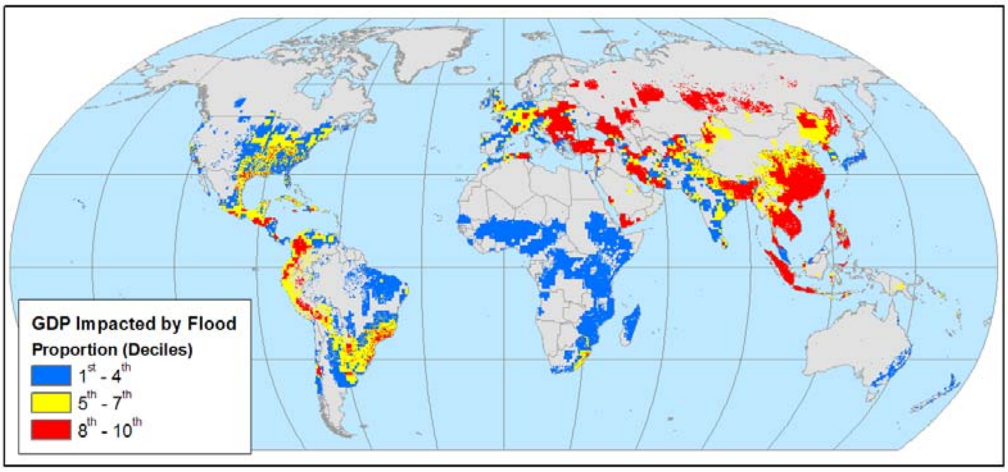
[7] Hotspots built it's map of exposure from identifying individual grid-cell exposure. This in turn was expressed within a decile range with 10 being the most exposed. Comparing population density for individual deciles shows that mean population density in those cells most exposed was around 300 people/km², the next highest density in decile 9 was around 150 people/km². Agriculture GDP density is also highly correlated with exposure to flooding, decile 10 cells have a mean agricultural GDP of around US$37,000, compared to the next highest, decile 9 with around US$29,000. GDP density is less strongly correlated with a mean concentration of around US$1300 in decile 10 and US$1200 in the next highest decile 9. Calculated transport density is negatively correlated with decile 10 cells having on average less transport infrastructure than cells in deciles 9,8 or 7.

Figure 5: Global distribution of flood economic loss risk



Source: Dilley et al (2004)

Figure 6: Global distribution of flood economic loss risk as a proportion of GDP



Source: Dilley et al (2004)

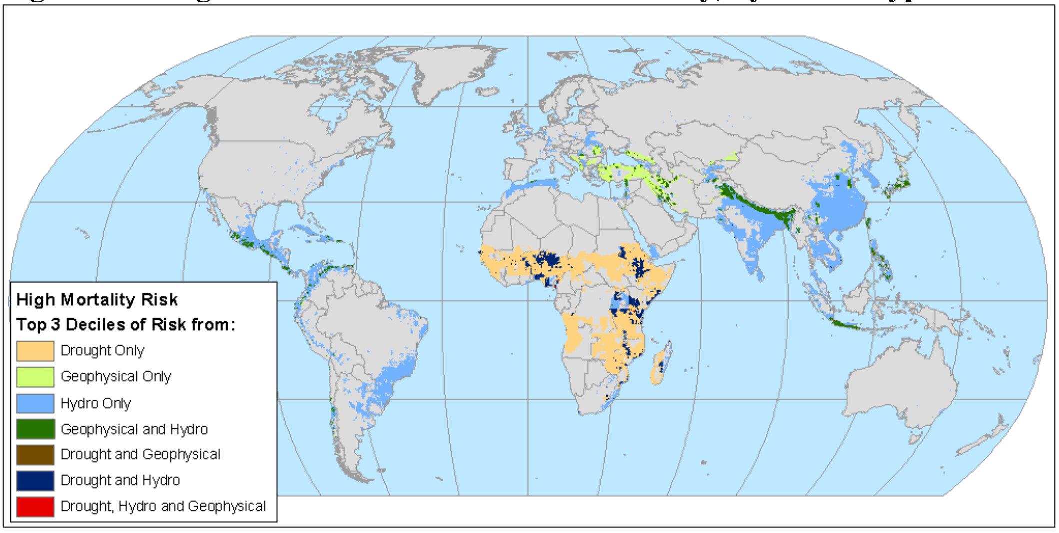
When Hotspots compared flooding with other hazard types at the global scale, it was found that flood risk affects the greatest land area (14.4 million km²), population (3.9 million), amount of GDP (US$22,859 billion), amount of agricultural GDP (US$528 billion) and length of road and rail (1.5 million) for any hazard type. Assets at risk from other hazard types are one or two orders of magnitude smaller[8].

[8] This comparison was made using the mortality calibrated risk index. A comparison based on economic losses also showed flood hazard to have the greatest associated risk in all categories but with comparable scales of risk being associated with drought and cyclones (see Dilley et al, 2004).

Hotspots Global Multi-Hazard Risk Indexes

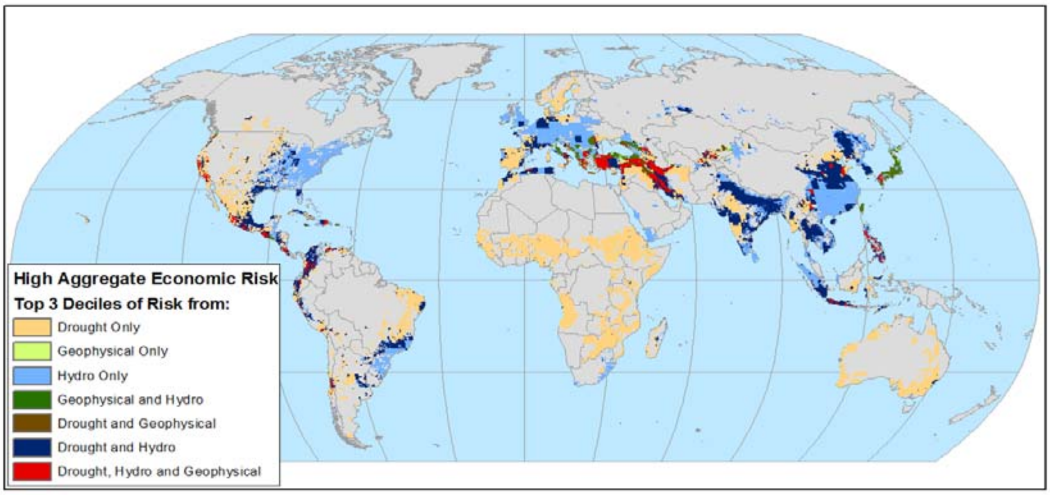
The Hotspots multi-hazard risk results for the highest risk areas are presented below. Risk of mortality is presented in Figure 7, risk of economic loss in Figure 8 and risk of economic loss as a proportion of GDP in Figure 9.

Figure 7: The global distribution of risk of mortality, by hazard type



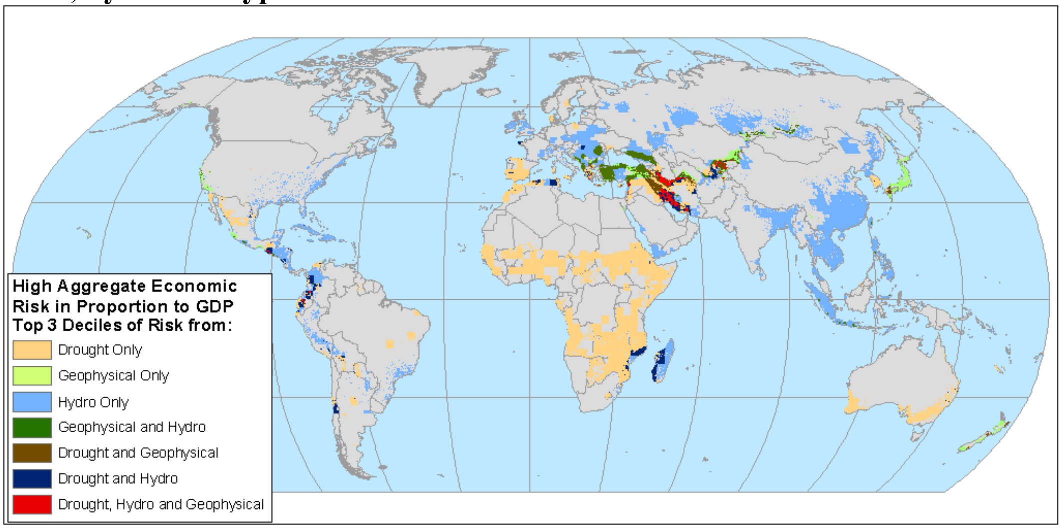
Source (Dilley et al, 2004: Figure 8a)

Figure 8: The global distribution of risk of economic loss, by hazard type



Source (Dilley et al, 2004: Figure 8b)

Figure 9: The global distribution of risk of economic loss as a proportion of GDP, by hazard type



Source (Dilley et al, 2004: Figure 8c)

The multi-hazard mortality risk assessment (Figure 7) was influenced strongly by high risk individual hazard hotspots including those associated with drought-mortality in sub-Saharan Africa, flood and cyclone associated mortality in Central America, the Caribbean, the Bay of Bengal, China and the Philippines, and earthquake and landslide associated mortality in Central America and Venezuela, Central Asia, the Himalayas, Japan, the Philippines and Indonesia. The Himalayas, sub-Saharan Africa and Central America show risk from two hazard sources.

A comparison of multi-hazard mortality risk with that for total economic loss (Figure 8) produces a familiar picture of risk shifting from low-income sub-Saharan Africa to the high-income states of Europe and North America. A large number of populous regions record high risk using both measures, including: Central America, the Caribbean, Mediterranean states, the Middle East, the Himalayas, east and central China, Japan, the Philippines, the Korean Peninsula and Vietnam.

When risks of economic losses are calculated as a proportion of GDP (Figure 9) compared to absolute GDP loss, multi-hazard risk remains high for the Middle East, is increased for eastern Africa including Madagascar, and reduced for the Mediterranean states, North America, Europe and the Himalayas.

Using measures for mortality risk, nearly one quarter of total land area and more than three-quarters of the world's population were shown to be at relatively high risk from one or more hazards. Around one twentieth of the total land area and about one in four people were subject to high risk from two or more hazards. About seven per cent of total population lived in areas at high risk from three or more hazards.

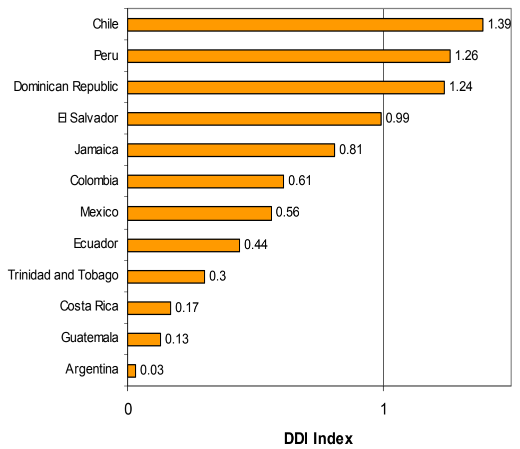
When risk was calculated using economic losses to represent vulnerability the analysis showed that more than four-fifths of world GDP producing activity was located in areas of relatively high risk from one or more hazards, with around a fifth of GDP producing activity in high-risk areas at high risk from three or more hazards. A focus on agricultural GDP showed a similar pattern of exposure to single hazards but less exposure to multiple hazards. Around a third of global road and rail infrastructure is located in places recording high risk to at least one hazard type.

3.3 The Americas Programme

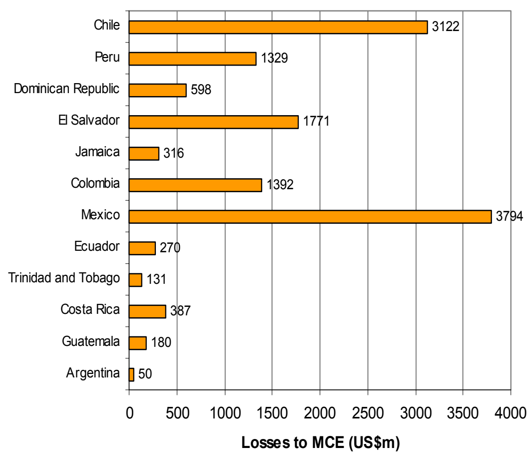
National financial exposure and capacity to finance disaster loss reconstruction

The DDI index had two elements, both shown in Figure 10. On the left is a ranked presentation of national financial capacity to cope with a Maximum Considered Event (MCE), on the right absolute economic losses are presented. Both are for an MCE with a 50 year return period (an 18% probability of occurring in any ten years). Chile, Peru, the Dominican Republic and El Salvador are shown not to be able to cope with such an event. Economic losses (shown in the right hand graph) are greatest for Chile and Mexico.

Figure 10: National financial exposure to catastrophic disaster



Source: Cardona (2004b)



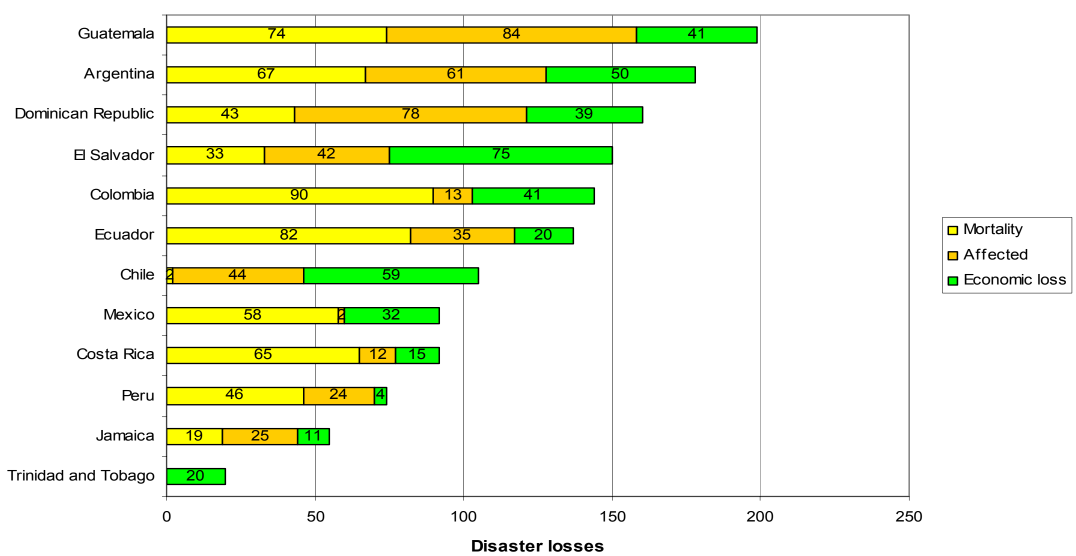
With an MCE of a 100 year return period (5% of occurring in any ten years), seven countries were unable to cope. At a 500 year return period (2% of occurring in any ten years) only Costa Rica could cope.

A complimentary assessment was developed, called the 'DDI prime' to indicate MCE losses as a proportion of current annual investment. In El Salvador, for example, future disaster losses are the equivalent of 32% of annual capital budget, in Chile the figure is 12.5% with only four countries below 5%.

Local disaster risk accumulation

In Figure 11 presents recorded mortality, people affected and economic loss associated with disaster events recorded in local and national media and reports from 1996 to 2000. Colombia and Ecuador show a high incidence of deaths with Guatemala and the Dominican Republic showing high numbers of people affected. Within the LDI an additional measure of the geographical concentration of disaster losses was calculated. This showed that losses were most evenly distributed within El Salvador. Ecuador, Peru, Chile and Colombia had the most geographically uneven distribution of losses.

Figure 11: Loss from locally and nationally recognised disasters, 1996-2000

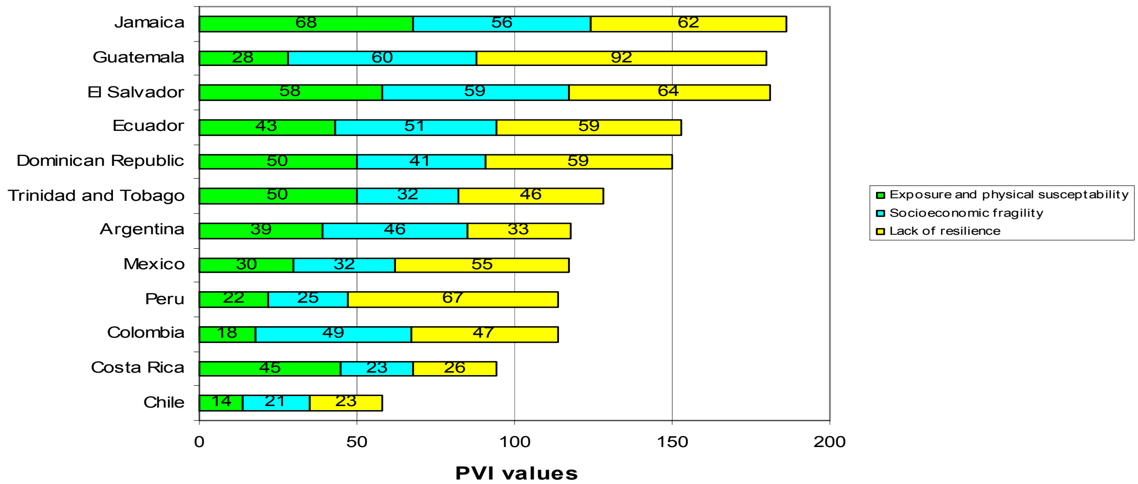


Source: Cardona (2004b)

Socio-economic susceptibility, fragility and resilience

Figure 12 shows PVI values for the year 2000. Jamaica is shown to have the highest vulnerability scoring highly in each of the three measures. Guatemala and El Salvador also register high composite vulnerability, with Guatemala showing very high levels of lack of resilience.

Figure 12: Socioeconomic vulnerability in the Americas, 2000

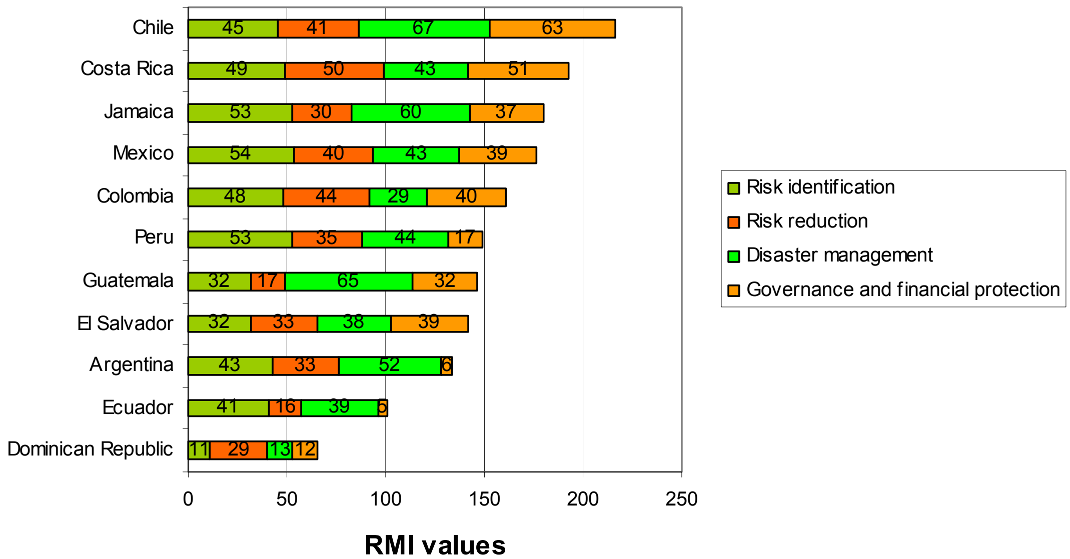


Source: Cardona (2004b)

Disaster risk management performance

Figure 13 shows RMI values for the year 2000. Chile and Costa Rica performed relatively well on all indicators. Chile returns particularly high scores for disaster management and governance and financial protection. Other countries returned a less even performance, Argentina and Ecuador in particular have weak scores for governance and financial protection, and the Dominican Republic for risk identification.

Figure 13: Disaster risk management performance in the Americas, 2000



Source: Cardona (2004b)

Chapter 4. Looking Ahead

This Chapter looks at the future potential for disaster risk indexing building from the three indexing programmes. Table 1 provides a summary of the similarities and differences between the three indexing approaches, their key contributions and constraints presented in the preceding chapters and points towards future areas of complementarity.

Table 1: Comparing the index approaches

	DRI	Hotspots	Americas programme
Objective	To demonstrate the ways in which development contributes to human vulnerability and risk.	To identify those sub-national places in the world with high multi-hazard risk.	To reveal national vulnerability and risk due to natural hazards, and risk management performance.
Coverage	Global	Global	Regional (12 countries of the Americas to date)
Principal audience	National and international agencies	International and national agencies	National authorities and international agencies
Unit of analysis	National	Sub-national (2.5' grid cells)	National and sub-national
Key contributions	Maps earthquake, tropical cyclone hazard and flood hazard worldwide. Identifies independent hazard specific socio-economic indicators of national vulnerability. Proposes a simple measure of relative vulnerability.	Maps flood, earthquake, landslide, drought, volcano and cyclone hazard worldwide. Identifies relative risks of mortality and economic loss for populations and economic assets exposed to single and multiple hazards. Estimates relative risks of mortality and economic losses.	Provides a group of four independent but related indexes covering local disaster loss, economic exposure and financial preparedness, intrinsic human vulnerability and national disaster risk reduction performance.
Hazard	Earthquake, cyclone, flood, and drought. Landslide has been partly studied through work coordinated by NGI.	Earthquake, cyclone, flood, landslide, drought and volcano.	Two of the indexes include hazard type. For the LDI hazard types are landslides and debris flows; seismo-tectonic; floods and storms and other technological and biological events defined by the Desinventar database. For the DDI a maximum considered event is calculated based on the most important sudden onset hazard type (flood, cyclone or earthquake).
Vulnerability	1) The ration between mortality and population exposed. 2) Derived from socio-	Represented by historical disaster mortality and economic loss rates for 28 groups of regions and	In the DDI vulnerability is a function of financial exposure and resiliency. In the PVI vulnerability was not hazard

	economic indicators calibrated against disaster mortality.	country wealth classes for each hazard type.	specific and is characterised by social and economic sub-indicators.
Risk	Disaster mortality calculated as a product of hazard, population exposed and vulnerability variables.	Disaster mortality and economic losses calculated as products of hazard, elements exposed and vulnerability.	Expressed through four independent indexes covering: financial exposure and capacity to finance reconstruction, local risk accumulation, socio-economic vulnerability and risk management performance.
Limitations	Short time-span for mortality loss data compared to hazard frequency (volcano and earthquake). Limited availability of appropriate socio-economic variables.	Lack of sub-national data on mortality and economic loss. Does not identify specific vulnerability factors.	As the indexes are inductive the results are not empirically verifiable against specific disaster-related outcomes. Selection of sub-index components (and their valuation in the RMI) rests on the judgement of national experts, making international comparison difficult. National level resources and support for data collection and dissemination are required.
Comparative Advantage	National dimensioning of vulnerability factors and disaster risk. Focus on large and medium events.	Sub-national dimensioning of hazard exposure and disaster risk. Focus on large and medium events.	National dimensioning of vulnerability factors and disaster risk. Characterisation of risk management performance at the national level. Includes large and medium as well as small (locally significant) events.
Future Possibilities	Measuring disaster risk to ecological and environmental systems that impact of human welfare. National and sub-national case-study ground truthing. Time-series analysis. Dynamic risk assessment. Contribution to benchmarking.	Measuring disaster risk to ecological and environmental systems that impact of human welfare. National and sub-national case study ground truthing. Temporal comparisons. Dynamic risk assessment.	Benchmarking for disaster risk reduction performance. A family of indicators could be developed for individual economic and social sectors at the national and sub-national levels.

4.1 Future possibilities for individual indexing and indicator programmes

Improving the quality of the DRI's identification of socio-economic variables associated with vulnerability should be a future goal of the DRI programme, and would require regular revision of available variables and efforts to increase the confidence with which drought and volcanic hazard can be incorporated into the multi-hazard DRI methodology. Initial efforts to encourage national level DRI assessments open opportunities for a higher resolution analysis and a pathway for engaging with the development planning community at the national level and should be encouraged.

In Hotspots, sub-national case studies to ground-truth assessments made using globally available data would be valuable, and some regional and national case studies have already been undertaken. National or regional presentations and analysis would bring greater resolution to the results. SIDS are noted for their high vulnerability, analysis of their risk is difficult in the current presentation. A dedicated assessment for SIDS would be worthwhile. An important strength of the sub-national analysis is that it avoids an analysis by political-administrative regions. Aggregate analysis of grid cells to compare disaster risk between urban agglomerations, environmental and livelihood zones might be worthwhile.

The first run of the Americas programme built a unique network of development planners and disaster risk specialist at the national level. This network should be built further to strengthen human resource and used to maximise the communication of sub-index findings with the development and disaster risk communities. The objective is to apply the indices to the remaining countries in the Americas, and especially the Caribbean, with the potential to extend beyond. The greatest constraint on this will be for the LDI, which requires local disaster loss data.

For all three of the indexing programmes, the future impact of the indexes will increase as the accessibility and robustness of input data is improved. This is a long-term goal with improvements initiated today making a lasting and cumulative contribution as enhanced datasets build-up data over time. Improvements in the quality and consistency of data collection, and in the higher resolution mapping of information on disaster mortality, economic loss, damage to infrastructure and the number of people affected in global data would contribute to the DRI and Hotspots. Similar gains made at the national level by DesInventar would contribute to the Americas programme LDI (see Appendicies 2 and 3).

4.2 Potential for Future Collaboration

Complementarity

The deductive methodologies of the DRI and Hotspots and the inductive approach of the Americas programme limit scope for methodological integration. For example, while using different methodologies the DRI and Hotspots have both measured vulnerability in the context of specific hazard types; the PVI measures intrinsic vulnerability using socioeconomic indicators theoretically associated with vulnerability to hazard stress. The deductive/inductive approaches do, however, open opportunities for verification and complementarity.

Potential exists for building on the complementarities between the indexes to develop a collaborative indicator or indexing programme.

Three principal lines of complementarity exist between the DRI, Hotspots and Americas programmes:

- The national resolution of the Americas project, which provides greater detail on aspects of country vulnerability, complements the analyses of the DRI and Hotspots, which with their global application provide additional possibilities for cross-country comparison

- The inductive approach of the Americas project – where variables are chosen to represent vulnerability and risk management performance and then applied - is complemented by the DRI methodology, which identifies and verifies vulnerability variables for individual hazards using a regression analysis. The statistical analysis of the DRI can add weight to the choice of indicators included in the Americas project although the overlap of variables available at the global and national scale is limited constraining the degree of potential for overlap in this first run of the indexes.

- Were the DRI and Hotspots produce hazard specific and multi-hazard measures of vulnerability and risk of loss, the Americas project builds an understanding of intrinsic or inherent vulnerability and exposure. Working with inherent vulnerability moves the Americas programme closer to the language and world-view of development and poverty alleviation work offering scope for the mainstreaming of disaster risk reduction. But at the same time the intrinsic construction of vulnerability is in danger of loosing sight of the specificities of vulnerability associated with exposure to and susceptibility of harm associated with particular hazard types. Ideally, hazard specific vulnerability should be noted and placed within the context of inherent vulnerability. For the first time, the indexes reviewed here begin to offer a way towards just such an analysis.

- The assessment of locally significant disasters in the Americas programme LDI complements the focus on medium and large disaster events used by the DRI and Hotspots. Ideally both levels of disaster risk and impact should be brought together, though a separate analysis may be useful in directing risk reduction policy and adding to our understanding of disaster risk accumulation processes.

The individual methodologies of the indexes do create some barriers to collaboration. The LDI, for example, can only be undertaken in countries with a sub-national record of disasters. Outside of Latin America such databases are rather undeveloped but would need to be built[1]. In contrast the PVI opens scope for national vulnerability assessment beyond that of the DRI which is constrained by internationally available socio-economic variables.

The RMI stands alone as the only index that targets disaster risk management performance. The need for such an index is great, and at least as important is the need for national benchmarks on disaster risk reduction performance. Progress towards the

[1] Estimates for building a database using DesInventar methodology will vary between countries but an initial, order of magnitude estimate of around US$15,000 - 20,000 suggests this would not prohibitively expensive.

benchmarking of disaster risk management performance could be informed by the ISDR's proposed Framework to guide and monitor disaster risk reduction set out in *Living with Risk.* The framework and RMI share a good degree of overlap. The dialectical relationship between risk management and vulnerability or disaster loss means that management performance should be measured independently of vulnerability and disaster risk. The DRI (which measures only vulnerability) as well as the PVI and RMI of the Americas programme maintain this separation. But it is only the RMI that can measure disaster risk management performance.

Benchmarking
International and national benchmarks of good practice and performance in disaster risk reduction would provide an important gateway for countries to advance further in this area. This is not least because of the absence of a target for disaster risk reduction in the UN Millennium Development Goals. The combination of the global and national level assessments of hazard, vulnerability and disaster risk produced by the three indexing project can point the way towards the development of a coherent set of indicators for tracking disaster risk reduction. The socio-economic variables of the DRI and the DDI, PVI and RMI of the Americas programme identify discrete variables that can indicate progress. DRI's Relative Vulnerability could be the basis for proposing national targets for reducing the proportion of people killed from populations exposed to individual hazard types based on international norms. The risk analysis of Hotspots and the DRI provide methodologies for indicating progress in disaster risk reduction and associated development policies.

Risk Management Toolkits
Over the long-term, there is potential for using indexes indicators and indexes in conjunction with other data analysis and decision-making tools to build participatory disaster risk management toolkits targeted at development planners and people at risk as well as disaster risk management professionals. Bringing disaster risk indexes together with other development indexes, indicators and tools will help to build a fuller picture of the interaction of disaster risk and development pathways. In particular, it would be useful to monitor disaster risk alongside development pressures where there is a theoretical case, but uneven empirical evidence for their association with disaster. Examples include, macro-economic restructuring and rapid economic liberalisation, the presence of disease such as HIV/AIDS as well as armed conflict, failed governance and rapid urbanisation.

At the local level the opportunity may exist for the overlapping of indicator assessments of local disaster risk already existing in Hotspots and the LDI of the Americas programme with more participatory vulnerability and capacity assessments undertaken by people at risk[2]. Such participatory assessments are most often conducted at the community level with some metropolitan level studies being aggregated up from community assessments. Metropolitan level participatory studies would compliment well the metropolitan data used by the LDI and the grid-cell analysis of Hotspots. This offers

[2] See ProVentium and Habitat websites for an introduction to the many examples of local vulnerability and capacity assessment methodologies and experience.

an opportunity for a strategic linkage between people at risk, risk management and development policy makers and a comprehensive approach to national disaster risk and risk management assessment.

A Suite of Indicators
Reviewing the opportunities for building a suite of disaster risk indicators dedicated to particular elements at risk suggests additional, longer-term opportunities. There are perhaps two areas for dedicated indexing, components of which are to varying degrees incorporated within the existing indexing programmes:

- The DRI has proposed a dedicated analysis of disaster risk for SIDS. This is justified by their high vulnerability to hazards, but also because their small size in spatial and population terms makes it difficult to incorporate them in statistical analysis alongside continental states. As presented the risk maps of Hotspots also obscure SIDS such as Micronesia. This suggests the DRI and Hotspots methods would benefit from a separate study with a focus on SIDS but drawing comparisons with continental states might be appropriate. This is made more difficult because of the large number of SIDS for which only incomplete hazards or socio-economic data are available. The Americas programme could also assess and similarly group the results for SIDS.

- The current indexes of human loss to disaster could be used alongside complementary indexes for ecological fragility to disaster impact. Human induced environmental change indicators are incorporated in the DRI and Americas PVI, but these are ultimately used to indicate the fragility of human livelihood systems and can not measure the ecological fragility of natural systems themselves. The development of complementary indicators or indexes for ecological fragility in the face of natural hazard and disaster impact could enhance our understanding of the interplay between changing root causes of disaster and disaster impact. In particular, connecting human and ecological disaster impact assessments could improve our understanding and potentially provide early warning of changes in hazard associated with global climate change. Within the existing indexes such an agenda could be built from the methodologies of the DRI socio-economic vulnerability indicators programme or PVI of the Americas project that could measure the fragility of ecological and environmental components alongside the vulnerability of human components of such systems. Reviewing existing indicators for environmental and ecological status and their potential complementarity with the indexes reviewed in this Report would be a useful starting point.

Move from a generic overview of elements at risk towards an assessment of individual social and productive sectors. Examples could include gender or age specific indexes or indexes for agriculture or industrial activities. The history of the UN Human Development Index which has generated a number of sister indexes suggests this may be a useful future path. Developing indexes that are more attuned to the specific characteristics of urban, peri-urban and rural sites of risk accumulation and loss may also be useful.

Chapter 5. Recommendations[1]

1. Establish a co-ordinated international disaster risk management assessment programme

This programme should provide a comprehensive framework through which to consistently profile disaster risk that countries face, to observe the performance of national disaster risk management systems and to develop, with the authorities in participating countries, appropriate risk management solutions.

The programme could be global or regional in scope. It might be hosted by an international research or disaster policy related institute and draw on experts from a range of national agencies and centres of excellence. The precise format and membership of such a programme are beyond the remit of this Report, however core elements of the programmes agenda are presented as recommendations 2, 3 and 4 below.

2. Review of methodologies to verify methods and results and recommend possible consolidation and expansion.

This programme should facilitate a comparison of the results of DRI, Hotspots and Americas programme indexes. Work should be peer reviewed and coordinated by an internationally recognised centre of excellence. The aim of this work would be to serve as an on-going mechanism for the verification of findings, for exploring the advantages and disadvantages of consolidation amongst the indexes and for defining the suite of core indicators for the programme of national assessments (point 3 below). Over the short-term, five exercises for verification, that could then also point towards opportunities for consolidation are:

i) the national mortality risk indexes of the DRI and Hotspots methodologies. This would require a reclassification of Hotspots to allow national level analysis;

ii) the PVI, RMI (and possibly the DDI) of the Americas programme could be compared with the socio-economic vulnerability method of the DRI;

iii) local hazard exposure data mapped into GIS by the DRI and Hotspots could be compared with the LDI index;

iv) national disaster losses as represented by the Americas programme LDI and the multi-hazard risk indexes of the DRI and Hotspots could be compared to identify the influence of the DesInventar and EM-DAT databases, as well as the project methodologies on national disaster risk;

[1] These recommendations are those of the author, although proposals made by the research teams have been taken into account.

v) a comparison of the vulnerability levels calculated for the 28 country wealth/region groups calculated by Hotspots with similarly grouped national risk rankings from DRI to verify the lack of bias introduced by the Hotspots aggregation.

vi) Within the Americas programme, it would be useful to compare the relative performance of each index (and sub-indicator) for individual countries. It would be particularly interesting to review patterns between country performance on LDI and PVI with RMI to compare relationships between disaster loss, vulnerability and national disaster risk management performance.

Over the medium term, the proposed programme should undertake to review opportunities for building on the policy impact of the indicators. In particular the following initiative is worth considering:

i) review opportunities for developing a suite of benchmarking tools for disaster risk status and risk management performance. An initial review could include the Relative Vulnerability index of the DRI and options for combining the DRI socio-economic vulnerability and Americas programme DDI, PVI and RMI

Over the longer-term, the proposed programme should undertake to review opportunities for broadening the scope of future disaster risk indexes by building a suite of more refined and specialised sub-indexes, as has been the case with the Human Development Index. Areas for more refined focus could include the development of indexes that can:

i) differentiate between the experiences and needs of individual social groups within nations, differentiated by gender, age, physical ability, socio-economic class, ethnicity, religion and extent of political participation. Of these an assessment by gender may be most useful for policy makers;

ii) distinguish between urban and rural vulnerability, hazard and risk;

iii) more fully incorporate ecological and environmental exposure, vulnerability and loss to natural disaster, and the implications of this for human wellbeing in current and future generations;

iv) time series analysis of model outputs (which is already available from the Americas programme) can be used alongside international comparison to examine the impact of development processes and pressures on disaster risk. Such pressures include armed conflict, disease such as HIV/AIDS and malaria and changes in national government.

3. Launch a programme of country-level assessments of disaster risk and risk management performance.

The programme would apply a core suite of indicators of disaster risk and risk management drawn from he DRI, Hotspots and the Americas indicators. Each country participating in the assessment programme would receive a national report detailing the results of the indicators, and the implications for strengthening their risk management systems. The basic results would also be published in a regional/global report, along with the results of other countries. National and sub-national assessments should aim to provide a minimum of standardised data to improve the in-country capacity for risk management policy making and to enable an aggregate international assessment. This could build on the national and regional case studies undertaken by Hotspots, by the DRI national level initiatives and by the Americas programme focus on national data collection.

Foundations, in terms of human resources required for such a programme, have been lain through the indexing programmes. The DRI and Hotspots have concentrated new expertise in international agencies. The Americas programme has enabled the building of human resource at the regional and national level. This national capacity could provide the application platform for the broader suite of national indicators and benchmarking tools proposed above.

4. Disseminate Effectively

The indexes have great potential to bring policy makers, technicians and people at risk from disasters together, to foster greater communication and collaborative efforts at understanding and managing disaster risk. If further international, regional or national applications of the indexes and indicators are to be undertaken maximising policy impact would be important. To this end it is recommended that the dissemination of the indexes, and additional work conducted under Recommendations 2 and 3, be published in a regular and high-profile publication, linked to an internet resource, targeted at the development as well as the disasters communities locally, nationally and internationally.

The following recommendations complement the core activities of a co-ordinated international disaster risk management assessment programme and are targeted at general efforts to improve disaster risk and risk management indicators and indexing. Recommendation 5 is methodological, Recommendations 6 and 7 are concerned with data issues.

5. Encourage stakeholder participation

At the national level, as far as possible the application of index programmes should include a discursive mode where policy makers are invited to discuss the rational of the indexing methodology and its outcomes. Opportunities for exploring collaboration with local vulnerability and capacity assessment tools and their results should be explored. Some of these tools now operate at the municipal scale. This provides an opportunity for comparison of the results of sub-national indexes with disaster risk and loss assessment work undertaken by people at risk.

6. Improvements in data

Data on all hazard types could be enhanced and made more accessible. International constants for measuring hazard and disaster loss would be helpful. Perhaps the greatest scope for improvement lies with flood data. A new global data set is expected from

NASA in 2004, and this may make some progress in allowing better detail for South Asia in particular. For earthquakes, hazard mapping could be made more accurate if data on soil and surface geology properties that influence the area affected by individual shocks were available. Work on the international drought database is currently being undertaken by IRI and CRED.

Improvements in international datasets will rest to a large degree on work at the national and sub-national level. In addition to hazard and disaster loss data, national and sub-national socio-economic indicators with global availability are needed to give vulnerability assessments policy bite. Priority should be given to indicators for political (corruption, institutional strength) and disaster specific (policy, legislation, community training, emergency services etc) variables. New databases will soon be available that can contribute to vulnerability assessments. For example, the urban extent database being developed by CIESIN, and the work of the Earth Institute, World Bank and Millennium Project in developing a database on sub-national poverty and hunger. These databases and their potential for inclusion in subsequent disaster indexing will need to be reviewed[2].

7. Build an integrated framework for the collection of disaster data

The clarity and certainty with which recorded disaster losses can be attributed to individual hazard events would be enhanced by a co-ordinated and unified system of disaster reporting that connects local, national and international datasets. The basis for developing such a network of disaster impact data collection, collation and presentation exists in the global archive of EM-DAT and the sub-national work of DesInventar dataset and the GLIDE[3] initiative that provides an existing resource for connecting sub-national and national data on disaster impact (mortality, economic loss and people affected as well as more qualitative statements are included) to a globally accessible database. The GLIDE initiative should be further supported, not only to add rigour to disaster loss data, but to increase the number of countries where local and national data is accessible globally.

[2] Improvements in international datasets will contribute to indexing but are not required as a pre-requisite to the launching of an indicators programme as outlined in these recommendations. Rather, improvements in integrated data collection, ongoing peer review of indexes and indicators, their results and applications should be ongoing components of the proposed co-ordinated international disaster risk management assessment programme.

[3] http://www.unisdr.org/task-force/eng/about_isdr/tf-meeting-6th-eng.htm

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APPENDIX 2: Data Sources

Four types of input data were used by DRI and Hotspots: hazard, elements at risk, vulnerability and disaster impact. Collaboration has enabled some sharing of input data. This section highlights data commonalities and differences.

A2.1 Hazard Data

Data sources used to generate data on the global distribution of hazard type are presented in Table 3.

Table 3: Data Sources for Hazards

Hazard Type		Data Source
Earthquake		
	Hotspots	Global Seismic Hazard Program, and Smithsonian Institute
	DRI	Council of the National Seismic System (as of 2002), Earthquake Catalog, http://quake.geo.berkeley.edu/cnss/
Cyclone		
	Hotspots	UNEP/GRID-Geneva PreView
	DRI	Carbon Dioxide Information Centre (1991), A Global Geographic Information System Data Base of Storm Occurrences and Other Climatic Phenomena Affecting Coastal Zones, http://cdiac.esd.ornl.gov/
Flood		
	Hotspots	Dartmouth Flood Observatory
	DRI	EM-DAT and U.S. Geological Survey (1997), HYDRO1k Elevation Derivative Database, http://adcdaac.usgs.gov/gtopo30/hydro/
Drought		
	Hotspots	IRI Climate library
	DRI	IRI/Columbia University, National Centres for Environmental Prediction Climate Predictions centre (as of 2002), CPC Merged Analysis of Precipitation (CMAP), monthly gridded precipitation, http://iridl.ldeo.columbia.edu/
Landslide		
	Hotspots	NGI (see Gregoire, Nadim, Rodriguez and Peduzzi, 2004)
	DRI	Hotspots methodology
Volcano		
	Hotspots	UNEP/GRID-Geneva based on National Geophysical Data Center: http://www.ngdc.noaa.gov/seg/hazard/vol_srch.shtml
	DRI[1]	National Geophysical Data Center: http://www.ngdc.noaa.gov/seg/hazard/vol_srch.shtml

[1]The DRI does not include landslide, drought or volcanic hazard in its final analysis.

A2.2 Vulnerability and Impact

Sources used to obtain data on disaster mortality, population and vulnerability are shown in Table 4.

Table 4: Data Sources for Disaster Mortality, Population and Vulnerability Variables

Input Required	Data Source
Disaster mortality/ economic loss	
DRI	EM-DAT
Hotspots	calculated with input from EM-DAT
Population distribution	
DRI	Gridded Population of the World Version 2. Human Population and Administrative Boundaries Database for Asia, http://www.grid.unep.ch/data/grid/human.php
Hotspots	Gridded Population of the World, Version 3
Assets Exposed	
DRI	Gridded Population of the World Version 2. Human Population and Administrative Boundaries Database for Asia, http://www.grid.unep.ch/data/grid/human.php
Hotspots	National/sun-national GDP and National agricultural GDP allocated to agricultural land area: World Bank DECRG based on Sachs et al. (2001) Transport infrastructure: VMAP(0)
Vulnerability Variables	
DRI	For Human Development Index: UNDP (2002) Human Development Indicators, http://www.undp.org. For the Corruption Perceptions Index: Transparency International (2001), Global Corruption Report 2001, http://www.transparency.org/. For soil degradation: ISRIC, UNEP (1990) Global Assessment of Human-Induced Soil degradation (GlASOD), http;//www.grid.unep.ch/data/grid/gnv18.php. Other socio-economic variables: UNEP/GRID (as of 2002), GEO-3 Data portal, http;//geodata.grid.unep.ch/ with data complied from World Bank, World Resources Institute and Food and Agriculture Organisation databases.
Hotspots	Calculated from mortality and economic loss rates from historical events, as recorded in EM-DAT

Table 3.3 presents the types and sources of data used. In most cases estimates of land area affected have had to be generated. Cyclone hazard was calculated using storm track data assembled into a GIS system developed by UNEP GRID-Geneva. Volcanic hazard was calculated by UNEP GRID-Geneva. A landslide hazard value was also calculated for each grid cell by UNEP GRID-Geneva, in this case using physical properties (angle of slope, lithology, soil moisture, precipitation and seismicity), so that frequency data is not available in this case.

Exposure Data: Initial gridded land area and population exposed were derived for the year 2000 from Gridded Population of the World version 3. Economic activity exposed to hazard for each grid cell was estimated using World Bank Developing Areas Research Group data. For about 50 countries GDP data were available for sub-national units otherwise national values for GDP were allocated weighted by population. To provide a measure of economic activity relevant to flood and drought national estimates of agricultural GDP were also applied to grid cells based on the amount of agricultural land. This is a rough estimate assuming that all agricultural land contributes equally to GDP. A measure of infrastructure at risk derived by computing the length of major roads and railways for each grid cell.

A2.3 Americas Indexing Project

National consultants undertook the systematic collection of data. Detail on the common methodologies used in national data collection can be found on http://idea.unalmzl.edu.co/.

APPENDIX 3: DRI vulnerability indicators

Categories of Vulnerability	Indicators
Economic	GDP/inhabitant at purchasing power parity
	Human Poverty Index
	Total debt service (% of export of goods and services)
	Inflation, food prices (annual %)
	Unemployment, total (% of labour force)
Type of economic activity	Arable land (in thousands of hectares)
	% of arable land with permanent crops
	% of population classified as urban
	% of GDP dependent on agriculture
	% of labour force employed in agriculture
Dependency on and quality of the environment	Forests and woodland (% of land area)
	Human-induced soil degradation (GLASOD)
Demography	Population growth
	Urban population growth
	Population density
	Age dependency ratio
Health and sanitation	% people with access to improved water supply
	Number of doctors (per thousand people)
	Number of hospital beds
	Life expectancy at birth (male and female)
	Mortality rate for under five year olds
Early warning capacity	Number of radios (per thousand people)
Education	Illiteracy rate
Development Status	Human Development Index

APPENDIX 4: Data Development

Three fields of data are discussed here: hazard modelling, disaster impact data and population data. The discussion focuses on the DRI and Hotspots approaches to hazard modelling. The Americas programme is not discussed in this section, comments on hazard data (LDI and DDI) and input data for the PVI and RMI were presented in the body of the report.

Earthquake Hazard

Earthquakes are challenging because of the long time-span needed to capture events when compared to more frequent weather-related hazard types. The high destructive force of earthquakes means that reliable records for disaster impact held by EM-DAT can be traced further back in time than for weather-related events. Consequently the DRI took account of the long return-period of earthquakes by extending the period of observation from 1980 - 2000 to 1964 - 2000[1]. Delimiting the land area affected by each earthquake to identify exposed population was made difficult for the DRI because of a lack of global information on soil type and geology with which to map the extent of past earthquake impact. In response DRI assumed standard spatial extents for earthquakes according to their maximum magnitude.

Hotspots used data from the Global Seismic Hazard Program (GSHAP). Hazardousness in GSHAP shows the peak ground acceleration (PGA) for which there is a 10 per cent probability of exceedence in the next 50 years. Hotspots set a PGA cutoff at $2m/s^2$ as a lower threshold above which damages would be expected to occur. For PGA values above $0.2m/s^2$ the GSHAP value was used to represent earthquake hazardousness at each grid point. Data from GSHAP was verified against observed earthquake data from the Smithsonian Institute.

Cyclone Hazard

The DRI mapped individual cyclone tracks into a GIS to derive national hazard profiles. Unfortunately, data on cyclone tracks, central pressure and sustained winds were not available for some heavily populated and high-risk countries including India, Bangladesh and Pakistan, forcing estimation in these countries.

Hotspots shared the DRI database and found that in their subsequent mapping of cyclone hazard Bangladesh and neighbouring areas of India were not identified as high hazard. In the DRI, this problem was resolved by using the frequency as recorded by the Carbon Dioxide Information Analysis Center (CDIAC). In addition to problems of data estimation it was argued that this anomaly reflected the importance of cyclone related impacts associated with storm surges in this region. Because the cyclone indicator only considered storms that made land-fall, storm surges caused by cyclonic activity at sea had not been included. Overall this hazard will have been included in the region's high flood

[1] The EM-DAT database from which DRI and Hotspots drew hazard impact data contains records from before 1900, but reliability decreases quickly from around 1980, with particular care needed in using pre-1960 data.

hazard. Separating flood, cyclone and landslide hazard will remain a challenge when estimates of hazard are based on event records rather than underlying physical processes leading to susceptibility[2].

Flood Hazard

Because no global database on flood hazard was available, the DRI project team created a GIS database. Each flood recorded by EM-DAT (1980-2000) was geo-referenced and the watershed related to this event was identified[3]. All watersheds thus affected were mapped. Watersheds were then split to follow country borders. Population for each event was multiplied by event frequency and then added to derive annual national flood exposure. This introduced controlled bias, by assuming the whole floodplain of any river recording a flood was impacted, exaggerating flood exposure[4]. A counter bias comes from the inclusion of only those events recognised as disasters by EM-DAT. Areas exposed to small events will not have been included potentially reducing the number of people exposed to flood by DRI.

Hotspots chose to use the Dartmouth Flood Observatory's World Atlas of Large Flood Events. This avoids the bias of overcounting encountered by DRI, but introduces a bias of undercounting in two ways. First, coverage is limited to 1985-2003 with incomplete data for 1989, 1992, 1996 and 1997 and with the only a limited quality of spatial data for 1990-91 and 1993-95. Second, because Dartmouth is based on satellite imaging, flash floods and floods where damage is caused by vertical rather than horizontal submersion are liable to be under-estimated. Finally the georeferencing used to map hazard in hotspots was constrained by the resolution of data available from individual countries. This can be seen in the very large areas of China and other parts of Asia highlighted in red in Figure 4.1c. While large areas of China, in particular the Yangtze River Basin, are exposed to flooding, and this provides adequate definition for a global assessment, more spatial refinement is desirable for an analysis at higher resolution.

The global flood hazard database is the highest priority for improvement among the major hazard types.

Drought Hazard

The DRI and Hotspots both used models of meteorological drought based on an analysis from the International Research Institute for Climate Prediction at Columbia University In both indexes, drought data was based on gridded monthly precipitation for the globe (1979 – 2001 for the DRI; 1980-2000 for Hotspots). Grid cells in desert regions or experiencing seasonal dry spells were excluded. For all other cells, a meteorological drought event was seen to have occurred when the percent of median precipitation was at or below 50 per cent of a rolling three month median precipitation value for the DRI and Hotspots.

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[2] The joint Hotspots and DRI analysis of landslide hazard was achieved through a calculation based on relief/slope, lithology and soil moisture, and seismic and precipitation triggers. It offers one example of an independent assessment of hazardousness that would avoid double counting or omissions.

[3] Watershed data was taken from US Geological Survey (1997), see http://edcdaac.usgu.gov/gtotp30/hydro/

[4] This has produced a systematic under-estimation of national Relative Vulnerabilities for flooding.

Volcanic Hazard
Volcanic hazard data is available at a high resolution globally. It was sufficiently detailed for inclusion in the Hotspots analysis.

Landslide Hazard
A landslide hazard assessment was developed by NGI (Norwegian Geotechnical Institute) as an integral part of Hotspots. The methodology calculated landslide hazard potential based on the physical characteristics of GIS grid cells. This differed from other hazard assessment methods used by DRI and Hotspots, which were built on past event data[5]. The assessment included a test for the association of socio-economic variables with landslide mortality as in the DRI.

Disaster Impact Data
Disaster impact data was taken for both projects from EM-DAT. This is at present the single publicly accessible global disaster impact database[6]. The quality of data produced by EM-DAT is influenced by three factors: the accuracy and uniformity of source data from the press, relief agencies and governments; the precision of its own categorising of losses into individual hazard types; and, its threshold of acceptance of data which excludes 'small' disasters[7].

The quality of data from EM-DAT declines quickly for records taken before 1980. DRI and Hotspots consequently assessed disaster loss data over a 21 year period (1980-2000). The DRI justified the inclusion of earthquakes in its analysis by extending the period for which impact data was reviewed to36 years, based on an assumption that the concentrated losses of earthquakes would have been reported more accurately than other hazard types in the this period.

The DRI's Disaster Risk Index was most sensitive to the type of data in EM-DAT, through the use of EM-DAT mortality data as the dependent variable against which socio-economic variables and physical exposure are selected to explain vulnerability to individual hazards. Hotspots and the DRI measure of Relative Vulnerability also used EM-DAT data to calculate vulnerability.

The Americas programme is independent of EM-DAT data. Only the LDI has disaster loss data as an input, the source here being the DesInventar database of locally and nationally recognised disasters. The comparability of the Americas and DRI/Hotspots approaches will be influenced by the comparability of the EM-DAT and DesInventar datasets. An initial review of these databases has concluded that while substantial

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[5] The exception is Hotspots earthquake hazard assessment which was built on probabilities of occurrence.
[6] For a comparison of EM-DAT with private sector reinsurance databases see: http://www.unisdr.org/eng/task%20force/working%20groups/wg3/Comparative%20Analysis%20of%203%20Global%20Data%20Sets.pdf
[7] Losses are only recognised by EM-DAT when associated with an event that can meet at least one of the following criteria: 10 or more people killed, 100 or more people affected, a call for international assistance, a declared state of emergency.

differences existed in records of people affected by disaster mortality records were comparable[8].

Population Data

DRI and Hotspots used different versions of Gridded Population of the World (GPW)[9] for their indexes. The DRI used global gridded population estimates for 1995 taken from GPW Version 2. This year was chosen as a mid-point measure of population compared to hazard and disaster impact data which was generally taken from 1980-2000. Hotspots used population gridded for 2000 from GPW Version 3. The principal aim in Hotspots was to produce a global map of hazard and risk with sub-national resolution. GPW Versions 2 and 3 use the same resolution of grid cells in their GIS but Version 3 has over twice as many input units reducing estimation and effectively sharpening resolution – an important asset for Hotspots. The extent to which the use of two different population datasets has influenced final results in the DRI and Hotspots is not clear. While individual grid cells may have dramatically changed population levels through urbanisation or rural out-migration, it is unlikely that any country will have changed its population rank relative to others over 5 years - though absolute numbers may be significantly different in terms of number of people exposed to hazard.

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[8] http://www.unisdr.org/eng/task%20force/working%20groups/wg3/Comparative%20Analysis%20of%20Disaster%20Database.pdf

[9] Produced by Center for International Earth Science Information Network, International Food Policy Research Institute and the World Resources Institute