Disaster Risk Reduction

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Table of Contents

Chapter 2

Global Disaster Risk: An Interpretation of Contemporary Trends and Patterns

2.1 Global Disaster Risk Identification

Disaster risk unfolds over time through the concentration of people and economic activities in areas exposed to hazards, e.g. earthquakes, tropical cyclones, floods, drought[23] and landslides; through the frequency and magnitude of hazard events[24] and through the vulnerability of communities and economies, understood in terms of lack of capacity to absorb and recover from hazard impacts. Risk becomes manifest when disasters occur but often is invisible to those taking development decisions at all levels. Risk identification and analysis can therefore be described as a process of making the invisible more visible. Only when risk has been visualized can it be addressed.

In disaster prone countries, identifying, locating, measuring and understanding risk is the first crucial step towards the design of policies, strategies and actions for disaster risk reduction, ranging from development planning through to addressing risk in preparedness for response. Disaster risk identification and assessment at the national and local levels are therefore key priorities for implementing the Hyogo Framework.

Identifying and displaying global patterns and trends in disaster risk does not provide the detailed information required by national planners and decision makers. However, an improved understanding of global risk is vital both to increase political and economic commitment to disaster risk reduction as well as to ensure that the policies and strategies of international organizations are effectively focused and prioritized. Identifying global risk patterns increases understanding of how underlying processes such as climate change, environmental degradation, urbanization and socio-economic development configure disaster risk and vulnerability over time and space. These processes are fundamentally global in character and require a coordinated international commitment.

Risk identification at the global level, will provide key information for the ISDR System. To justify sufficient investment in risk reduction, accurate information on probable disaster losses and costs is required. To be able to predict likely losses, it is necessary to identify the spatial distribution of disaster risk, its likely magnitude and its evolution over time. To be able to reduce disaster impacts effectively, the linkages between development processes, such as urbanization and environmental change, and risk trends and patterns, must be revealed and understood in addition to ‘invisible’ risk factors such as gender bias, social inequity, socio-political conflict and poor governance. In other words, if the ISDR System is to contribute to reducing disaster risk and not just respond to its manifestations, then it is essential to identify, understand and visualize the nature of risk.

This chapter interprets past reports and studies produced by UNDP, UNEP, the World Bank, IDB and Centre for Research on the Epidemiology of Disasters (CRED)[25] to profile contemporary trends and patterns in global disaster risk. The interpretation provides a baseline of current knowledge on global disaster risk against which progress in reducing risk can be examined. These reports have made crucial progress in identifying patterns of global hazards, the exposure of people and economic activities and initial profiles of vulnerability and risk. In addition, links between development and disaster risk, such as between rapid urbanization and earthquake risk, have been established.

At the same time, it is clear that more progress has been made in identifying and measuring global patterns of natural hazard and exposure than in highlighting those factors that contribute to social, economic, political, cultural and other kinds of vulnerability. For example, global data on disaster loss and on disaster risk is not disaggregated in a way that facilitates an analysis of the different socio-economic implications disaster risk has on women and men, on the young and old, or on other most vulnerable sections of societies across different risk scenarios.

[23] Since drought has a strong food insecurity component, in some analysis it is differentiated from other climatic hazards.
[24] See Annex 1 (Technical Annex): Note 1 – Hazard.
[25] UNDP, UNEP, World Bank, IDB, CRED, op. cit.

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Taking into account the limitations posed by existing global knowledge, this Review examines two kinds of hotspots:

1. Intensive disaster risk, where people and economic activities are heavily concentrated in areas exposed to occasional or frequent hazard events with chronic impacts; and
2. Regions of extensive disaster risk, where people are exposed to highly localized hazard events of low intensity, but with frequent asset loss and livelihood disruption over extensive areas.

In both kinds of hotspots, the review contrasts the risk associated with climatic and geological hazards - with respect to both mortality and economic loss.

The concepts and definitions used, based broadly on standard definitions used by the ISDR[26], are explained to make the analysis accessible to readers non-conversant with the technical use of such terminology. A set of technical notes, contained in Annex 1, provide greater detail on definitions, as well as on the technical and methodological aspects of the evidence presented.

[26] Different academic communities have developed concepts and definitions that vary widely. In particular, terms and concepts are used very differently in each language. The ISDR secretariat has adopted a set of standard definitions that are now widely accepted and which form the basis for the analysis presented here. These definitions were published in Living in Risk: a Global Review of Disaster Reduction Initiatives (2004).

2.2 Intensive Disaster Risk Hotspots

Intensive risk

Intensive disaster risk describes a scenario where significant concentrations of people and economic activities are exposed to severe, large-scale hazards, with major impacts in terms of mortality and economic loss.

Realized disaster risk[27] is heavily concentrated in a number of intensive risk hotspots, at least in terms of mortality. Between 1975 and 2005, the total number of disaster deaths recorded by the CRED EM-DAT[28] database was more than 2,300,000. However, as Table 1 indicates, 82 per cent of these occurred in only 21 large disasters with over 10,000 deaths each. Of these, 450,000 deaths occurred in the 1983 famine in Africa and 138,866 due to tropical cyclone Gorky in Bangladesh in 1991. More recently, of the 89,916 deaths recorded in EM- DAT in 2005, 73,338 corresponded to the Kashmir earthquake. Of the 241,400 deaths EM-DAT recorded in 2004, 226,408 corresponded to the Indian Ocean tsunami. Most disaster mortality therefore is concentrated in a very small number of major disasters.

Table 1
Largest disasters 1975-2005 (>10,000 killed)

Year	Hazard	Country	Number killed
1975	Earthquake	China	10,000
1976	Earthquake	China	242,000
1976	Earthquake	Guatemala	23,000
1977	Cyclone	India	14,204
1978	Earthquake	Iran	25,000
1981	Drought	Mozambique	100,000
1983	Drought	Ethiopia and Sudan	450,000
1985	Volcano	Colombia	21,800
1985	Cyclone	Bangladesh	10,000
1985	Cyclone	Bangladesh	10,000
1988	Earthquake	Soviet Union	25,000
1990	Earthquake	Iran (Islamic Rep.)	40,000
1991	Cyclone	Bangladesh	138,866
1998	Hurricane	Honduras	14,600
1999	Flood	Venezuela	30,000
1999	Earthquake	Turkey	17,127
2001	Earthquake	India	20,005
2003	Earthquake	Iran (Islamic Rep.)	26,796
2003	Heat wave	France, Italy	34,947
2004	Tsunami	Indian Ocean	226,408
2005	Earthquake	Pakistan	73,338

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

[27] See Annex 1 (Technical Annex): Note 3 – Disaster Risk.

[28] The EM-DAT (Emergency Events Database) is maintained by CRED (Centre for Research on the Epidemiology of Disasters), a non-governmental organization based at the Catholic University of Louvain in Belgium. EM-DAT at present provides the best global assessment of disaster occurrence and loss, available in the public domain, and therefore accessible by the disaster risk management community. For further information on EM-DAT, see Annex 1 (Technical Annex): Note 2 - EM-DAT Disaster Database.

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In terms of economic loss, realized risk is slightly less concentrated. Table 2 indicates that 38.5 per cent of total economic losses between 1975 and 2006 were concentrated in 21 disasters that each caused more than USD 10 billion of damage.

Table 2
Disaster causing more than USD 10 billion economic losses (1975-2006)

Year	Hazard	Country affected	Total damages in million USD
2005	Hurricane	United States	125
1995	Earthquake	Japan	100
1998	Flood	China (People's Rep.)	30
2004	Earthquake	Japan	28
1992	Hurricane	United States	26.5
1980	Earthquake	Italy	20
2004	Hurricane	United States	18
1997	Wild Fires	Indonesia	17
1994	Earthquake	United States	16.5
2004	Hurricane	United States	16
2005	Hurricane	United States	16
1995	Flood	Korea D.P.R.	15
2005	Hurricane	United States	14.3
1999	Earthquake	Taiwan (China)	14.1
1988	Earthquake	Soviet Union	14
1994	Drought	China	13.8
1991	Flood	China	13.6
1996	Flood	China	12.6
1993	Flood	United States	12
2002	Flood	Germany	11.7
2004	Hurricane	United States	11

Data source: EM-DAT OFDA/CRED International Disaster Database

Hazard exposure

Intensive risk hotspots occur because hazard exposure is concentrated in regions where large numbers of population and economic activities coincide with high levels of single or multiple overlapping hazards, e.g. earthquake, tropical cyclone, flood, drought, volcanic eruption and landslide.

The concept of hazard exposure or physical exposure is used to measure this concentration by combining the level of a hazard's frequency and potential severity in a location, with the number of people and assets including infrastructure and economy exposed. Processes such as urbanization, growing population density and unregulated economic activities can play a key role in concentrating exposure in certain hazard-prone areas. Through other processes such as environmental degradation and land-use change, development can also increase the severity of hazard itself, particularly climatic hazards. Development activities, therefore, are a key driver of patterns of hazard exposure, and unfolding risk.

According to UNEP's Global Resource Information Database (GRID) Europe and UNDP[29], 118 million people are exposed annually to earthquakes (magnitude higher than 5.5 on Richter Scale), 343.6 million people are exposed annually to tropical cyclones, 521 million are exposed annually to floods while 130 million people are exposed to meteorological drought[30]. Additional analysis by UNEP/GRID and the Norwegian Geotechnical Institute has shown that 2.3 million people are exposed to landslides every year mostly in Asia and the Pacific (1.4 million) and Latin America and the Caribbean (351,600)[31].

Vulnerability

Hazard exposure goes a long way in explaining why disaster risk is concentrated in intensive risk hotspots but by itself it is not enough. Disaster risk is also a function of the vulnerability[32] of whatever is exposed. Vulnerability can be broadly defined as a measure of the capacity to absorb the impact and recovery from a hazard event and is conditioned by a range of physical, social, economic and environmental factors or processes. Like hazard exposure, development activities influence patterns of vulnerability in a society and modify those conditions over time, making different social and economic sectors in a society more or less able to resist and recover from hazard events.

Human vulnerability (used here to describe people's vulnerability to hazard as opposed to the vulnerability of physical elements such as buildings/ infrastructure or the vulnerability of an economy) is often characterized by precarious settlements located in fragile ecosystems, structurally unsafe buildings and uncertain livelihood options.

One way of measuring human vulnerability[33] is that, for a given level of hazard exposure, countries experience very different levels of mortality. Mortality for a given level of hazard exposure over a given period of time can be described, from one perspective, as a measure of relative mortality risk. However, it can also be viewed as a proxy value for all the physical, social, environmental, economic, political and cultural vulnerability factors that increase or decrease the probability of mortality. For example, improved disaster preparedness systems and emergency health facilities or improved building standards may reduce mortality. Other factors, such as the occupation of extremely hazard-prone locations by socially and economically excluded populations, environmental degradation that alters the strength, frequency, extent and predictability of hazard events and chronic poverty trends, are factors that may increase mortality.

Clearly, mortality is one possible outcome of vulnerability. Other outcomes include injury, loss of livelihood, long-term health problems and psycho-social ailments, the partial or total displacement of communities, and the deterioration of living conditions, social services and the environment, which, for some hazard scenarios, may be far more significant

[29] See Annex 1 (Technical Annex): Note 4 - Hazard Exposure.
[30] 'Meteorological drought' refers to a significant deficit in rainfall over an extended period, e.g. three months with less than 50 per cent of the usual precipitations. Meteorological drought may lead to agricultural drought, where crops and harvests are negatively affected. However, lack of precipitation may be offset by irrigation, use of ground water and by water storage in many cases. Similarly, agricultural drought does not necessarily lead to mortality and other human impacts, given that it can be offset by food imports, stockpiles and other measures.
[31] Nadim, F. O. Kjekstad, P. Peduzzi, C. Herold and C. Jaedicke, (2006), Global Landslides and Avalanches Hotspots, Landslides.
[32] See Annex 1 (Technical Annex): Note 5 – Vulnerability.
[33] See Annex 1 (Technical Annex): Note 6 – Disaster Risk Index.

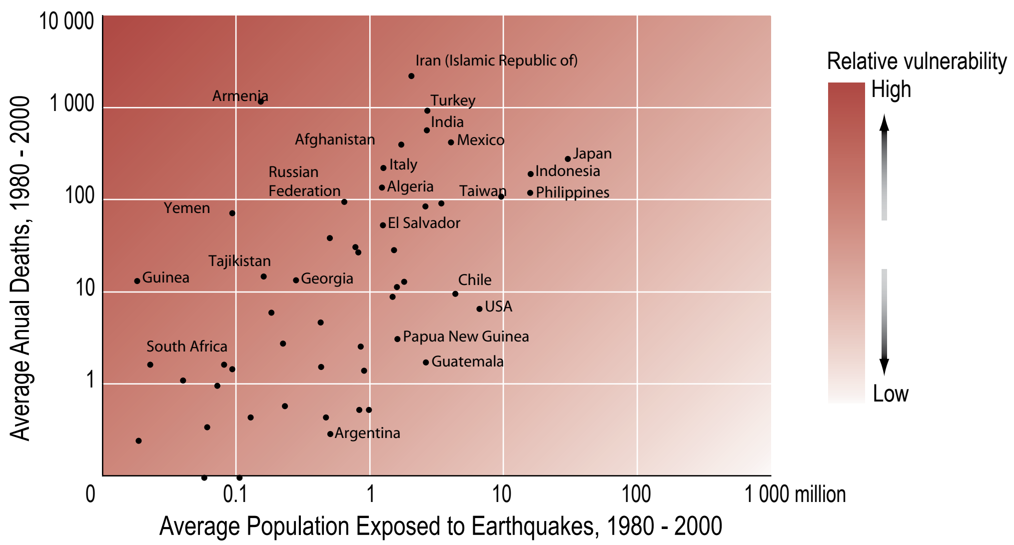
than mortality. For example, frequent floods may cause low mortality but a very extensive disruption of livelihoods and infrastructure. Unfortunately, data availability constraints do not currently allow the analysis of human vulnerability using disaster-related outcomes other than mortality.

Figure 1 shows a distribution of relative human vulnerability for earthquakes, expressed in terms of realized mortality from 1980-2000 for populations exposed to earthquakes. Countries on the top left of the figure are more vulnerable relative to those on the bottom right. It is important to highlight this difference when interpreting the figure. Below the trend line, countries like Japan and the United States of America may have high levels of hazard exposure but low levels of vulnerability relative to that exposure. In contrast, a country like Yemen has a high level of vulnerability relative to its level of hazard exposure. From this perspective, there are very wide variations in relative vulnerability between countries. In the case of earthquakes[34], the number of people killed per million exposed each year in the Islamic Republic of Iran (1,074) is over 1,000 times greater than that of the United States of America (0.97) and 100 times greater than that of Japan (9), even though exposure is greater in the latter two countries. That implies very wide variations in mortality for similar levels of hazard exposure that can only be explained in terms of differential contexts of vulnerability. The level of mortality that occurred in Bam, Iran, in December 2003, where 26,796 were killed would never have occurred if a similar earthquake had affected a similar sized city in the United States of America or Japan. At the same time, risk increases along the trend line from bottom left to top right illustrated by countries such as the Islamic Republic of Iran, which combine high relative vulnerability with large numbers of people exposed.

Figure 1

Relative Vulnerability to Earthquakes

This graph shows the vulnerability of national population for earthquakes. On the x-axis, the number of population yearly exposed (in average) to earthquakes while the y-axis, shows the average number of deaths as recorded in EM-DAT. The ratio killed / exposed provides a proxy for vulnerability, e.g. Iran is 1000 times more vulnerable than the USA.



Source: Reducing Disaster Risk, UNDP 2004
Data on exposure: UNEP/GRID-Europe,
Data on mortality, EM-DAT OFDA/CRED International Disaster Database

[34] Taking into account the methodological limitations of the DRI explained in Annex 1 (Technical Annex): Note 6.

In the case of tropical cyclones (Figure 2), the relative vulnerability of the United States of America (2.49) is more than 15 times greater than that of Cuba (0.16). This result was also illustrated recently by the very low level of mortality produced by hurricanes affecting Cuba in 2004 and 2005, compared to the 1,833 lives lost when Hurricane Katrina affected New Orleans and Mississippi in 2005. Similarly, Figure 3 shows that the relative vulnerability of Haiti is far greater than that of the Dominican Republic, even though both countries share the same island and have similar numbers of exposed population.

Risk

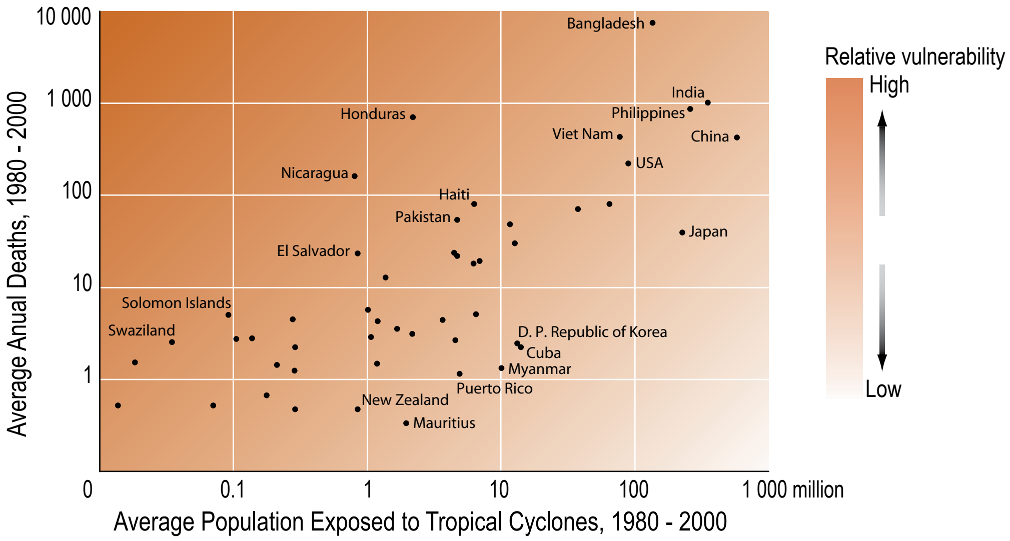
Unless existing risk levels are drastically reduced, it is likely that in the future, large-scale catastrophes involving significant mortality, economic loss and other outcomes will occur in intensive risk hotspots, where high relative vulnerability is combined with major concentrations of hazard exposure. The level of disaster risk in these intensive risk hotspots has been calculated for earthquake, flood, tropical cyclone, drought and landslide and for multiple hazards, by multiplying hazard exposure with a vulnerability indicator[35]. Disaster risk has been calculated in terms of mortality, total economic loss and economic loss as a proportion of Gross Domestic Product (GDP) density.

Mortality and economic loss hotspots for earthquakes (Figures 4) include the trans-Himalayan and trans-Caucasian regions as well as parts of Japan, Indonesia, the Andean countries and Central America. In terms of economic loss, Japan, Turkey and Iran are at particular risk, as well as parts of South and South-East Europe and Central Asia. Mega cities such as Tehran represent both mortality and economic loss hotspots where enormous concentrations of vulnerable people and economic activities interface with a high

Figure 2

Relative Vulnerability to Tropical Cyclones

Same representation as in Figure 2, this plate shows vulnerability to tropical cyclones. Yearly average exposed population is on the x-axis, average recorded killed on the y-axis. Once comparing the killed per exposed, Cuba is 12.5 times less vulnerable than the USA.



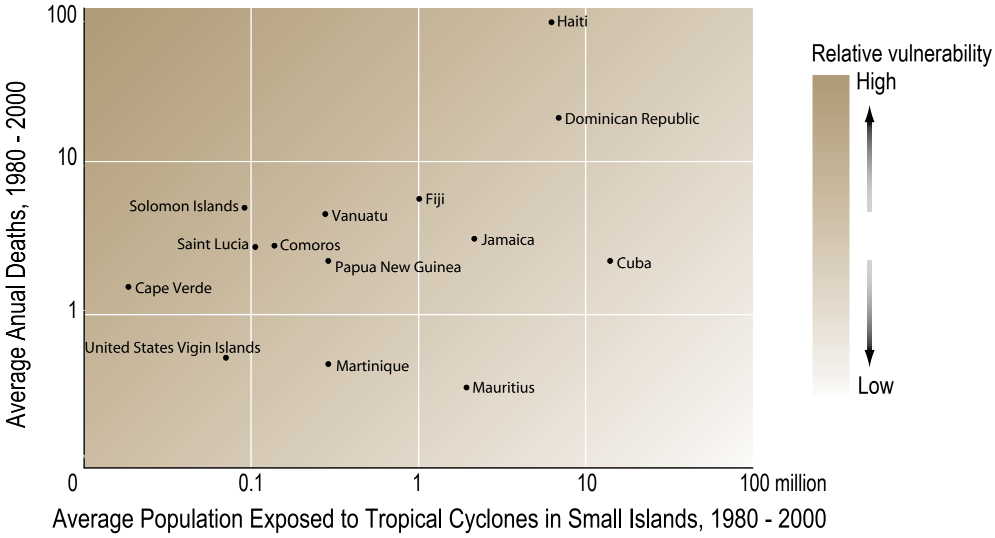
Source: Reducing Disaster Risk, UNDP 2004
Data on exposure: UNEP/GRID-Europe,
Data on mortality, EM-DAT OFDA/CRED International Disaster Database

[35] See Annex 1 (Technical Annex): Note 7 – Disaster Risk Hotspots.

Figure 3

Relative Vulnerability to Tropical Cyclones in Small Islands

This is a zoom in from Figure 2 with a special focus on small island developing states (SIDS). Haiti and the Dominican Republic are located on the same island and quite logically have a similar exposure to tropical cyclones. However, Haiti suffers on average 4.6 more deaths per person exposed than the Dominican Republic.



Source: Reducing Disaster Risk, UNDP 2004
Data on exposure: UNEP/GRID-Europe,
Data on mortality, EM-DAT OFDA/CRED International Disaster Database

level of hazard. Cities concentrate a substantial proportion of a country's gross domestic product (GDP), implying that the indirect economic loss would be national in character. In the case of some mega-cities, for example Tokyo, the impact in economic terms would be global. In the case of earthquakes, both economic loss and mortality hotspots are heavily concentrated in rapidly urbanizing developing countries.

In the case of cyclones, mortality hotspots include coastal areas in South and East Asia, Central America and the Caribbean and parts of Madagascar and Mozambique. Economic loss hotspots however include the eastern seaboard of the United States of America, a region with relatively low mortality risk.

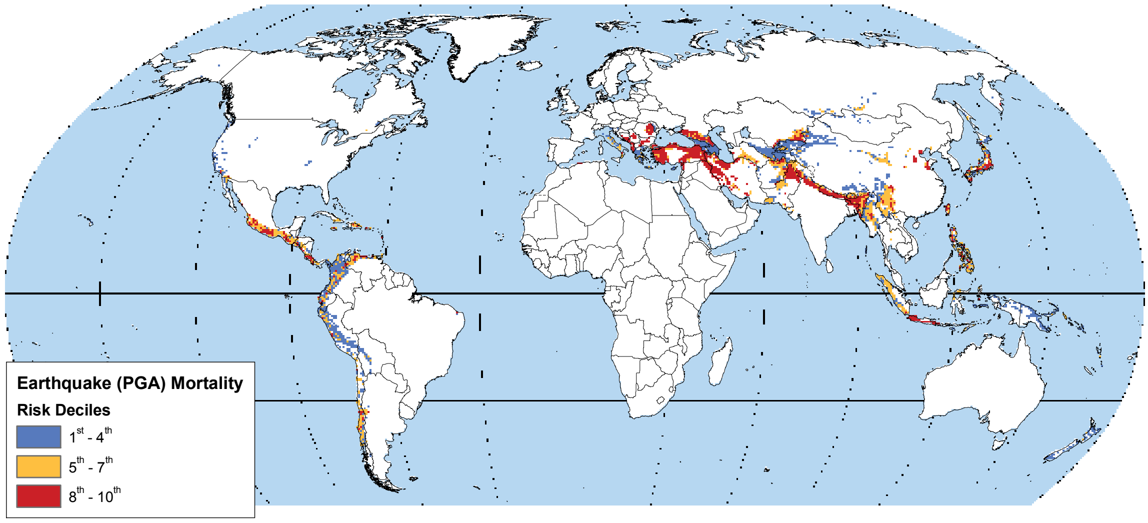
Flood mortality hotspots are concentrated in major river basins in South and East Asia as well as in Latin America. As in the case of cyclones, economic loss hotspots include areas of Europe and the eastern United States of America, with relatively low mortality risk.

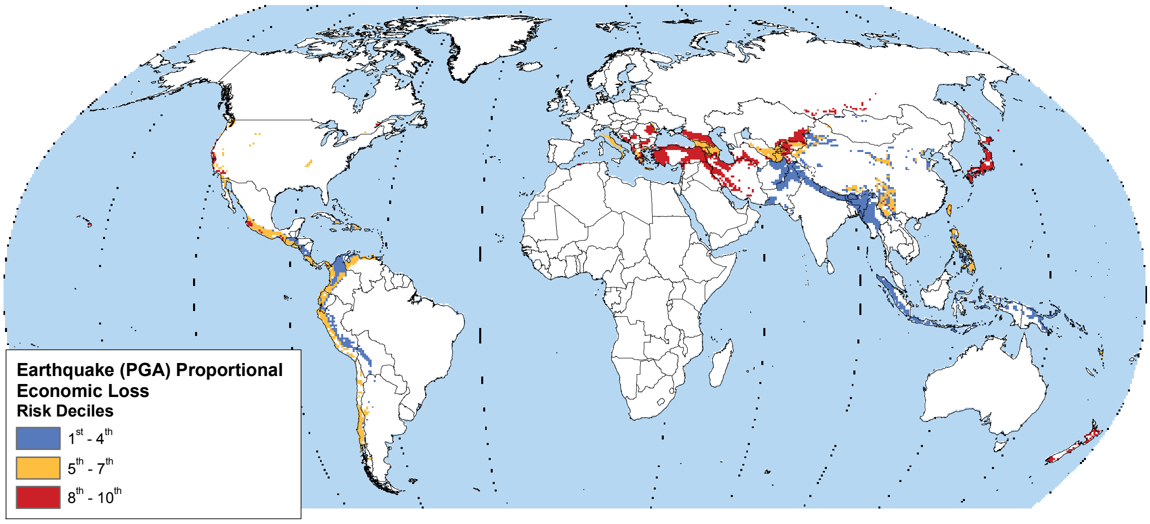
Drought mortality hotspots (Figures 5) are concentrated exclusively in sub-Saharan Africa. Economic loss hotspots for drought, in contrast, are located in more developed regions, for example in southern Europe and the Middle East, Mexico, north-east Brazil and north-east China.

Figure 4

Mortality, economic and proportional economic loss from earthquakes

These maps show distribution of mortality and economic risk for earthquakes. This visualization shows a broadly similar distribution of mortality and economic loss risk for earthquakes.





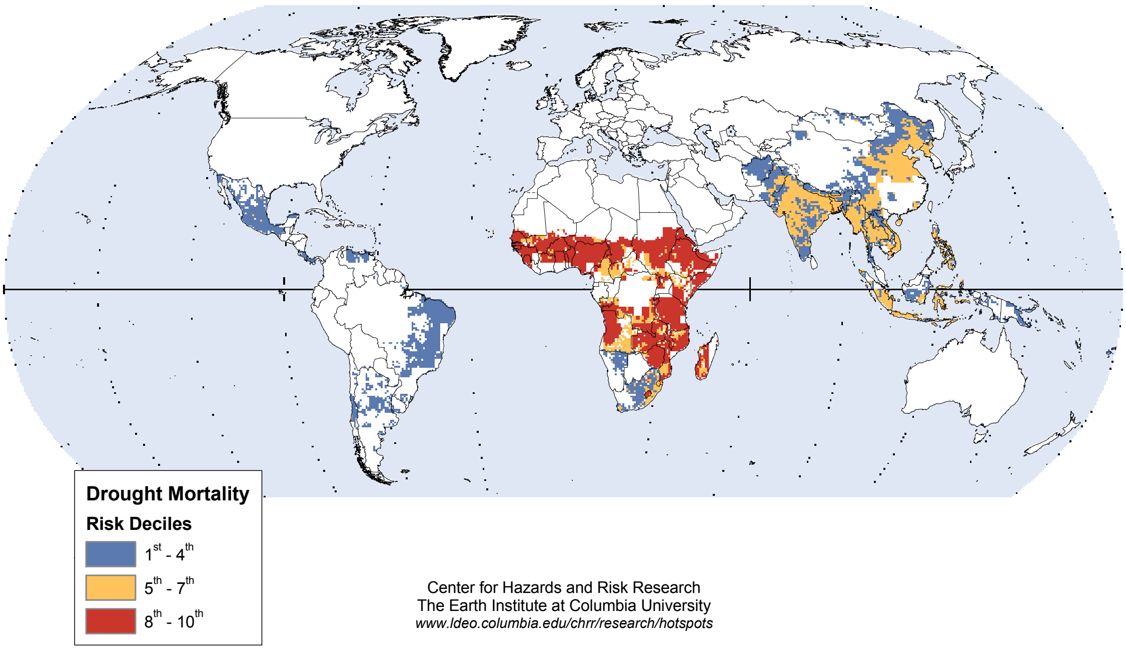
Source: Natural Disaster Hotspots: a Global Risk Analysis Synthesis Report, World Bank

Figure 5

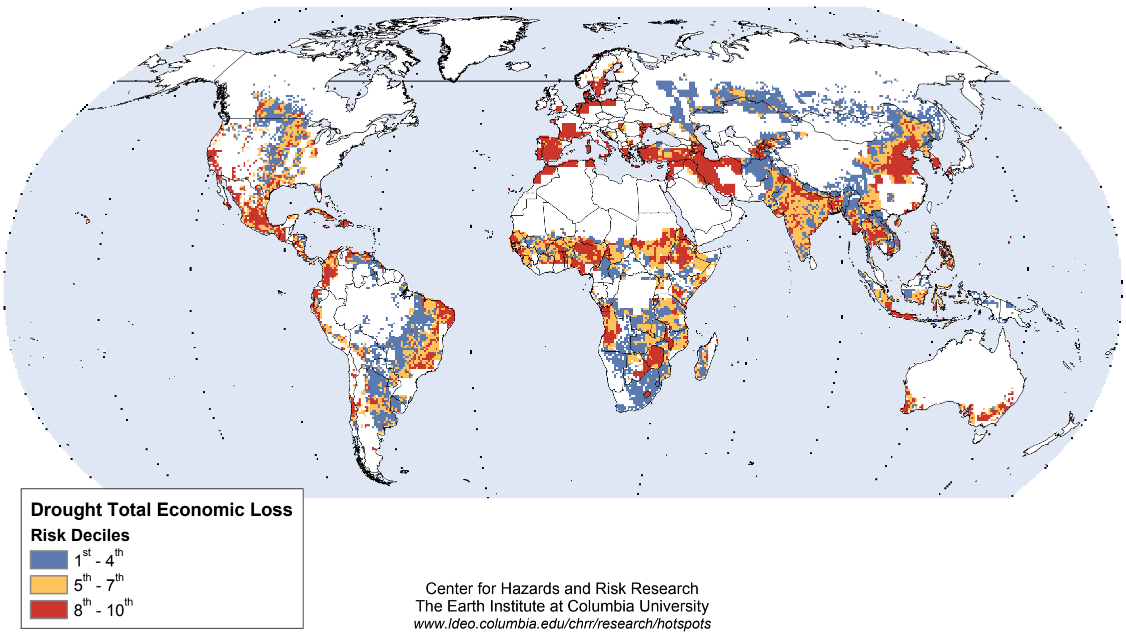
Drought mortality and economic loss distribution

These maps show the distribution of both mortality and economic risk from drought. This visualization shows a radically different distribution pattern in the case of drought. Mortality is heavily concentrated in Africa and other developing countries, whereas economic loss risk also affects developed countries.

Drought mortality loss distribution



Drought economic loss distribution



Source: Natural Disaster Hotspots: a Global Risk Analysis Synthesis Report, World Bank

Economic resilience

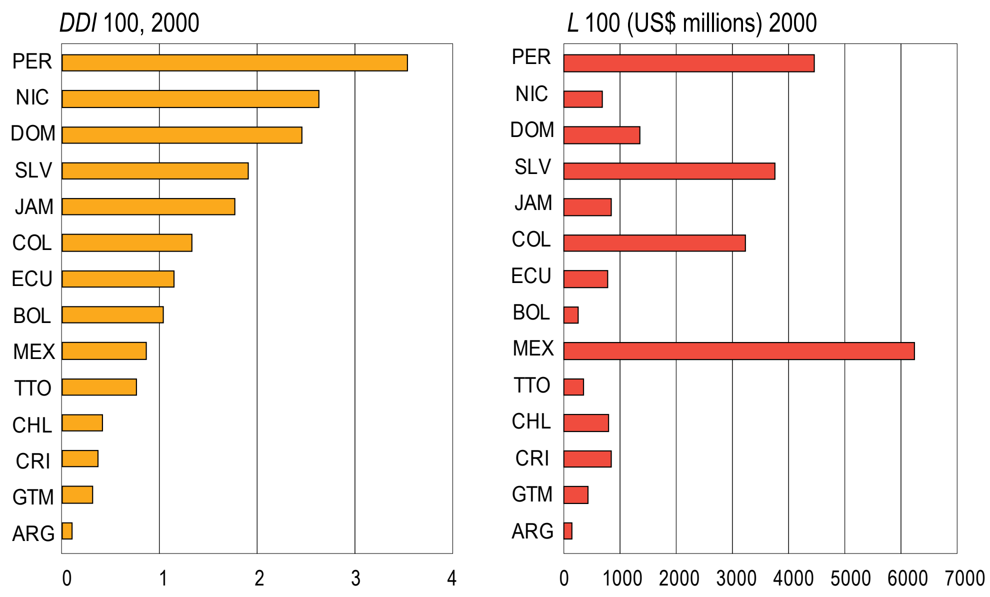
Even when economic loss risk is described in relative terms as a proportion of GDP, it provides only a crude measure of the capacity of a country to absorb and recover from the economic impact. This depends on many other factors associated with economic resilience to cope with extreme catastrophic events, including potential reinsurance and insurance payments, the existence of disaster reserve funds, access to external credit from multilateral organizations and capital markets and others. A study of the economic resilience of 14 Latin American and Caribbean countries, on the basis of the likely impact of a maximum probable event and a combination of seven resilience indicators, was calculated by IDB[36].

This study shows enormous variations between countries. Figure 6 shows the likely maximum loss values for the maximum catastrophe likely to occur in a 100-year period for the 14 countries and the calculation of a Disaster Deficit Index which compared the maximum loss value with the combined resilience indicators. All values above 1.0 indicate an inability to cope with the likely cost of a maximum catastrophe in a 100-year period[37]. Six countries would have problems coping, in particular Peru and the Dominican Republic. In contrast, Mexico could cope, even though in absolute terms it has the highest potential loss figure.

Figure 6

Disaster Deficit Index for a 100-year catastrophe

The Disaster Deficit Index (DDI) measures a country's economic resilience with respect to the probable maximum loss that could occur from a natural hazard with a100-year return period. The right hand graph expresses the maximum probable losses. The graph on the left shows the country's capacity to cope with such losses. A value above 1 reflects lack of resilience. Although the maximum probable loss is much higher for Mexico compared with Nicaragua (6,273 and 682 million USD respectively), Mexico has far greater resilience (0.86) than Nicaragua (2.63). See Annex 1 (Technical Annex) Note 8 for further explanation.



Source: Cardona, O.D, (2005), Indicators for Disaster Risk and Risk Management. Program for Latin America and the Caribbean

[36] Cardona, O. D, (2005), Indicators of Disaster Risk and Disaster Risk Management. IDB. For further information see Annex 1 (Technical Annex): Note 8 – Disaster Deficit Index.

[37] Maximum Considered Event in a 100-year period. Five per cent probability of occurrence in a 10-year period.

Trends in mortality

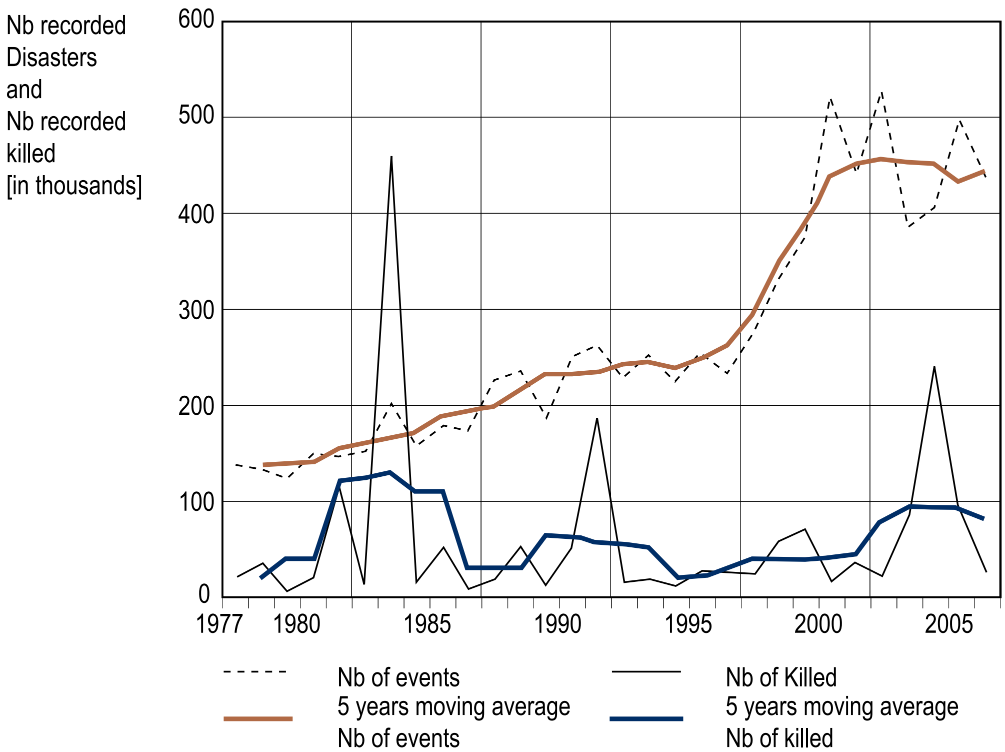
Figure 7[38] indicates that disaster occurrence, over the last 30 years, has increased far faster than the number of deaths, which has remained relatively constant.

From a global perspective, this could imply that at the same time as hazard exposure is increasing (more people and assets exposed to hazards and therefore more disasters) relative human vulnerability may be decreasing (similar numbers of deaths for more people exposed). However, this apparently optimistic conclusion is challenged when mortality data is examined for different hazard types across regions. As Figure 8 indicates, most of the reduction in mortality is due to a dramatic fall in drought mortality since the major drought disasters of the early 1980s in Africa. In contrast, as Figure 9 shows, mortality rates for other climatic hazards and for geological hazards are still rising globally while mortality is also increasing in all regions.

Figure 7

Trends of recorded natural disasters and numbers killed, 1977-2006 (CRED)

This graph displays two different sets of information - the annual number of disaster events recorded by EM-DAT and the annual recorded mortality - using a five-year moving average. The fact that disaster occurrence has almost doubled between 1995 and 2005 may be influenced by increased access to information and increasing exposure of population and economic assets. However, it is likely that this is also associated with a dramatic increase in the number of small-scale climatic hazard events with relatively low mortality. In contrast, the 'flat' mortality trend is conditioned by major reduction in drought mortality in Africa since the early 1980s.



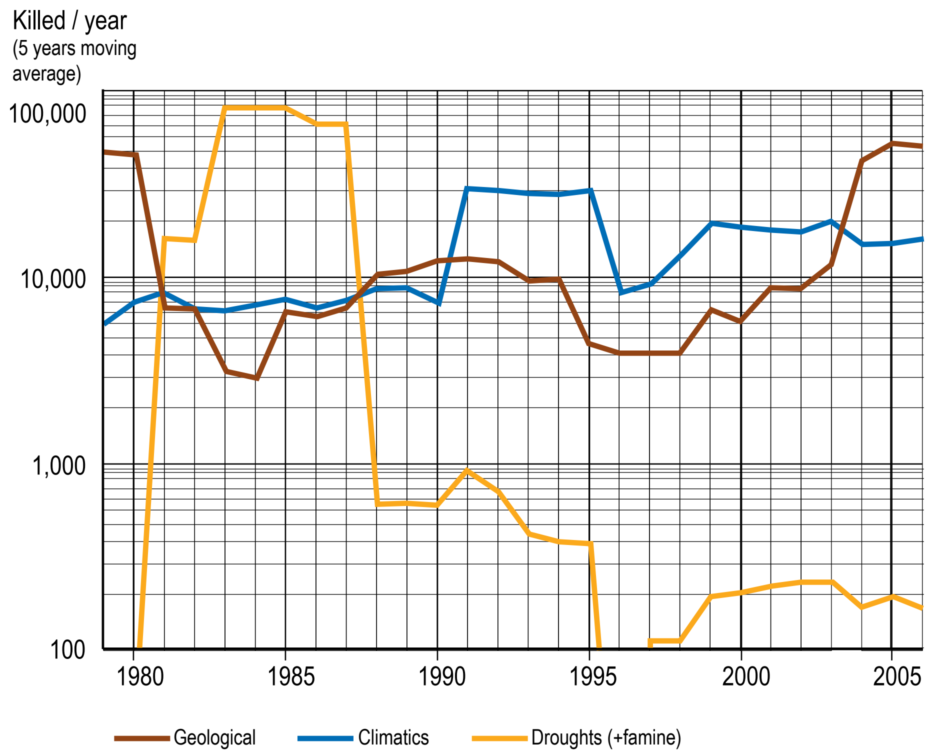
Sources: EM-DAT: The OFDA/CRED International Disaster Database

[38] See Annex 1 (Technical Annex): Note 9 – Disaster Loss.

Figure 8

Numbers killed per year, by type of hazard

Annual mortality recorded by EM-DAT, displayed using a five-year moving average, evolves in radically different ways for specific hazard classes. While mortality associated with geological hazards has increased since the late 1990s (in particular due to the 2003 Bam earthquake in Iran, the 2004 Indian Ocean tsunami and the 2005 Kashmir earthquake), mortality associated with climatic hazards has remained stable, except for drought where mortality has dramatically reduced.--



Data source: EM-DAT, OFDA/CRED International Disaster Database

One possible explanation for the apparently rapid increase in disaster occurrence is that this is associated with large numbers of smaller scale climatic hazards with relatively low mortality. This will be examined in detail in the section on extensive risk below. Given that most deaths occur in large-scale catastrophes, mortality risk in intensive risk hotspots would still seem to be increasing, particularly for geological hazards. This would be unsurprising given that mortality risk is sensitive to the underlying development processes in geological risk hotspots and climatic risk hotspots in very different ways.

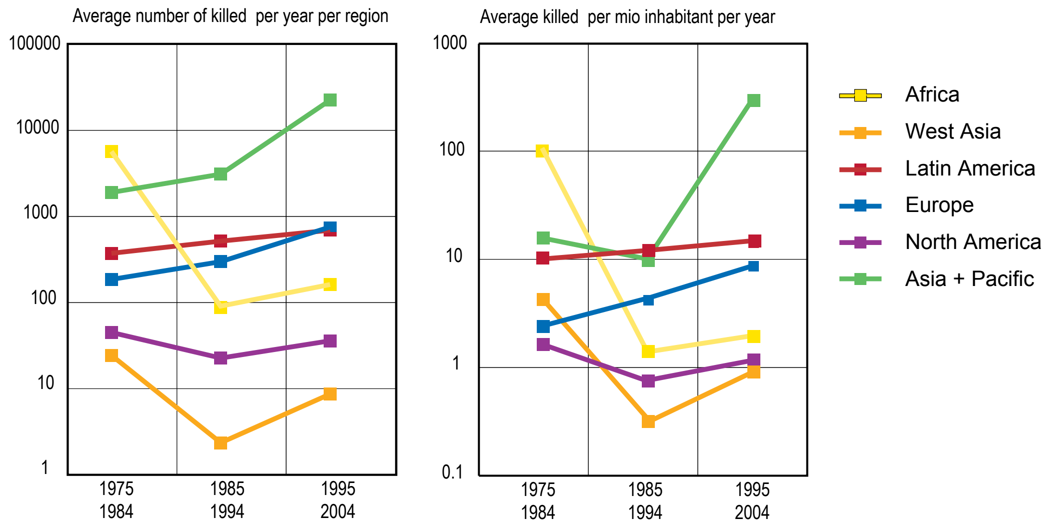
In the case of two key climatic hazards (tropical cyclones and floods), a correlation of mortality risk[39] with a range of social, economic and environmental indicators[40] showed that high mortality was correlated with factors such as large rural populations and low levels of human development. This implies that economic and social development with improved

[39] The existence of a correlation does not imply a causal relation; however it does pose hypothesis regarding possible causalities.
[40] UNDP op. cit.

Figure 9

Trend in numbers killed by region over decades

The two graphs show trends by averaging killed and killed per million inhabitants by decades and by regions. During the large famine of the eighties, Africa was the continent most affected by natural hazards. The decrease is well shown after 1984. The continent that suffers the most casualties in both absolute and relative terms is Asia. Although, the high figure is largely due to the victims from the 2004 tsunami.



Data source: EM-DAT, OFDA/CRED International Disaster Database

health, sanitation, infrastructure and communications in many rural areas is associated with a reduction in mortality risk. Improved early warning, disaster preparedness and response may also contribute. As a consequence, mortality in climatic risk hotspots in developed countries, as well as in some developing countries like Cuba, is now relatively low. While mortality risk in climatic risk hotspots in less developed regions remains high[41], its evolution in recent years (Figure 9) is fairly flat.

This conclusion is supported by the spatial distribution of mortality risks in climatic risk hotspots[42]. In the case of floods, cyclones and drought, mortality risk is heavily concentrated in less developed regions and is far less in more developed regions. In the case of drought (Figures 5), this distribution is particularly notable. This indicates that economic and social development, together with factors such as improved disaster preparedness and early warning, can lead to a reduction in mortality risk in the case of climatic hazard.

In the case of geological hazard, in particular earthquakes, mortality risk corresponds very differently. High earthquake mortality risk is closely correlated with very rapid rates of urbanization, particularly in developing countries such as Turkey and Iran. Given that earthquake mortality is closely associated with building collapse, this may reflect contexts where there are difficulties in implementing building regulations and planning controls when urban growth is very fast accompanied by the growth of unregulated urban settlements. When economic

[41] See Annex 1 (Technical Annex): Note 10 – Vulnerability factors.
[42] World Bank op. cit

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and social development is characterized by this kind of urban growth, it may lead to an increase rather than a decrease in earthquake mortality risk.

In contrast to climatic hazard, earthquake mortality risk is far less sensitive to reductions through enhancements in early warning, preparedness and response. The relatively infrequent occurrence of earthquakes also conspires against the incorporation of risk reduction considerations into urban development. Earthquake mortality risk is less in developed countries with slower rates of urban growth, associated with established planning and building standards and regulated settlement and urban development.
Clearly a more disaggregated analysis by gender, age and other factors is required to better understand the processes driving these risk trends; however, the trends in the case of climatic and earthquake risk hotspots would appear to be very different.

Given that economic development will continue to drive rapid urbanization in areas characterized by earthquake hazard, it would seem likely that earthquake risk hotspots will continue to concentrate mortality risk. It is projected that by 2010 more than 50 per cent of the world's population will be living in cities. More than 30 per cent of urban population is living in slums[43] - which are unregulated. Improvements in disaster preparedness and response are unlikely to reduce more than a small part of this mortality risk. As much of this risk has already been accumulated, as in large mega-cities without a history

[43] UN-Habitat, (2003), Water and Sanitation in the World's Cities: Local Action for Global Goals. Waking Up to Realities of Water and Sanitation Problems of Urban Poor.

of recent major earthquakes, a significant part of future mortality in such locations is perhaps inevitable.

In the case of climatic hotspots, even in less developed regions, there is evidence to suggest that mortality risk may be stabilizing and perhaps reducing due to the combined effects of social and economic development and improvements in early warning, disaster preparedness and response. However, the experience of the 2003 European heat wave and of Hurricane Katrina in the United States in 2005 shows that even highly developed countries can experience serious rates of mortality, when preparedness and response capacities are unable to cope with unexpected events or response systems and mechanisms have been allowed to lapse. The next section will discuss how climate change may drastically modify current assumptions about risk levels.

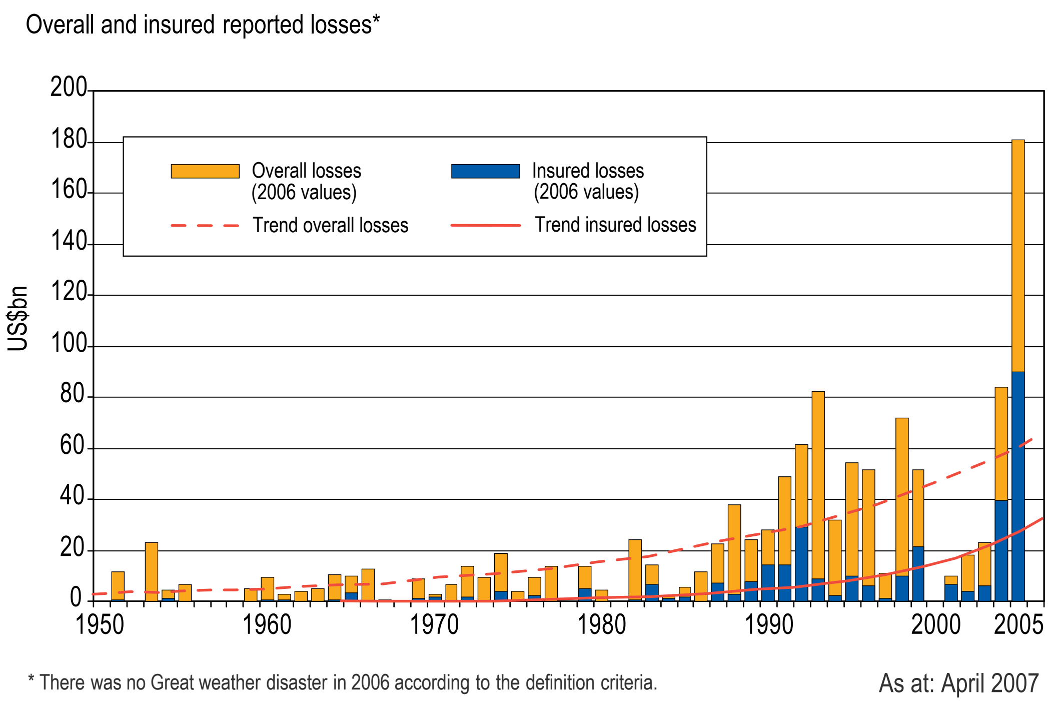
Trends in economic loss risk

In the case of economic loss risk, Figures 10 and 11 show a total economic loss of USD 1,700 billion, insured losses of USD 340 billion and a very clear upward growth trend in large-scale disasters over the last 50 years. In contrast to mortality risk, it is likely that economic loss risk is driven by development in similar ways in both geological as well as climatic risk hotspots[44]. This assumption can be supported by the spatial distribution of economic loss risk for all kinds of hazards in more developed countries. As the value of assets such as property increases in many developed countries, economic loss risk will also increase. However, in general, higher levels of economic development are consistent with a greater number of economic assets at risk for both kinds of hotspots.

Figure 10

Great weather disasters 1950–2006

Economic losses recorded by Munich Re are increasing. However, this could be due to different causes (not mutually exclusive): increase in value property, increase in assets exposure, increasing access to climatic hazard information (due to Internet and launch of new satellites), or if weather hazards are increasing due to climate change. The causalities have to be further studied.



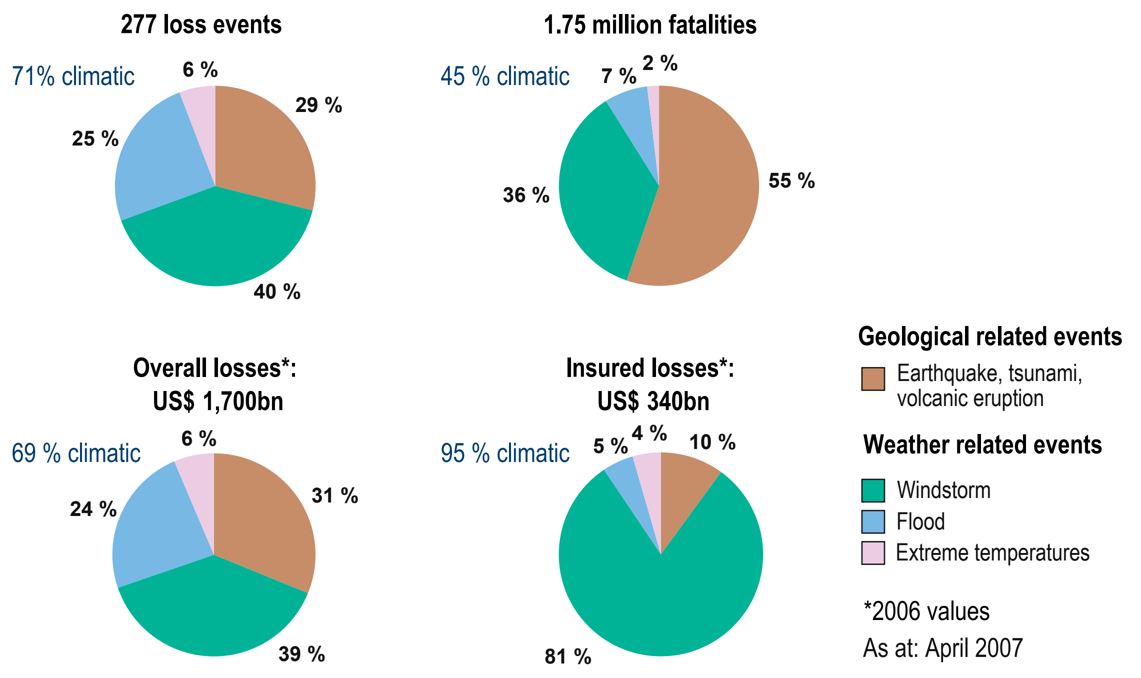
Sources: © 2007 Münchener Rückversicherungs-Gesselschaft Geo Risks Research, NatCat SERVICE

[44] See Annex 1 (Technical Annex): Note 11 – Economic Loss Data.

Figure 11

Great natural disasters 1950–2006: Percentage distribution worldwide

Climatic events represent 71 per cent of large-scale economic disasters, causing 45 per cent of recorded mortalities, but responsible for 69 per cent of economic losses and 90 per cent of insured losses.



Sources: © 2007 Münchener Rückversicherungs-Gesselschaft Geo Risks Research, NatCat SERVICE

In the case of climatic risk hotspots, while measures such as enhanced early warning, disaster preparedness and response can save lives, they do not reduce the loss and destruction of economic assets, except when applied to agricultural planning. Even countries like Cuba that have achieved a very low level of relative human vulnerability to tropical cyclones, can suffer significant economic losses with every major event. Figure 11 shows that windstorms, floods and extreme temperatures accounted for 71 per cent of the disasters recorded, 69 per cent of the total economic loss but only 45 per cent of disaster mortality.

Given that economic loss in climatic risk hotspots is concentrated in the developed world, it is possible that economic loss risk will become increasingly associated with major climate-related hazard events affecting more developed regions. For example, while Hurricane Katrina in 2005 was responsible for 1,833 deaths in the United States of America, it caused more than USD 125 billion in economic losses. In contrast, Hurricane Mitch in 1998 in Central America was responsible for over 11,000 deaths but only USD 5 billion in economic losses[45].

[45] Sources: EM-DAT, (2007).

2.3 Extensive Disaster Risk

Extensive disaster risk describes a scenario where smaller concentrations of people and economic activities are exposed to frequently occurring but highly localized hazard events, such as flash floods, landslides and wild fires, with relatively low intensity asset loss and livelihood disruption over extensive areas

The attention of the humanitarian community, the private sector and the media is overwhelmingly focused on the effects of large-scale catastrophes in intensive risk hotspots. As described above, these disasters account for the vast majority of mortality cases. Discounting these large-scale events, annual disaster mortality across the globe, according to EM-DAT, was only 11,260 for the decade 1975-1984, 14,586 for 1985-1994 and 7,021 for 1995-2004 (Table 3), figures that are extraordinarily flat if one considers population growth over the same period. The global population reached 6.54 billion in 2006[46] and continues to grow at a rate of 80 million per year (the equivalent of a country the size of Germany or Viet Nam).

Table 3
Mortality trends excluding large-scale catastrophes

Decade	Mortality in disasters that killed over 10,000	Other mortality	Total annual mortality	Total annual mortality excluding disasters with over 10,000 killed
1975-1984	864,204	112,596	97,680	11,260
1985-1994	235,666	145,864	38,153	14,586
1995-2004	360,971	70,211	43,118	7,021
TOTAL KILLED	1,460,841	328,671		

Data source: EM-DAT OFDA/CRED International Disaster Database

EM-DAT shows (Figure 12) that the number of climate-related disasters is increasing far faster than the number of geological disasters, particularly since the late 1970s. At the same time, EM-DAT also indicates that the number of small and medium-scale disasters is growing much faster than large-scale disasters[47]. These figures are consistent with the fact that, if the mortality from large-scale disasters is excluded (Figure 13), mortality in climatic disasters related to an increasing number of small-scale events is rising far faster than in geological disasters albeit from a low baseline.

These results indicate that in parallel with intensive risk hotspots, extensive risk scenarios are also unfolding, characterized by large numbers of highly localized, mainly climatic hazard events spread over extensive areas and affecting relatively low concentrations of people and economic assets. Many climate-related hazards such as landslides, flash floods, localized storms and coastal flooding, result in highly localized disaster impacts and thus an increase in small and medium-scale disasters. The rapid growth in the number of small-scale climatic disasters and of mortality in these events tends to indicate that extensive risk is increasing rapidly, although it has been studied far less systematically than the intensive risk hotspots and large-scale disasters.

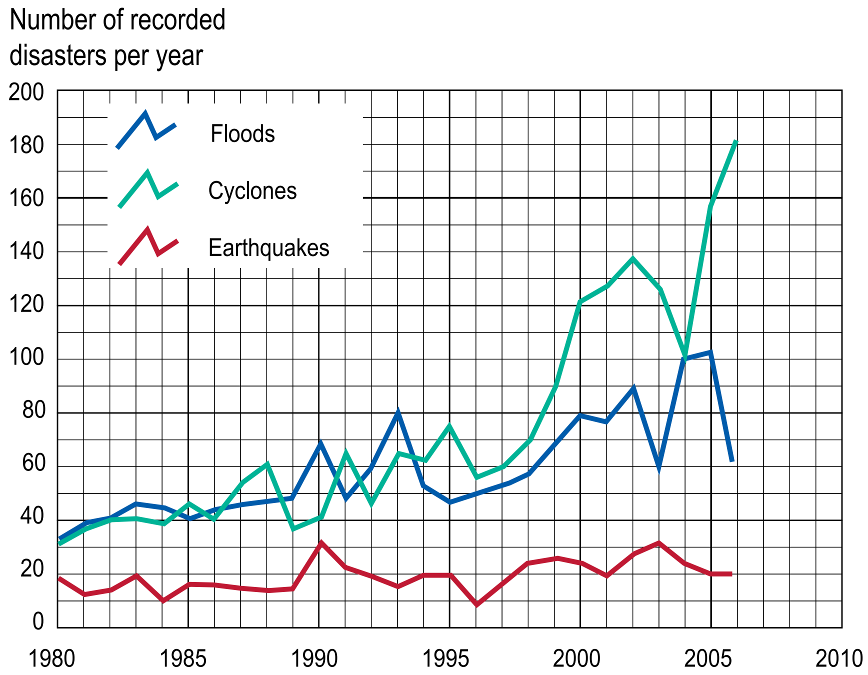
It is likely that these emerging patterns of extensive risk are being driven by concurrent processes of urbanization, population growth, environmental degradation and the productive transformation of new territories. The combined effects of this process generates an increase in the extent, the frequency and magnitude of localized flooding, flash flood, landslide and wildland fire events, create new climate-related hazards in previously hazard-free areas due to

[46] World Population Prospects: The 2006 Revision Population Database: http://esa.un.org/unpp/
[47] Defined as over 50 deaths or 150,000 affected people or USD 200 million in economic losses.

Figure 12

Trends of events by hazard types

The number of recorded disasters per year is steady for earthquakes. However, one can see an increase in recorded tropical cyclones and flood disasters. There are two possible hypotheses (which are not exclusive): either access to information on climatic hazards has increased (e.g. due to development of new satellites) or climatic hazards are increasing due to climate change and other factors.



Data sources: EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net

environmental change and increase in the population and economic activities exposed. For example, forests are currently being reduced by 130,000 km2 per year[48] globally, while increases in landslide frequency in deforested areas are likely.

A closer look at extensive risk is provided by the data available in national disaster databases. Accurate global data on small-scale disasters below the EM-DAT reporting threshold[49] does not exist. However, a number of countries in Asia and Latin America have made significant progress in developing disaster databases using the DesInventar (Inventario de Desastres - Disaster Inventory)[50] methodology with a national level of observation and a local scale of resolution[51]. These databases show that extensive risk probably does not make a significant global contribution to disaster mortality. However, in specific countries, in particular those that are not exposed to or have not recently experienced a large-scale catastrophe, the small-scale disasters that characterize extensive risk may make up a very significant part of total mortality[52]. For example, in the case of Panama, Chile and Jamaica, small-scale disasters below the EM-DAT threshold represented 74 per cent, 53 per cent and 43 per cent of the total mortality registered in the national

[48] UNEP, Billion Tree Campaign: www.unep.org/billiontreecampaign

[49] The EM-DAT database records all disaster events with more than 10 deaths, 100 affected or where a call for international assistance was made.

[50] See Annex 1 (Technical Annex): Note 12 – National Disaster Databases; and visit DesInventar website at:www.desenredando.org

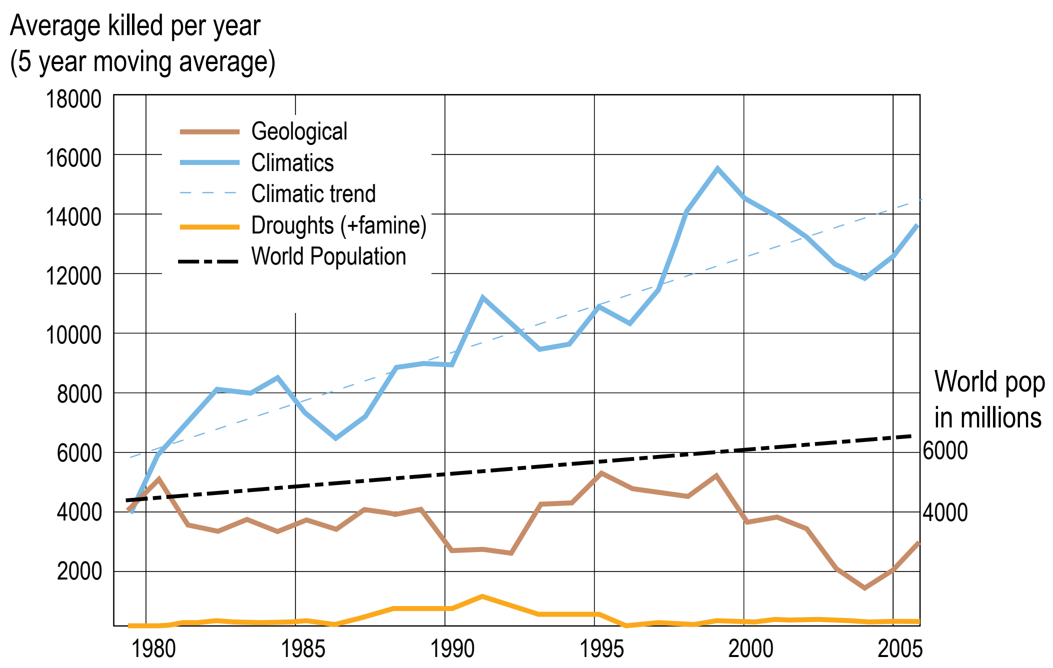
[51] National databases containing usually 30 years of disaster data currently exist for 14 Latin American and Caribbean countries as well as for Sri Lanka, Nepal and a number of States in India. Databases in Indonesia, Thailand, Maldives and the Islamic Republic of Iran are in various stages of completion.

[52] See Annex 1 (Technical Annex): Note 13 – Mortality in Extensive Risk Scenarios.

Figure 13

Average killed per hazard per year without "mega events"

If 'mega-disasters', with over 10,000 deaths, are excluded (since they mark the trends) mortality in climatic disasters is increasing far faster than those in geological disasters, and at a faster rate than world population growth.



Data sources: EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net

databases respectively. In the case of Colombia by contrast, that figure was only 4 per cent, given the large mortality associated with a single large-scale disaster – the eruption of the Ruiz Volcano in 1985.

While the absolute mortality that characterizes extensive risk may be relatively low, damage to housing, infrastructure and agriculture may be very significant, with serious consequences for local livelihoods. According to the national disaster loss database of Chile, while small-scale disasters in Chile accounted for less than 1,000 deaths over a 30-year period - an average of only 33 deaths per year, 5,564 houses were destroyed, 22,060 houses were damaged and 601,457 hectares of crops were affected in the same events. These figures highlight a significant under-reporting of local economic loss related to livelihood disruption in marginal rural and urban communities. As with mortality, it is likely that the economic value of the assets lost may not be globally significant if compared to the massive value of losses in large-scale catastrophes in developed countries but may be significant in the context of specific local economies. Unfortunately, no systematic measurement of the economic loss associated with extensive risk scenarios has been attempted. In the national databases, the panorama is nebulous because very little reliable economic data is reported.

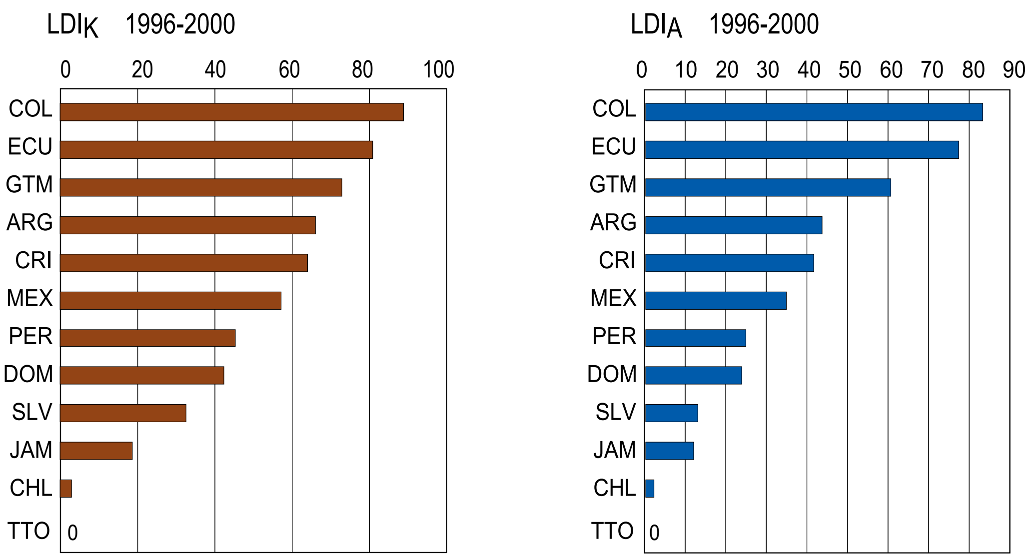
The extensive nature of disaster risk associated with these small-scale events can also be examined by looking at the spatial distribution of disaster loss across local administration areas in a country. If losses are more evenly spread across a large number of local administration areas, then this will reflect a greater extensiveness of risk. Figure 14 examines the distribution of mortality (Local Disaster Index for People Killed, LDIK)[53], which represents the most robust variable in the source data. Countries like Colombia, Ecuador and Guatemala showed an extensive distribution across the national territory in contrast to Chile which showed a very low level of uniformity. The processes that are driving extensive, localized climate-related disaster risk play out in very different ways from country to country depending on geography, ecology and patterns of urbanization and economic activities.

It is possible that as more and more risk unfolds over extensive areas, through urbanization, population growth, environmental change and the productive transformation of new territories, new intensive risk hotspots will gradually unfold. This can happen, for example, when hazard exposure grows in areas that were previously sparsely populated but which are seismically active. The large-scale losses associated with Hurricane Mitch in Central America in 1998 revealed the emergence of an intensive risk scenario from a very complex pattern of extensive risk.

Figure 14

Local Disaster Index for People Killed and Affected (LDIK and LDIA)

This graph shows the extensiveness of risk in 12 Latin American and Caribbean countries, with respect to both people killed and affected. Higher values indicate an extensive distribution of risk over a country's territory, lower values indicate a concentration of risk in particular areas.



Source: Cardona, O.D, (2005), Indicators for Disaster Risk and Risk Management. Program for Latin America and the Caribbean

[53] The Local Disaster Index calculated in a study commissioned by IDB, illustrates the relative distribution of deaths, affected people and direct physical damage for 12 Latin American and Caribbean countries for the period 1996-2000.

2.4 How Will Climate Change Affect Global Risk Patterns?

The unfolding of intensive and extensive disaster risk as outlined above is being driven by development processes including urbanization, economic globalization, poverty and environmental degradation. A factor which underpins development impacts to create further conditions of risk to human development is climate change. In recent months, major reports have laid out with a far greater degree of confidence than was previously possible both the likely magnitude of global climate change as well as its likely impact on water resources, ecosystems, food production, coastal systems, industry, human settlements and society, health, labour mobility and local economies. Climate change in itself is perhaps the ultimate hazard. It not only magnifies existing patterns of disaster risk but is now producing dramatic changes to the planet's ecosystems, which in turn threaten the continued social and economic viability of entire regions. The global nature of climate change implies that climatic risk, wherever it occurs, must increasingly be considered as a global public responsibility and not just a problem specific to a particular locality or country.

Climate change will alter patterns of climatic hazard as well as increase physical, social and economic vulnerability in many regions. The combination of increasing climatic hazard with declining resilience may conspire against the continued effectiveness of those factors (such as social development and enhanced preparedness and early warning) which would appear to have contributed to a decline in mortality rates in climatic disasters in developed as well as some developing countries. The 34,947 deaths attributed to the 2003 heat wave in Western Europe – across countries with sound national health systems, is an indication of how mortality rates can easily rebound due to extreme climatic events that exceed expected parameters.

At the same time, other processes that drive disaster risk, such as urbanization and environmental degradation, will contribute to an increased exposure and vulnerability to climate hazard. The increasing concentration of population and economic activities in flood and cyclone-prone coastal areas is such an example, which, when combined with stronger and more frequent floods and cyclones, will magnify the risk associated with climate change.

The potential linkages between evolving disaster risk trends and patterns and the likely impacts of global climate change are non-linear and complex and have only been partially explored in the reports mentioned. In fact, climate change might have unforeseen impacts that cannot be predicted by the current models, which could lead to accelerated modification of climate patterns and therefore to major crisis in ecological and socio-economic systems.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[54] indicates that climate change is likely to alter risk patterns in several ways:

- Increase the frequency and intensity, reduce the predictability and change the spatial distribution of extreme climatic hazards, such as temperature extremes, storms, floods and droughts. As the water cycle becomes more intense, many climate-related hazards will become more severe, including floods, droughts, heat waves, wildland fires and storms with a range of effects in different regions. Some impacts will occur in regions with no history of a given hazard.
- Increase the vulnerability of particular social groups and economic sectors, as existing vulnerabilities are compounded by climate change-related processes, such as sea level rise, glacier melt and ecosystem stress. The increase in vulnerability in regions dependent on subsistence agriculture may be particularly drastic, due to food and water shortages, in small island developing states and coastal zones due to sea level rise and in regions depending on water from glacier melt for agriculture and human consumption.

In the context of this Review, it is only possible to provide an indicative description of some of these linkages.

[54] Intergovernmental Panel on Climate Change, op. cit.

Drought

Drought is a particular concern in Africa, given its existing high level of mortality risk due to hazard exposure and already existing vulnerabilities. According to the IPCC, the areas suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. By 2020, between 75 and 250 million people are projected to suffer greater water stress due to climate change in the region. Agricultural production and access to food in many African countries and regions is therefore projected to be severely compromised by climate variability and change. Increased drought hazard and decreasing availability of food and water could lead to scenarios of greatly increased risk that could stretch existing humanitarian response systems and lead to a rebound in mortality.

Flood

The IPCC confirmed that it was very likely that heavy precipitation events would become more frequent. Small island developing states face flooding, storm surge, erosion and other coastal hazards, which threaten infrastructure, livelihoods and settlements. Heavily populated mega-deltas in South, East and South-East Asia will be at greatest risk of flooding associated with sea level rise and in some mega-deltas from flooding of rivers. Europe will face greater risk of inland flash floods, as well as more frequent coastal flooding and increased erosion. In Africa, rising sea levels will affect low-lying coastal areas with large populations.

To the extent that more flooding events, exceeding historical parameters, affect areas without developed early warning, preparedness and response systems, mortality risk may increase, while a generalized increase in economic loss risk in all regions could be foreseen.

Tropical cyclone

Higher sea temperatures are likely to lead to more intense tropical and extra-tropical cyclones (Table 4). This will directly increase hazard exposure in existing cyclone hotspots particularly if combined with an increase in the concentration of population and economic activities in these areas.

At the same time, higher sea temperatures may also alter cyclone tracks, meaning that hazard exposure to tropical storms could increase in regions that historically have not suffered cyclones, creating new hotspots. The 2004 Catarina hurricane, the first ever in the South Atlantic, hit the coast of Santa Catarina, Brazil, causing severe damage. In such regions, vulnerability will be higher than in regions that historically suffer cyclones, given that the development of settlements, buildings and social systems has not taken cyclone hazard into account.

The year 2005 acted as a strong warning – it was the warmest year in the northern hemisphere and it had the highest number of tropical cyclones (26), of which 14 became tropical cyclones and seven super-cyclones. The previous record was 21 tropical cyclones in 1933. 2005 saw the highest economic losses from climatic events: USD 200 billion losses, mostly as a result of

Table 4
Change in number and percentage of hurricanes (categories 4 and 5): 1975-1989 and 1990-2004 for different ocean basins

	1975 – 1989		1990 - 2004	
Basin	Number	Percentage	Number	Percentage
East Pacific Ocean	36	25%	49	35%
West Pacific Ocean	85	25%	116	41%
North Atlantic	16	20%	25	25%
South western Pacific	10	12%	22	28%
North Indian	1	8%	7	25%
South Indian	23	18%	50	34%

Sources: P.J. Webster, G. J. Holland, J. A. Curry, H.-R. Chang, (2005), "Changes in Tropical Cyclone Number, Duration and Intensity in a Warming Environment", Science, 16 September 2005: Vol. 309.

Katrina (USD 125 billion). It recorded the strongest winds: Wilma wind gusts reached 330 km/h and the lowest central pressure - 882 hPa - ever recorded (previous record 888 hPa - Gilbert in 1988)[55].

Glacier melt: flood and drought hazard to increase across regions

There is evidence from across regions to project the likelihood that increased glacier melt in the Himalayas will lead to the formation of larger glacier lakes. This phenomenon is likely to lead to increased flooding in many river systems in South Asia, including potentially catastrophic glacial lake outburst floods (GLOFs), rock avalanches from destabilized slopes, overflow floods and natural dam rupture. Previous experience from Peru - where the surface of Lake Safuna Alta in the Cordillera Blanca, increased spectacularly between 1975 (7.4 ha) and 2000 (37.8 ha)[56] is perhaps an indication of the kind of impacts the Himalayan glacial lakes will have on the Indian, Nepalese, Bhutanese and Bangladeshi population.

These changes are likely to increase hazard exposure, associated first with flood and landslide and eventually with drought in large areas around the Andes and Himalayas. Water stress will increase for agriculture, power generation, industry and human consumption, increasing both social and economic vulnerability, with a consequent impact on disaster risk patterns.

Sea level rise

Different scenarios of sea level rise have been presented, ranging from serious (0.2-0.6 m) to catastrophic (4-6 m) by the end of this century. In terms of direct impacts, this is very likely to lead to a rapid increase in hazard exposure due to increased coastal flooding, wave and storm surges and erosion, particularly if population and economic activities continue to be concentrated in coastal areas (Table 5).

Table 5
Impacts of sea level rise in 84 developing countries

	1m	2m	3m	4m	5m
Area of 84 countries (Total = 63,332,530 km²)					
Impacted area in km²	194,309	305,036	449,428	608,239	768,804
% of total area	0.31	0.48	0.71	0.96	1.21
Population (Total = 4,414 million)					
Impacted population (in million)	56.3	89.6	133.1	183.5	245.9
% of total population	1.28	2.03	3.01	4.16	5.57
GDP (Total = 16,890,948 million USD)					
Impacted GDP (in million USD)	219,181	357,401	541,744	789,569	1,022,349
% of total GDP	1.30	2.12	3.21	4.67	6.05
Urban extent (Total = 1,434,712 km²)					
Impacted urban area in km²	14,646	23,497	35,794	50,742	67,140
% impacted urban area	1.02	1.64	2.49	3.54	4.68
Agricultural extent (Total = 17,975,807 km²)					
Impacted agricultural area in km²	70,671	124,247	196,834	285,172	377,930
% total agricultural area	0.39	0.69	1.09	1.59	2.10
Wetlands area (Total = 4,744,149 km²)					
Impacted area in km²	88,224	140,365	205,597	283,009	347,400
% of total wetlands area	1.86	2.96	4.33	5.97	7.32

Sources: Dasgupta et. al., (under publication, 2007)

[55] NASA Earth Observatory: http://earthobservatory.nasa.gov/Newsroom/NasaNews/2006/2006021321735.html

[56] Silverio, Jaquet, (2002), Land Cover Changes in Cordillera Blanca (Perú) : Glacial Retreat, Avalanches and Mining Development. In “Atlas of Global Change”, UNEP GRID - Sioux Falls (USA). www.grid.unep.ch/proser/remotesens/cordillera_blanca.php

Many areas where population and economic activities are concentrated may become uninhabitable or non-productive for agriculture in the future if catastrophic sea level rise occurs. Agricultural land may be lost to the sea and coastal soils become saline. The potential large-scale displacement of people due to sea level rise could lead to a drastic and non-linear realignment of disaster risk patterns, which Governments and international organizations need to look into as a priority. Rising sea levels damaging coastal regions through flooding and erosion, desertification and shrinking freshwater supplies, displaced up to 10 million people in 2006, and will create up to 50 million environmental refugees by the end of the decade[57].

Increased vulnerability from multiple stressors

The degradation of ecosystems, including livelihood supporting coastal ecosystems, will increase the fragility of many rural livelihoods and thus intensify human vulnerability. Women are often at greater risk, due to gendered divisions of labour which affect livelihoods and resource use differently. In Africa, food insecurity is likely to increase and access to safe water is projected to diminish. In Asia, increased vulnerability will be characterized by water stress, declining agricultural productivity and an erosion of coastal livelihoods. In Latin America, a very significant proportion of agricultural lands will be subjected to desertification and salinization while there will be a loss of biodiversity in tropical forests and an increase in savannah type vegetation. The increased prevalence of disease vectors will also contribute to greater human vulnerability, compounding the above causes. All these increases in vulnerability may result in a reversal of the trend towards reducing mortality risks for climatic hazards, both in the case of intensive risk hotspots as well as in areas of extensive risk. Migration due to deterioration of livelihoods in rural areas may also contribute to increasing intensive risk in urban centres, one of many non-linear effects of climate change that are possible but which are difficult to model and predict.

[57] Institute for Environment and Human Security (IEHS) at the United Nations University (UNU) in Bonn, Germany.