Natural Disasters

Natural Catastrophes: Do We Have to Live with Them?

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Introduction: recent catastrophic events

Hardly a year passes in which at least one country around the world suffers from a large natural catastrophe. The first months of 2010 have already seen a series of severe earthquakes in different parts of the world such as Haiti, Chile, Indonesia, China and Mexico, and a volcanic eruption in Iceland. Winter storms in Europe (Kyrill 2007, Klaus 2008, Xynthia 2009) remind us regularly that billion-dollar loss events are a continuing threat to Europe, as are widespread floods. The ones in Britain in 2007, along the lower Danube in 2006, in the Alps in 2005, and in central Europe in 2002 all set new loss records in the regions where they occurred. In 2004 and 2005, hurricanes in the North Atlantic – Katrina, Wilma, Rita (2005) and Ivan (2004) to mention just a few names – did the same with respect to their number and monetary losses. Nargis, a tropical cyclone in the Gulf of Bengal in 2008, devastated the Irrawaddy Delta through wind and storm surge and cost the lives of more than 140,000 Burmese. The Philippines were drenched in 2009 by enormous amounts of rainfall. Countless numbers of flash floods all over the world, of which only events like those in Istanbul (September 2009), Madeira (February 2010) and Rio de Janeiro (April 2010) became generally known, claim lives and cause huge destruction practically every day.

Sometimes, very expensive events – recent examples being two hailstorms in Australia (Melbourne and Perth, March 2010) – are hardly noticed outside the country hit. But there are also less spectacular catastrophes such as the extreme heatwave in Europe in 2003 (70,000 deaths and over USD 10 billion damage), the snow damage in China in early 2008 (more than 21 billion US dollars) and droughts like the one in Southeast Asia in 2009–2010 – let alone the many 'silent' disasters in Africa – which go unnoticed because their onset is not sudden. In poor countries, natural catastrophes often do not produce high monetary loss numbers in absolute terms, and sometimes not even high death tolls, but nevertheless they may be more severe and momentous for the country affected than, for instance, hurricane Katrina for the United States.

On the other hand, events which cause hardly any physical damage – like the eruption of the Eyjafjallajökull volcano in Iceland (April 2010) – may produce costs running into several hundred million US dollars a day by interrupting private and business lives and the flow of goods.

From the above, it becomes clear that disasters can assume different forms: in terms of scale (regional intensity or large-scale impact), number of fatalities, monetary losses and impact on the local economy. It is without doubt, however, that natural catastrophes, especially weather-related events, have been increasing dramatically in frequency and intensity. The 20 greatest natural catastrophes in terms of monetary losses and the ten deadliest catastrophes since 2000 are listed in Tables 1 and 2 respectively (see below).

From hazard to risk – from event to catastrophe

It is important to understand the circumstances under which natural catastrophes happen. Some people even claim that there is no such a thing as a natural catastrophe. Why? Because nature alone does not produce catastrophes, it only produces natural extreme events. We regard catastrophes from the point of view of their impact on man, so an extreme event like the one that caused the extinction of the dinosaurs is not a catastrophe in this sense. For this reason, even a very strong earthquake in an uninhabited region without human property cannot result in a catastrophe. Similarly, a

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strong earthquake in a well-prepared region may not be catastrophic. In a poorly prepared region, however, even a moderate tremor may cause a devastating disaster.

A natural catastrophe happens if people and/or their possessions are affected so severely that a society's life is disrupted. A well-prepared society is not likely to experience a catastrophe as easily as one where many aspects of preparedness, from education and knowledge to building codes, and from functioning governance to availability of financial means are missing, making it vulnerable to impacts from nature. Catastrophes are hence not only products of chance but also the outcome of interaction between political, financial, social, technical and natural circumstances.

The earthquakes in 2010 clearly support this statement. Haiti's capital Port-au-Prince was razed by a magnitude 7.0 quake at 13 km depth on 12 January. The energy set free by the event was relatively moderate, but concentrated on a small area. Additionally, the disadvantageous underground conditions amplified the shaking. Presumably more than 220,000 people died as their dwellings were not the least designed for earthquake forces (the US Embassy was well designed and suffered practically no damage, by the way). The catastrophe happened because of the high concentration of humans at the epicentre and the extreme vulnerability. The physical parameters of the earthquake in Baja California, Mexico on 4 April were very similar, with a magnitude of 7.2 at 10 km depth. Two people died, the damage is expected to be less than 1 billion US dollars. Here, the quake hit an almost unpopulated area with only one larger settlement (Mexicali) at some 50 km distance. The lower population density and values and better building standards made the difference to Haiti.

The magnitude 8.8 Chile earthquake on 27 February was about 500 times stronger than the Haitian, and 250 times stronger than the Mexican. While the depth of 35 km, the distance of 100 km from the city of Concepción, and the vast area which was exposed to the shaking certainly played a role with respect to the impacts, the fact that less than 300 people died (plus some 200 due to a tsunami) can clearly be attributed to the higher standard of construction. Hence, the governing parameter for this catastrophe was the high magnitude, i.e. the hazard parameter.

The overall losses in Chile are estimated as exceeding 30 billion US dollars (as at 7 June 2010). This shows that well-prepared regions may still face high repair and reconstruction bills, but the loss of life, the number of people injured, and the interruption to regular life are definitely less severe than at highly vulnerable locations. To be fair, one must consider the previous costs for precautionary measures as well. It follows from this that better precaution does not necessarily result in reduced overall costs, but there is no indication either that they are higher than if nothing is done. To sum up, precaution, even if costly, pays off.

Reconstruction costs in Haiti will also be well above 10 billion US dollars. The difference to Chile is that Haiti's buildings and infrastructure will be raised to a higher level of safety by (hopefully) proper planning and construction, i.e. it will have its vulnerability significantly reduced. This must be considered when comparing the material losses in Haiti with those in Chile; the term 'costs' rather than 'losses' would therefore be more appropriate.

The above statements hold, in a similar way, for natural catastrophes caused by windstorm, flood, tsunami, etc. Whether a location is risky depends on (a) the likelihood that a natural event may occur; (b) the presence of people/items; and (c) their vulnerability (Kron 2005). Where there are no people or values that can be affected by a natural phenomenon, there is no risk. Vulnerability can refer to human health (human vulnerability), structural integrity (physical vulnerability), or personal wealth (financial vulnerability). Insurance's contribution to risk control addresses the last of these factors. All three components have been and still are increasing unabated. Rising sea levels, increased tropical cyclone intensities (wind and rain), unprecedented flood experiences, on the one hand, and megacities with exploding populations and industrial development, on the other, are making many regions ever riskier, in particular those on coasts. The overall risk is determined by computing the integral over all possible threatening events and their consequences. The thus quantified risk is identical to the expected average annual loss.

Natural catastrophe statistics and trends

Munich Re has been systematically collecting information on natural catastrophes for more than

Table 1

Overall and insured losses of the 20 costliest natural catastrophes since 2000

Rank	Date	Event	Affected country/region[a]	Losses in billion US$ (original values, not adjusted for inflation)	
				Overall	Insured
1	Aug. 2005	Hurricane Katrina, storm surge	USA*	125	62
2	May 2008	Earthquake	China (Sichuan)	85	0.3
3	Sep. 2008	Hurricane Ike	Caribbean, USA*	38	18.5
4	Feb. 2010	Earthquake	Chile*	30	8
5	Oct. 2004	Earthquakes	Japan (Niigata)*	28	0.76
6	Sept. 2004	Hurricane Ivan	Caribbean, USA*	23	13.8
7	Oct. 2005	Hurricane Wilma	Caribbean, Mexico, USA*	22	12.5
8	Aug. 2002	Floods, severe storms	Europe	21.5	3.4
9	Jan.–Feb. 2008	Winter damage	China	21.1	1.2
10	Aug. 2004	Hurricane Charley	Caribbean, USA*	18	8
11	Sep. 2005	Hurricane Rita, storm surge	USA*	16	12.1
12	Jul. – Aug. 2003	Heatwave, drought	Europe	13.8	2
13	Jul. 2007	Earthquake	Japan (Niigata)*	12.5	0.335
14	Sep. 2004	Hurricane Frances	Caribbean, USA*	12	5.5
15	Dec. 2004	Tsunami	Indian Ocean*	10	1
	Jan. 2007	Winter storm Kyrill	West and Central Europe*	10	5.8
	Jan. 2008	Floods	USA (Midwest)	10	0.5
	Sep. 2008	Hurricane Gustav	Caribbean, USA*	10	3.5
19	Sep. 2004	Hurricane Jeanne	Caribbean, USA*	9.2	5
20	Sep. 2004	Typhoon Songda	Japan*	9	4.7

[a] Area near the coast is marked with *.

Notes: Losses from the Haiti earthquake are not included. The extent of incurred damage is not likely to exceed 9 billion US dollars, although estimates of the reconstruction costs exceed 10 billion US dollars.

Source: Munich Re.

35 years. The firm's NatCatSERVICE database, the world's largest with respect to losses from natural catastrophes, contains more than 28,000 entries for the period 1970 to 2009. US dollars are used as the lead currency in the database. This means that all losses are converted from the local currency/ies into US dollars, applying the exchange rate at the time the event occurs.

The analyses conducted by Munich Re's Geo Risks Research department deliver the most accurate estimates of the total economic and insured losses caused by any kind of natural peril. The results and conclusions of these analyses are not only used for determining insurance premiums but also made available to governments and non-governmental organisations to assist them in better planning and developing prevention measures against natural catastrophes.

Table 1 reveals that catastrophes with high monetary losses occur in well developed countries, often near a coast (15 of 20), and are mostly caused by weather events (15 of 20). Despite the fact that showing original values not adjusted for inflation might give a biased picture, normalisation would not change this picture fundamentally, which shows: (a) natural catastrophes have never been so expensive; (b) losses in the two-digit billion dollar range have become more frequent; and (c) loss potentials have reached new dimensions. This is not only true for overall economic losses but also for the insurance industry's share. 11 events in Table 1, i.e. in just the past ten years (all those with insured losses larger than 4 billion US dollars), belong to the top 18 all-time insured losses from a single event.

In Table 2 (deadliest events in the past ten years), we also see that many events (five) are related to coasts, but – with the exception of Europe in 2003 – hit poor regions. If one considers the past 60 years instead of only the past ten, the events ranked 9th and 10th with less than 10,000 fatalities are no longer among the top ten; they fall back to ranks beyond 50. This

Table 2

The 10 deadliest natural catastrophes since 2000

Rank	Date	Event	Affected country/region[a)]	Fatalities
1	Jan. 2010	Earthquake	Haiti*	222,500
2	Dec. 2004	Tsunami	Indian Ocean*	220,000
3	May 2008	Cyclone Nargis, storm surge	Myanmar*	140,000
4	Oct. 2005	Earthquake	Pakistan, India (Kashmir)	88,000
5	May 2008	Earthquake	China (Sichuan)	84,000
6	July – Aug. 2003	Heatwave, drought	Europe	70,000
7	Dec. 2003	Earthquake	Iran (Bam)	26,200
8	Jan. 2001	Earthquake	India (Gujarat)	14,970
9	May 2006	Earthquake	Indonesia (Java)*	5,749
10	Nov. 2007	Cyclone Sidr, storm surge	Bangladesh *	3,360

[a)] Area near the coast is marked with *.

Source: Munich Re.

reflects the fact that many catastrophes with very high death tolls occurred in the second half of the 20th century, although the population density everywhere then was less than nowadays. This development testifies to the efficiency of modern technological achievements and efforts in disaster reduction, initiated for instance by the International Decade for Natural Disaster Reduction (IDNDR), which was proclaimed by the United Nations in the 1990s. However, the top six events in Table 2, all recorded in the past seven years, would still rank among the top 14 since 1950 and hence suggest that it is by no means guaranteed that catastrophic death tolls are becoming more and more limited.

Tables 1 and 2 clearly reveal the distinct difference between rich and poor countries. Large financial losses – in absolute terms – occur in the developed world, which is also quite well insured. The actual impact on a country must be measured in relative terms though. While a one billion dollar loss in the United States or in certain European countries is not outstanding, it may cripple the economy of a small, poor country. Munich Re therefore defines the so-called Great Natural Catastrophes (GNCs) using relative criteria (see note to Figure 1). This definition also helps when it comes to trend analyses. Looking only at GNCs means the reporting bias introduced by the development of communication technology in the past 60 years is largely eliminated. While GNCs are likely to be documented in the records of the affected countries and their consequences can be assessed, smaller events are not. In contrast to that, we quickly learn in today's internet age of almost any minor local loss event, no matter where it happens.

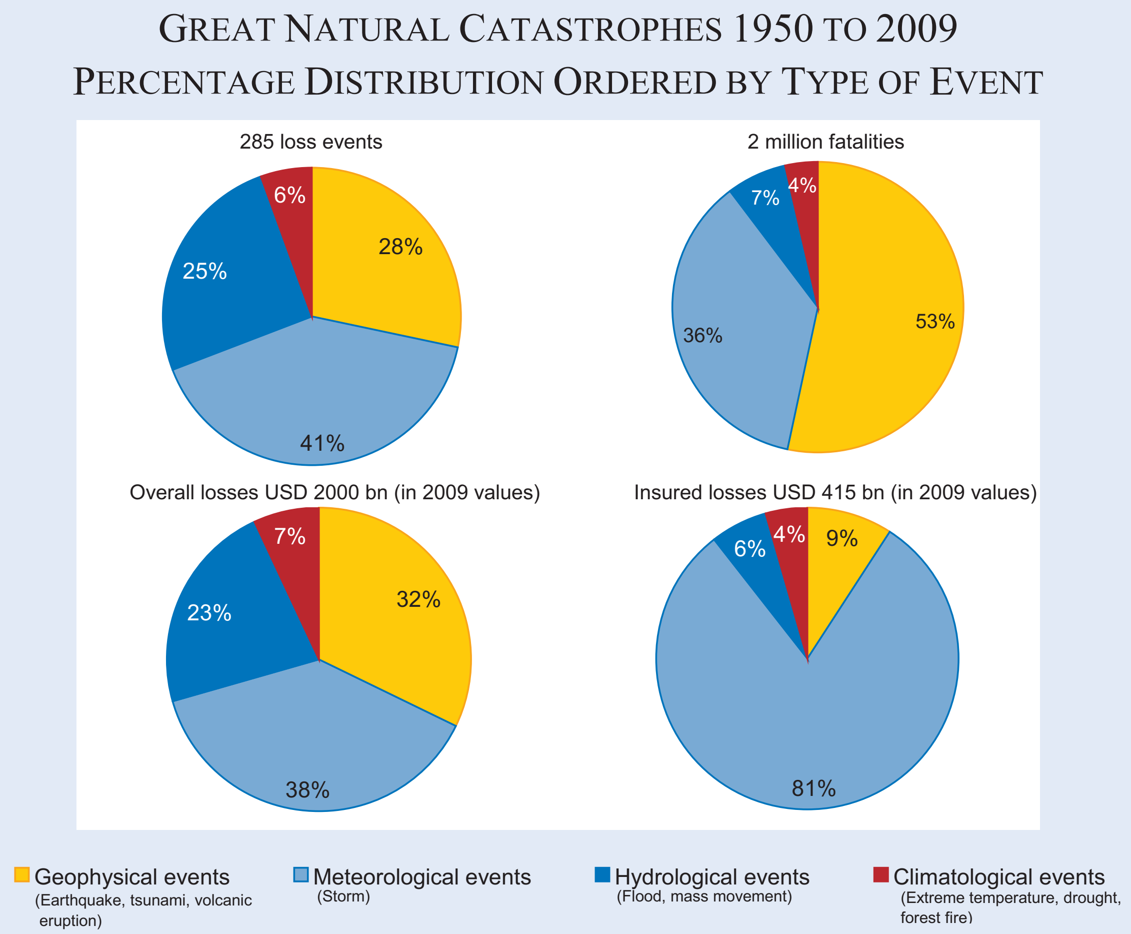
For statistical analyses, in particular for trend analyses, one cannot use original loss values, but must take into account that these values are changing over time. The least that can be done is to adjust for inflation. Currently Munich Re, together with various scientific institutions such as the London School of Economics (LSE), is intensely studying the potential effects of other parameters that may affect comparability and bias results, such as changes in population and wealth (e.g. the development of the value of assets relative to GDP), as well as implications of improved precautionary measures, etc.

An illustration comparing the parameters, number of loss events, fatalities, overall losses and insured losses for GNCs caused by different hazard categories is presented in the pie charts of Figure 1. They show that, for the past 60 years, 72 percent of loss events were weather-related (meteorological, hydrological and climatological events). Of this portion, tropical cyclones and extratropical winter storms make up more than half. If it comes to fatalities, earthquakes (including tsunamis) are responsible for roughly half of all deaths, followed by meteorological causes (including storm surges), which account for about 40 percent.

The charts for monetary losses in the lower part of Figure 1 reveal distinct differences between insured and overall losses. Weather events are, with more than 90 percent, by far the costliest ones for the insurance industry, while the overall losses are more evenly distributed among the three main categories.

We found that the annual average monetary losses from GNCs have increased dramatically over the past 60 years (Figure 2). Even if a high fluctu-

Figure 1



Note: Great natural catastrophes are those where the affected region's ability to help itself was overtaxed and international assistance required because thousands were killed, hundreds of thousands made homeless, or substantial economic or insured losses (relative to the regional situation) sustained.

Source: Munich Re.

ation is observed from year to year, the overall trend is obvious. As weather-related catastrophes predominate in terms of losses, this rise is mainly attributable to windstorms and floods. The question is: what are the driving factors of this development?

Reasons for increasing losses

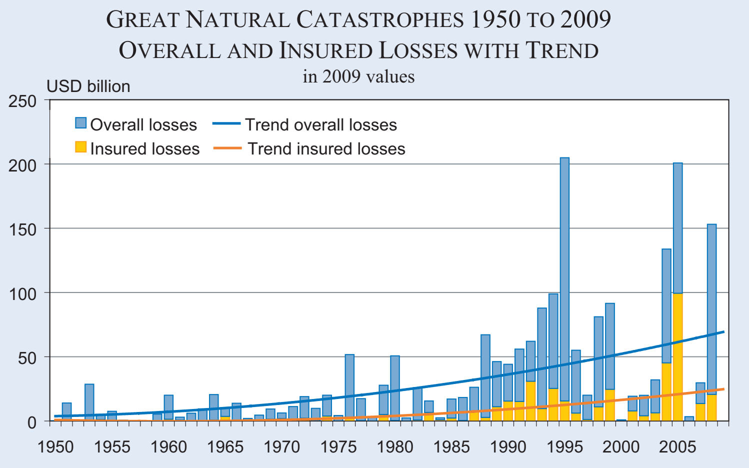
There is no doubt that the main reasons for the increase of catastrophe losses are global population growth, the settlement and industrialisation of regions with high exposure levels, and the fact that modern technologies are highly susceptible to external disturbances. Due to its complexity, international trade is even more susceptible. Changing environmental conditions, in particular climate change and the lack of adequate risk perception, are additional features.

People – land use – risk perception

At the moment, about 6.8 billion people require a place to live on the earth, up from 3 billion in 1960 and heading for nine billion in the 2050s. Adequate and safe areas are limited by natural circumstances, but also by economic needs. While in the past settlement areas could be chosen because of their sheltered location with respect to adverse natural conditions, nowadays any available piece of land has to be used. Furthermore, new residents are often unfamiliar with the local hazard situation or lulled into a sense of security by trusting in the technical controllability of the forces induced by nature.

Coastal areas, in particular, have been very attractive to people. Today, already one tenth of the world's population lives within 5 km of the coast, one-third within 50 km and two-thirds within 300 km, and 15 of the 20 largest cities in the world are located on

Figure 2



Source: Munich Re.

coasts. And this trend is still unbroken. According to an OECD study (Nicholls *et al.* 2007), 113 million people will live in the flood-prone neighbourhoods of the 20 most populated coastal cities in 2070, an almost five-fold increase in today's number. The same study predicts that assets in the 20 cities with the highest concentration of flood-exposed values will increase from the current 2.2 billion US dollars to about 27 billion. In addition to permanent residents, millions of tourists choose coastal regions as their holiday destination.

The state of Florida in the United States, which has always had a high hurricane exposure, is a good illustration of how socio-economic factors act as natural catastrophe loss drivers. The population has grown from three million in 1950 to the current 19 million (plus 86 million tourists every year). This means that a hurricane making landfall in Florida today will have a multiple of people and their belongings in its path compared with the past.

In the interior of countries, river plains are – if one neglects the flood hazard – also well suited for development, and preferably used for this purpose. While flood-control measures prevent frequent losses and inconvenience, this effect is counterbalanced by the feeling of security it creates, leading people to expose more and more objects of increasing value to the risk of flood. This sense of security is transmitted not only by dykes and embankments, early-warning systems, and the availability of disaster-relief organisations, but also by the intentional or unintentional transmission of false information and by local authorities or groups with a vested interest (e.g. the tourist trade) playing down the risk. While this is a worldwide problem, there are some striking examples such as areas along the Yangtze River in China that were devoted and designed for flood retention in the 1950s, but can no longer be used for this very purpose as several hundred thousand people live there today.

Complexity – wealth – susceptibility

Several outages in recent years in Europe, North America and Asia have shown how badly we depend on functioning power supply and telecommunication networks. Given a complex infrastructure (e.g. traffic and power networks), a failure in one place may cause a domino effect that brings the whole system to a standstill. It is scarcely conceivable what would happen if a large-scale and long-term power breakdown were to occur that turned off the (electrical) lights completely in Europe and/or North America for weeks and even months. This could come about, for instance, in a strong electro-magnetic event ('sun storm') which destroys several large, system-relevant transformers. Replacing/repairing these may take months – as might the outage. Another recent event, actually one with minor catastrophic potential, has had a dramatic impact: the ash of Eyjafjallajökull volcano that kept aircraft on the ground led to chaotic situations at airports and in hotels, interfered with business activities, and even started to lead to shortfalls in supplies – and this just after a few days.

Wealth has increased in practically all regions of the world. At developed locations, even in poor countries, buildings have expensive features such as glass facades and sensitive claddings for architectural reasons – not just walls and windows. The potential for destruction from shaking, wind pressure, hail and flying debris is high, while more and more expensive items can be found inside buildings as was the case in the past. In general, modern equipment is highly vulnerable. Almost everything contains electric or electronic components, and these items often suffer severely when exposed to vibrations, heat, sand and dust, water or even humid, salty air. Whereas years ago water-damaged items had simply been dried and re-used, they are now discarded.

Urban concentration and environmental changes

It is not only the development of hazard-prone regions, but additionally the concentration of commercial and industrial centres which attracts people. More than 50 percent of the world's population lives in urban areas compared to just 30 percent in 1950 – and the percentage is still increasing. Half a century ago, there were eight megacities in the world with a population exceeding five million. Today the number of megacities has grown to over 60. It is obvious that the chance of a severe natural event hitting one of these high-concentration regions is steadily growing.

Large cities not only represent huge value accumulations, but are also very vulnerable to disturbances. Many dwellings are being built in an uncontrolled way, i.e. on unstable ground (e.g. the favelas in South American metropolitan areas) or near bodies of water, and they are certainly not erected according to any construction code. Infrastructure (roads, electricity, water, sewage, etc.) is added later on (if at all) as a kind of emergency measure rather than in a planned and designed fashion. That makes these systems highly unreliable and vulnerable. On top of that, little attention is paid to governance in poor neighbourhoods. Early warning and evacuation in the event of imminent severe threats can therefore be extremely difficult.

Colonisation of land has always the consequence of changing the environment. Forests are removed, rivers have to be tamed or diverted, and the local micro-climate is possibly altered. Most of these measures improve the situation in the short term but deteriorate it in the long term. One fairly common consequence of urban growth is subsidence, caused for instance by groundwater extraction or sometimes simply by the weight of buildings erected on relatively soft and unconsolidated coastal soil. A few decimetres of subsidence can create huge problems in already low-lying port cities and deltas, some areas suddenly finding themselves below a given flood level or even below the local sea level. The most severe – and globally effective – change of the environment, however, concerns our climate.

Climate change

The scientific facts are clear: the global average temperature in the atmosphere has risen by 0.74°C over the last 100 years; the last nine years were among the 11 hottest in recorded history; 2010 has a high potential to become the warmest year ever. Climate change is taking place and it is mainly caused by human activities.

The fourth status report of the Intergovernmental Panel on Climate Change (IPCC 2007) regards the link between global warming and the greater frequency and intensity of extreme weather events as probable. The report finds, for instance, with more than 66 percent probability, that climate change already produces more heatwaves, heavy precipitation, droughts and intense tropical storms. The expected rise in global average temperatures of between 1.6 and 6.4°C by the end of the century, depending on future emissions of greenhouse gases, significantly increases the probability of short-term record temperatures (heatwaves). Warmer sea surface temperatures enhance evaporation and warmer air can hold more water vapour, thus increasing precipitation potential. Combined with more pronounced convection processes, in which warm and moist air rises to form clouds, this results in more frequent and more intense precipitation events. Particularly over dense urban areas – i.e. areas with high concentrations of values – the more intense convection may lead to local severe weather events that often involve a high density of lightning strokes, hailstorms and gale-force gusts, sometimes even tornadoes. On account of the large proportion of impervious surfaces in urban areas, the torrential rain runs straight into the drainage systems, which are not designed to cope with such volumes, with the result that underpasses, cellars and sometimes subway tunnels are flooded. A striking example is the 2005 Mumbai flooding: within 24 hours, 944 mm of rain fell in the Indian industrial metropolis on 26 July, that is more than 40 percent of the city's average annual rainfall (2170 mm). The flood losses added up to 5 billion US dollars, of which 770 million US dollars were insured.

The fact that the average number of great weather catastrophes has tripled since 1950 is again evidence of causal links between global warming and increasing frequencies and severity of natural events. Socioeconomic factors like the ones mentioned above cannot explain the rise of catastrophes in total. It is highly likely that climate change also is responsible for a part of it and that the number of severe, weather-related natural catastrophes will further increase in the long term as a result of continuing climate change. This, combined with the trend towards higher value concentrations in exposed areas, will increase loss potentials dramatically.

Even before publication of the Stern Review by Lord Nicholas Stern (2006), it was clear that climate change is not just an ecological problem; it is also an economic issue. Stern predicted that climate change could cost 5 to 20 percent of the worldwide GDP annually until 2050. These costs could be reduced to 1 percent by proper and timely actions. If damage costs continue to rise, this also affects industry and primarily, of course, insurance companies.

The role of the insurance industry

The insurance industry plays an important role in raising awareness and coping with natural hazards: it quantifies risk by means of adequate premiums and thus makes risks transparent. Therefore, it creates incentives for reasonable behaviour and prevention, and so reduces the losses for the society. The insurance industry also has tremendous potential for promoting climate protection and climate change adaptation, and thus positively influencing future losses, by taking account of such issues in its products, investments, sponsoring activities and communications.

Driven by high losses from weather-related catastrophes, 2008 was the third most expensive year on record, taking inflation into account. It has only been exceeded by the hurricane year of 2005 and by 1995, the year of the Kobe earthquake. Overall economic losses totalled some 200 billion US dollars (2007: 82 billion US dollars), which is not too far from the record set in 2005 (232 billion US dollars in current values). Worldwide insured losses in 2008 rose to 45 billion US dollars, about 40 percent higher than the average in the previous ten years (32 billion US dollars). The large number of tropical cyclones and the earthquake in Sichuan made 2008 also one of the deadliest years on record; 98 percent of the fatalities occurred in Asia (Munich Re 2009).

The following year, 2009, was practically free from large disasters and spectacular record losses on a global scale, but the sum of all losses was only marginally below average (Munich Re 2010). 2010 has again started differently. With the various earthquake catastrophes and some – particularly for the insurance industry – very costly weather events, it has become likely that the year will be an outstanding one with respect to natural disasters. But despite unfavourable loss trends, the insurance industry continues to offer a wide range of natural peril covers whilst trying, at the same time, to encourage its clients to focus more on loss prevention. It is also making strenuous efforts to control its own loss potentials with the help of modern geoscientific methods. It is still difficult, however, to predict in quantitative terms the effects that future changes will have on the frequency and intensity of extreme events.

For Munich Re as a leading reinsurer, the natural catastrophe trends of recent years have resulted in three action strategies. Firstly, we call for effective and binding rules on CO_2 emissions in the international debate, so that climate change is curbed and future generations do not have to live with weather scenarios that are difficult to control. Secondly, with our expertise we develop new business opportunities in the context of climate protection and adaptation measures. And thirdly, in our core business we only accept risks at risk-adequate prices.

In the same way as private individuals, insurance companies try to avoid volatility in their payments. Natural perils insurance is highly volatile. Large single losses (from one event) can be reduced by transferring part of the risk to the reinsurance sector, in which companies often do business worldwide. When catastrophic losses occur in one country, they are distributed all over the world, thus relieving the local insurance market and possibly even preventing its collapse.

The insurance industry's natural catastrophe risk models have already been adjusted in the light of the latest findings. For instance, they now incorporate sea temperatures that remain above the long-term average due to the ongoing cyclical warm phase in the North Atlantic; the effects of this warm phase are enforced by global warming. We can expect the above-average water temperatures to increase further the intensities of cyclones. There are two model types that are applied in the context of insuring natural catastrophes: (a) those to determine the individual risk of a given object (or a portfolio of objects) to be insured, and (b) those to assess expected losses, in particular for accumulation losses of extreme events.

Hazard zonation and premium calculation

Premiums for the various hazards should reflect the individual exposure. For the bulk of business, i.e. for private homes and small businesses and their contents, the effort required to assess the exposure of a particular building has to be seen in the context of the annual premium income for one such property, which may be in the order of less than 100 US dollars in low-risk areas. Since individual assessment of the risk and calculation of an individual premium for such properties are impossible, the premium has to be fixed on the basis of a flat-rate assumption. For this purpose, zones with a similar hazard level (storm, flood, earthquake, landslide, etc.) have to be identified and/or defined, premiums (per unit value) being constant within a given zone. In most developed countries, hazard zone data of this kind are available.

Modelling probable expected losses

Insurance and especially reinsurance companies must be prepared to pay large amounts of money after major events. One example: Munich Re faced claims in the order of 2 billion US dollars after hurricane Katrina in 2005. The company is not threatened in its existence even by such enormous amounts. However, volatility is expensive. Money for payments must be made available very quickly and cannot be placed in long-term – and thus profitable – investments. With increasing single losses, the whole financial market, including banks, loan institutions and investors, is becoming more and more involved in covering risks.

Assessing probable maximum (accumulation) loss (PML) and holding adequate reserves are crucial to an insurer's economic survival. PML models are based on the definition in the second section of this paper where the expected loss is a function of the hazard, the values at risk and their vulnerability. The values at risk are represented by the portfolio under consideration, i.e. the distribution of (insured) values in a country. Typical (average) loss rates for different types of buildings and given loads (wind speed, water level, ground acceleration) are applied and account for vulnerability. The hazard is introduced by simulating a storm/earthquake/flood event in the area. By simulating a large number of – stochastically generated – events and arranging the resulting losses according to size, one obtains an (empirical) PML curve, which is the same as a probability distribution of losses. From this curve, the expected loss for a given return period, or the return period of a historical event with a known loss, can be read off. While such models for windstorm and earthquake have been available for many years, flood loss models have only become operational for the past few years as they require considerably more detail.

The partnership for risk reduction

Risk and loss minimisation call for an integrated course of action. The risk must be borne by several shoulders: the state, the people and enterprises affected, and the financial sector, in particular the insurance industry. Only when they all cooperate with each other in a finely tuned relationship, in the spirit of a risk partnership, can disaster prevention really be effective.

The job of public authorities (i.e. the state or the government) is primarily to reduce the underlying risk to society as a whole. They provide access to observation and early-warning systems, build river dykes and sea defences, determine the framework for the use of exposed areas by enacting statutory provisions, and prepare emergency plans, including programmes to alleviate recovery (temporary housing, financial assistance, tax relief, etc.). In some countries, insurance programmes are state-run. Unlike in the case of earthquake and windstorm, where homeowners themselves are responsible for ensuring their houses are properly protected, the responsibility for protection from flooding is largely shifted to public authorities.

Those immediately affected (individuals, companies, communities) have a great potential for loss reduction. The crucial point is whether they keep their risk awareness alive. Even those people who do not neglect the danger of a natural peril from the very beginning often quickly forget about it, especially if nothing happens for some time. They rely on technological protection systems and at the same time make their property more and more valuable by adding additional items that are often susceptible to damage. These people must be informed and educated to build in an appropriate manner, control the exposure of their values, and be ready to take action in an emergency. This includes preparing for catastrophic losses by taking financial precautions, e.g. buying insurance.

The true task of insurance companies is to compensate financial losses that would have a substantial impact on insureds or even bring about their ruin. They carry the financial risk from events that have such a low probability that they cannot be considered foreseeable. Insurance redistributes the burden borne by individuals among the entire community of insureds, which is ideally composed in such a way that they all have a chance of being affected – even if the degrees of probability differ. Furthermore, they perform educational and public relations services, e.g. by publishing brochures in which they draw attention to hazards and explain ways of dealing with them (e.g. Munich Re 2010).

What can and should be done?

Impacts from natural disasters are not as devastating to rich societies as to those in less developed parts of the world. There, whole countries are sometimes thrown back in their development for years. Rich states, on the other hand, have a significant financial burden not only from catastrophe losses, but also from the costly precautionary measures that citizens demand from their governments to protect themselves and their properties.

Disaster prevention and risk reduction has several levels. Starting from protecting the global climate from becoming more and more threatening, they range via forecast, warning, and technical control systems to the individual's (person, company) behaviour and provisions to make sure she/he/it will not be ruined by an extreme event. While there is no discussion that loss of life must be prevented by all means, the costs of efforts for prevention of monetary losses should not be completely out of balance with the value of the protected items.

Emerging countries

Effective and economical solutions have to be found for emerging countries. These countries – especially in Africa or Southeast Asia – are often faced with a higher risk of natural disasters. At the same time, the level of insurance density is generally very low, as these markets are less industrialised and people have less available income to insure themselves against existential risks.

An attempt to provide assistance for climate-change-related risks is the Munich Climate Insurance Initiative (MCII). The idea of MCII is to collect money through global emissions trading and pay it into a pool. In this way, the largest CO_2 emitters would ultimately finance the insurance solutions. The MCII has already introduced this idea into the negotiations for a successor to the Kyoto protocol, which is absolutely vital. To restrict global warming to the rise of 2°C that experts estimate to be just about controllable, well-conceived measures are needed quickly. This can only succeed if an international agreement with clear emission reductions and supported by all the major CO_2 emitters is adopted as a successor to the Kyoto Protocol, which expires in 2012.

Other measures being initiated in emerging countries include microinsurance. Munich Re recently launched a pilot product offering low-income households in the Indonesian capital Jakarta the opportunity to insure against the direct economic losses and social risks caused by severe flooding. The product – the first microinsurance flood product worldwide – is trigger based, depending on the height of the flood at a specific, public river gauge.

Chances and opportunities

While we cannot stop or even reverse climate change, there are many opportunities to mitigate it and to adapt to it. New technologies and innovative products will open up extraordinary economic opportunities for companies, sectors and countries leading the process.

For whole countries, the mitigation of climate change offers exceptional chances. New technologies are emerging and specific sectors can expand. Especially economies with a high percentage of technological industries have enormous potential with regard to mitigating and adapting to climate change.

Climate change is a global problem and can therefore only be solved globally. The biggest challenge is to quickly create and implement a global action plan that includes both the largest emitters of greenhouse gases and the developing countries, which are affected the most. Industrialised countries have to take the lead as their emissions have mainly created the problem. If we do not take ambitious action, the effects of global warming may become unmanageable. The longer we wait, the harder it will be for future generations to cope with climate change and the more expensive it will become. From the economic point of view, it definitely makes sense to act now: investments in climate protection come much cheaper than paying for the damage that would ultimately occur. And in the end, it is people in general that have to bear the costs of natural catastrophes – not least because a large portion of the damage is always uninsured, as Munich Re's statistics show abundantly. Overall, the costs of not acting will certainly be vast.

However, it is important to keep the debate on an objective level and to clarify some misunderstandings. The world will not immediately be destroyed by climate change and we will not be overwhelmed by a sudden endless series of destructive weather. In connection with global warming, we are talking of statistical changes in natural events. No single event can serve as a proof for the change. However, we still need to adapt to the consequences of climate change in order to lower the vulnerability, for example through better building standards or flood prevention measures, and avoid ever rising loss potentials by uncontrolled development of hazard-prone areas.

Conclusion

The Swiss writer Max Frisch once stated (1981, 103): "only man knows natural disasters, so far as he survives them. Nature does not know disasters". These have become more frequent and more intense during the last decades. The main causes are increasing global population and its need – and sometimes wish – to settle in areas that are prone to natural hazards, often in highly concentrated urban agglomerations. At the same time, the amount and susceptibility of possessions grow as risk awareness fades. A further significant contribution is added by climate change.

The latest IPCC report has clearly documented that climate change is real and caused by human activities. It is today one of the greatest risks facing societies, and the rising number of severe weather-related natural catastrophes will cause higher loss burdens for economies in the future. At the same time, it offers growth opportunities for innovative economies and businesses.

Great natural events are not avoidable. Great catastrophes are. Catastrophes are inevitably the net result of the effects of extreme natural events and the response to those events. Effective safeguards are both achievable and indispensable, but they will never provide complete protection. The determining factor is awareness that nature can always come up with events against which no human means can prevail.

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