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3.2.12 Flood disasters and climate change: Trends and options – A (re-)insurer's view

WOLFGANG KRON & GERHARD BERZ

SUMMARY: *Flood-related disasters account for almost a third of all natural catastrophes throughout the world (in terms of numbers, fatalities, and economic losses). Trend analyses reveal that major flood disasters and the losses generated by them have increased drastically in recent years. Co-operation between the state, the affected population, and the insurance industry assumes a key role with regard to the flood hazard. Scientists, engineers, and insurers must work together in formulating their requirements and shaping them in such a way that politicians can derive clearly recognisable policy options (e.g. land-use restrictions) from them. Another important aspect is stepping up the efforts being made towards curbing climate change, which will, otherwise, exacerbate the risk situation in the future.*

Losses and loss potentials

The first years of the new century have already made one thing clear. All around the globe we have to reckon with more and more water-related catastrophes. Of the many events that have occurred in recent times the largest were the floods in Mozambique (February 2000), the southern Alps (October 2000), England (November 2000), Texas (June 2001), central China (August 2002, June 2003, June 2005), central and eastern Europe (August 2002, April 2006), southern France (December 2003), India and Bangladesh (August 2004), and the northern Alps (August 2002, August 2005). Additionally, the destruction and the overwhelming majority of the fatalities from the Indonesia earthquake in December 2004 and Hurricane Katrina in September 2005 were due to the tsunami and storm surge respectively, i.e. caused in both cases by floods. In global terms, the great inland flood catastrophes (excluding secondary effects of earthquake and storm events such as tsunami and storm surge) of the 1990s alone accounted for losses exceeding US$ 250billion (*Table 3.2.12-2*).

But it is not just the large and spectacular events that generate losses; in fact, it may be assumed that, when added together, the many small and medium-sized local floods account for at least the same loss amount again. Additionally, the financial means societies all over the world spend on flood control (sea dykes, levees, reservoirs, etc.) is a multiple of the costs they devote to protection against other impacts from nature.

In contrast to windstorm losses, only a small proportion of flood losses are usually insured (*Table 3.2.12-1*). Flood (including flash flood) losses accounted for only 8% of insured losses from natural disasters between 1980 and 2005, in comparison to 25% of economic losses (*Fig. 3.2.12-1*). One of the reasons for this is that the majority of the damage is to public facilities: roads, railway lines, dykes, river embankments, bridges, and other infrastructure installations such as the public water supply and sanitation. Besides, the market penetration of flood insurance is low.

WKron@munichre.com

Reasons for the increase in flood losses

Table 3.2.12-2 clearly shows that economic flood losses virtually exploded in the last decade of the 20th century. While they averaged US$ 28bn per decade in the previous 40 years, they increased almost tenfold in the nineties. Even more dramatic was the increase in the insured losses: here there is a factor of 13. It is obvious that a number of changes play a role in this development. The most important ones are discussed briefly below.

Land use

The increase in losses is a direct function of the number of people that live in exposed areas. Whilst the population pressure often leaves the people in poor countries with no other choice than to settle in flood-prone areas, the motivation in industrial countries is provided by other factors.

Floodplains (and coastal plains) are – if one neglects the flood hazard – well suited for development. They are flat, provide easy access to process and cooling water, allow transport of raw materials and products by boat, and are easy to develop with roads, water and power networks, and other lifelines. Rivers are usually thought to be »tamed« by the construction of a dyke, and residents and property owners feel safe, especially if no major event happens in the first few years after they have occupied the land. In such a situation, huge values are built up in the form of buildings, equipment, and stocks. Additionally, many jobs are dependent on the industries and businesses located on floodplains, which becomes a problem as soon as production or business is interrupted by inundation and people cannot work or even go to work.

Towns and cities are interested in further development. They have to make land available for housing or for commerce and industry. Many owners are either not aware that there is a danger of flooding because they do not come from the region and assume that if land is released for development it will not be unsafe, or they ignore the danger.

When it comes to deciding between flood control and jobs, the second option will always prevail: the retention area is reduced and more loss potential created. Municipal decision-makers usually only look at local aspects, but flood control must always be seen in a wider context. The decision as to whether a piece of land that is prone to flooding should be developed or not should therefore be made at a higher level.

Increase in exposed values and their vulnerability

Never before have people had so many valuable but at the same time vulnerable possessions. The rooms in the basement where people used to store coal and wood, preserves and potatoes, and all manner of junk, have now made way for party rooms and playrooms with wall-to-wall carpeting, upholstered furniture, stereos and computers, and freezers and high-tech washing machines. In former times, most belongings were hardly susceptible to damage by water. The ones that were could be carried to a safe place and even if they were destroyed, the loss was relatively minor. Today's contents often suffer total damage if they come into contact with water. Especially electric and electronic machines, appliances, and other devices are highly vulnerable to humidity and the dirt and other pollution particles always contained in flood waters. Due to their weight or because they are fixed to the building, some of these devices are difficult to move to a higher level when a flood rises. The greatest problem, however, is presented by central heating equipment and oil tanks (the rule of thumb being that the original water damage is roughly doubled by escaping oil).

The situation is basically the same in commercial and industrial buildings too. Here, electronic and electrical installations such as computer centres, air-conditioning control centres, and elevator machinery are the typical –

Table 3.2.12-1: The costliest inland floods since 1990 (original values, not adjusted for inflation).

Rank	*Year*	*Country/ies (mainly affected regions)*	*Economic losses US$ bn*	*Insured portion [%]*
1	*1998*	*China (Yangtze, Songhua)*	*31*	*3*
2	*1996*	*China (Yangtze)*	*24*	*2*
3	*1993*	*USA (Mississippi)*	*21*	*6*
4	*2002*	*Central Europe (Elbe, Danube)*	*20*	*16*
5	*1995*	*North Korea*	*15*	*0*
6	*1991*	*China (Yangtze, Huai)*	*13*	*3*
7	*1993*	*China*	*11*	*<1*
8	*1994*	*Italy (North)*	*9.3*	*<1*
9	*1993*	*Bangladesh, India, Nepal*	*8.5*	*<1*
	2000	*Italy (North), Switzerland (South)*	*8.5*	*6*
11	*2002*	*China (Yangtze)*	*8.2*	*<1*
12	*1999*	*China (Yangtze)*	*8.0*	*<1*
13	*2003*	*China (Yangtze, Huai)*	*7.9*	*<1*
14	*1994*	*China (South-east)*	*7.8*	*<1*
	2004	*China (Yangtze, Yellow, Huai)*	*7.8*	*<1*
16	*1995*	*China (Yangtze)*	*6.7*	*1*
17	*2001*	*USA (Texas)*	*6.0*	*58*
18	*1997*	*Czech Rep., Poland, Germany (Odra)*	*5.9*	*13*
19	*1998*	*Bangladesh, India, Nepal*	*5.0*	*<1*
	2005	*India (Mumbai)*	*5.0*	*15*

Table 3.2.12-2: Great inland flood catastrophes 1950–2005.

	1950–1959	*1960–1969*	*1970–1979*	*1980–1989*	*1990–1999*	*Factor 1990s: average 1950–1989*	*Last 10 years 1996–2005*	*Factor: Last 10 years: 1960s*
Number	6	6	8	18	26	2.7	12	2.0
Economic losses	34	24	22	31	254	9.2	127	5.3
Insured losses	0.4	0.3	0.6	1.6	9.1	13	7.6	25

Note: Natural catastrophes are classed as being great if they cannot be handled by the affected country/region alone and necessitate interregional and international assistance. This is usually the case when thousands of people are killed, hundreds of thousands are made homeless, or when a country suffers substantial economic losses, depending on the economic circumstances generally prevailing in that country. Great catastrophes can be analysed very well in retrospect because even records that go back several decades can still be investigated today. If the statistics were based on all the loss information collected (including small and medium events), the influence of advanced communication technology over the past decades would introduce an unacceptable bias.

and highly vulnerable – contents of basements. Underground car parks for employees and customers are component parts of most new office buildings. Although cars are relatively easy to remove, they still represent a very high loss potential which could be realised in the event of a flash flood when there is no lead time for warning. Underground car parks may also constitute a deadly trap.

Risk perception

Many people still believe that flood events can be fully controlled as long as appropriate technological precautions are taken. Flood control measures make loss events less common. The positive effect is that frequent losses and discomfort can be prevented. This effect is counterbalanced, however, by the fact that the feeling of security it creates leads people to expose more and more objects of increasing value to the risk of flood. This feeling 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. If an event occurs which existing safeguards cannot cope with, an immense loss potential suddenly emerges.

Flood control systems are designed to cope with a rare event with a given exceedance probability, e.g. once in 100 years. However, it does not make sense – either economically or aesthetically – to protect everything at this level of safety. The design of flood control measures should be

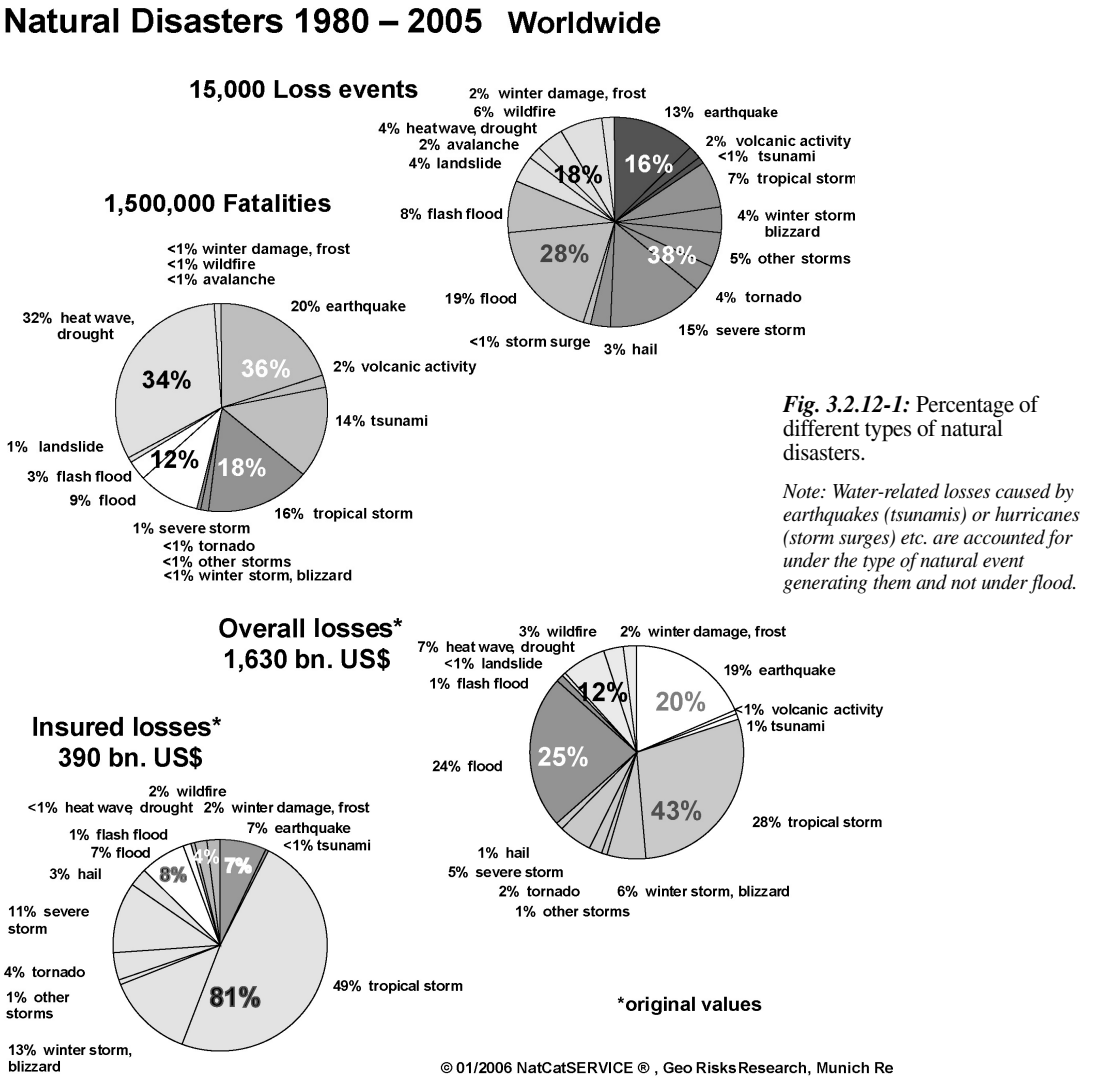

Fig. 3.2.12-1: Percentage of different types of natural disasters.

Note: Water-related losses caused by earthquakes (tsunamis) or hurricanes (storm surges) etc. are accounted for under the type of natural event generating them and not under flood.

geared to the population and values to be protected; agricultural areas should have a lower standard of protection than cities. This leads from a hazard-based to a risk-based design procedure.

Behaviour of the people concerned

People like living close to streams and rivers. A water surface is more attractive to look at than the neighbour's wall. The hazard associated with a river is initially accepted by many, but soon forgotten if nothing (i.e. no flood) happens. Only a dangerous event or a loss will wake people up. The two following examples make this clear.

On the River Mosel, a tributary of the Rhine in Germany, floods occur very frequently. The losses are more moderate than on other rivers because the people have learned to live with the floods. Lower parts of the buildings are used for parking and storing quickly removable items; the walls are faced with tiles, which prevent damage to the building and make cleaning up after the inundation very easy. The residents accept the frequent inconveniences and enjoy a beautiful view of the river – instead of a dyke – in the times between flood events. In contrast, residents on rivers elsewhere face a chaotic situation in a crisis – both psychologically and with respect to the amount of work and time they have to devote to the situation.

The two great flood events on the River Rhine in December 1993 and in January 1995 produced comparable flood stages. Nevertheless, the losses in the second event were only half as high. The main reason for this difference was that the preparedness on the organisational side was much better in 1995 because the people and the authorities still »knew what to do«. Thus, many losses could be avoided.

Owners are unwilling to move many items of property even though they are movable, and this often delays their evacuation. Examples are heavy washing machines and freezers filled with food. The chances are high that eventually it will be too late to save them. Also, reports suggest that some owners do not care about carrying things to a safe place, because they expect that insurance or the government will pay for their losses, thus enabling them replace a used item with a new one.

The effects of climate change

It is indisputable that a warmer climate will lead to a higher water vapour content in the atmosphere. The upshot will not only be larger amounts of precipitation generally but also extreme rain intensities in regional or local severe weather situations especially during the summer, as observations in many places have confirmed over the past few years in particular. In no way should this be considered inconsistent with the general tendency towards drier summers in certain regions (e.g. in Europe); it must rather be seen as an indication of greater variability in precipitation and hence more frequent extreme events at both upper and lower ends of the intensity distribution scale. Although there will be less rain in the summer, it will be more concentrated in time, so that more flash floods will occur. The fact that losses occur is attributable to these very extremes and not to a change in the mean values. The costs that arise from flood events and in connection with them must therefore be expected to increase dramatically. 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 induce extreme precipitation intensities. These 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 with water.

At the same time, the trends observed in recent decades as well as the model calculations of future climate scenarios lead us to expect much milder and wetter winters in many regions. This will have a substantial impact on the flood risk because precipitation will come in the form of rain rather than snow. Without the buffer that snow provides, the precipitation runs off directly into rivers and streams. This effect is intensified by the fact that in winter – when the level of evaporation is low – the soil is often almost completely saturated so that the surface acts as a natural impervious cover. Furthermore, for about 30 years now, Europe has seen a distinct increase in westerly weather patterns during the winter; these are very rainy low-pressure systems that often trigger floods.

Isolated extreme events are nothing new, a fact to which the numerous high water marks on historical buildings bear witness. Consequently, even such exceptional floods as those that swamped central Europe in the summer of 2002 cannot be cited as proof of global warming. On the other hand, the indications that climate conditions have already changed significantly are so strong and unmistakable that no unbiased observer can deny them. Extremes have

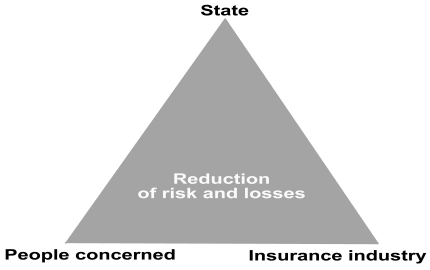

Fig. 3.2.12-2: The partnership for risk and loss minimisation.

increased in frequency and intensity or they now occur more often in seasons that are untypical for them. This development is due at least in part to anthropogenic global warming and is likely to continue and even accelerate in the future. As it will be impossible to reverse for decades to come, design assumptions must take into account that a 100-year discharge will be higher in the future. The state, the emergency services, the population, and the insurance industry must come to terms with the fact that there will be more frequent and more catastrophic events with generally greater losses.

The partnership for risk reduction

Risk and loss minimisation call for an integrated course of action. At the same time, the flood risk must be carried on several shoulders: the state, the people affected, and the insurance industry (*Fig. 3.2.12-2*). Only when all three partners co-operate with each other in a fine-tuned relationship in the spirit of a risk partnership is disaster prevention really effective. Reducing the underlying risk for society as a whole is primarily the job of the state. It provides access to observation and early-warning systems, builds dykes, deploys flood retention areas, and by enacting statutory provisions determines the framework for the use of exposed areas. Those affected are also obliged to make their own contribution to loss prevention by building in an appropriate manner, controlling the exposure of their values (e.g. not converting the basement), being prepared for emergencies (e.g. writing a checklist), and being ready to take action as soon as disaster strikes. Finally, insurance companies should be on hand, their main task being to compensate financial losses that would have a substantial impact on insureds or even constitute their ruin. This means that although insurers are not social institutions (in the sense of charities), they are indispensable institutions within the social system. They redistribute 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 at different degrees of probability. 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 1997).

Disaster prevention

It is important to prepare for more frequent and more extreme flood situations. It should not be expected that they will be avoided completely by technological means. There will always be a residual risk. The crucial point is how to cope with that risk adequately. Prevention of flood risk and flood losses involves various aspects that must be seen as component parts of a prevention system.

Prevention of floods

A flood occurs when there is significantly more water in a river, in a lake, on the ground, or below the surface than normal. Floods are part of the natural water cycle; but mankind has ways of intervening in this cycle. They include influencing the climate (resulting in more frequent and more intense precipitation), changing the infiltration capacity of the soil (impervious surfaces, soil compacted by agriculture), keeping the rainwater where it falls (decentralised retention, forced infiltration), discharging water into rivers and lakes (drainage ditches, sewers), and directing it towards the sea (e.g. river regulation, removal of flood retention areas).

Prevention of flooding

Flooding occurs when the soil, a lake, or a river is unable to take up any more water. The water then stands or flows into areas that are usually dry. Flooding can be influenced by technological measures such as retaining the water at specially designated places (retaining basins, polders, reservoirs), or directing the flood waters by means of dykes within in a predetermined area, possibly by means of flood channels. All these measures are based on what is called a design flood, i.e. a relatively high flood level used as the basis for designing protection measures.

Prevention of losses

Losses occur when people and their possessions are affected by flood waters. In such cases, damp, dirt, mechanical forces, and erosion play a major role. The precautions that can be taken are warding off the water or extricating oneself and one's valuables from its effects. Solutions also include revising land-use regulations (prohibiting residential areas in flood-prone districts), adopting permanent and temporary structural measures (building elevated structures, waterproofing cellars and buildings), modifying the management of values (avoiding installations or objects of great value or susceptible to water in lower parts of buildings), and taking appropriate action in the event of an impending flood (e.g. clearing out threatened parts of buildings) (DKKV 2004).

Prevention of risk

The risk is derived from the combination of flood occurrence probability and ensuing costs. At any given place, the risk is nil either if there is no possibility of a flood occurring there or if there are no values there (or both). It can be minimised by suitable measures designed to prevent floods, flooding, and losses. Nevertheless, there will always be a residual risk; and that is where insurance, for example, comes in. Insurance makes the uncertainty of future financial strains calculable. In return for a premium, the policyholder can either buy complete freedom from that uncertainty or (by paying a lower premium) limit the loss to a certain deductible.

Table 3.2.12-3: Measures designed for flood control and flood prevention, in the order of their effectiveness and importance.

Frequent floods (return periods below approx. 20 years) *»Natural« or »soft« measures*	• Improved infiltration, removal of impervious surfaces • Decentralised retention • River restoration • Dyke relocation, widening of river cross sections • Simple dykes • Early warning
Rare floods (return periods between 20 and 100 years) *Technological measures*	• Retaining basins, retention areas • Engineered dykes • Polders • Dyke relocation, widening of river cross sections • Early warning
Very rare floods (return periods (far) exceeding 100 years) *Organisational measures*	• Early warning • Flood management • Flood response • Emergency relief • Financial provisions (insurance)

In the discussion of flood control measures, the various sizes of flood are usually all lumped together. No distinction is made between relatively common floods (e.g. with a return period of up to twenty years), major floods (e.g. 100-year events), and catastrophic floods, which only occur on average every few centuries. This approach is fundamentally wrong and results in conflicting stances and solutions. A distinction must be made between frequent and very rare floods and between small and large catchments, because the measures called for in each case are quite different. *Table 3.2.12-3* lists the most important measures for each group of events roughly in the order of their significance and efficacy. Of course, all other measures have to be incorporated as well, but the fact is that they are not always equally effective.

Final remarks

There is no denying that the losses generated by floods have increased tremendously in recent decades. This is primarily due to two factors: trends in the settlement of areas near bodies of water and the accumulation of sensitive values in those areas, modifications of the landscape (river training works, loss of natural flood plains, deforestation, changes in agricultural land use, compacted soil and impervious surfaces, etc.) and a lack of risk awareness (partially on account of the excessive trust in flood control measures). Even if our own human activity is partly responsible for many catastrophes, we must appreciate that the errors we make are not all to blame. We simply have to get accustomed to living with extreme – and even catastrophic – natural events. It is important that we come to terms with the fact and refrain from placing our hopes on – or our trust in – these kinds of events being fully controllable by technological or other means. There will always be a residual risk. The crucial factor is to make an appropriate response to this residual risk. Flood prevention may include the following measures: improving structural flood control (usually the first thing to be called for following catastrophes), enhancing the organisational response to events (which is often very inadequate but which is only possible to a limited degree anyway), and sharing the risk with others (e.g. with an insurer, whose services have to be paid for, however).

In general, it is not fair to blame politicians and engineers for wrong developments in the past, since they only executed what society requested at the time. In past centuries the population needed agricultural land; engineers drained water meadows and straightened watercourses to conduct the (flood)water away quickly. Today, society asks for restored river landscapes. However, each measure has its pros and cons. This applies in particular to the different interests of the parties concerned in various aspects of flood control, e.g. conservation of nature, aesthetics, loss prevention, urban development, navigation etc.. The challenge is to find an optimum solution for society as a whole; each individual must be willing – or be forced – to shoulder his/her part of the burden.

The most important thing is to be optimally prepared to deal with catastrophe situations. This includes, above all, early-warning systems and an operable alarm plan. Therefore, if we take the correct action, we can make an existing risk bearable even if we cannot make it controllable. After all, a catastrophe situation should be regarded as the net result of the largely negative effects of extreme natural events and the largely positive response to these events. Catastrophes are not only products of chance but also the outcome of interaction between political, financial, social, technical, and natural circumstances. Effective safeguards are both achievable and indispensable, but they will never provide complete protection. The decisive point is the awareness that nature can always come up with events against which no human means can prevail. As Aristotele (384–322 B.C.) said, »It is probable that the improbable will happen« ♦