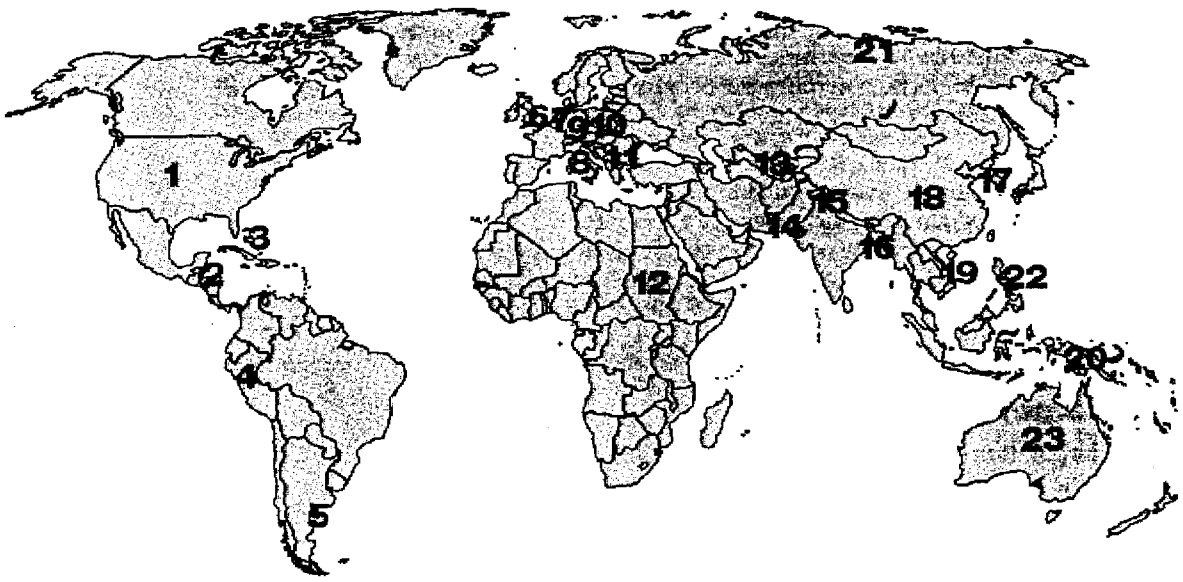
Major floods of the past 50 years



	Country		Year	Killed (circa)	Affected	Economic loss (US$)
1	USA	Mississippi/Missouri floods	1993	40	31,000	16 bn
2	Central America	Hurrricane Mitch	1998	10,000	6,700,000	5-7 bn
3	Caribbean	Hurricane Georges	1998	4,000	600,000	10 bn
4	Peru	El Niño rains/mudslides	1982-83	400	*	400 m
5	Argentina	Floods	1998	20	360,000	2.5 bn
6	Netherlands, Belgium, UK	Storm surge	1953	2,100	*	500 m
7	Germany, France, Benelux	Floods	1993-95	0	*	6.5 bn
8	Florence, Italy	Floods	1966	0	*	1.3 bn
9	Czech Rep., Poland, Germany	Floods	1997	100	210,000	5 bn
10	Slovakia	Floods	1998	55	10,850	24.5 m
11	Romania	Floods	1998	25	12,000	150 m
12	Sudan	Floods	1998	1,400	338,000	9 m
13	Uzbekistan/Kyrgyzstan	Mountain lake burst	1998	110	25,600	*
14	Pakistan (Baluchistan)	Floods	1998	1,000	25,000	*
15	N. India/Nepal	Heavy monsoon	1998	3,250	36,000,000	*
16	Bangladesh	Monsoon rains/tropical cyclones	1970	300,000	*	*
		Monsoon rains/tropical cyclones	1991	140,000	*	*
		Monsoon rains/tropical cyclones	1998	1,300	31,000,000	223 m
17	Korea	Floods	1998	400	188,000	868 m
18	China	Floods	1954	30,000	*	*
		Floods	1996	2,700	100,000,000	*
		Floods	1998	4,150	180,000,000	30 bn
19	Viet Nam	Tropical storms	1998	50	2,400,000	13.7 m
20	Papua New Guinea	Tidal wave	1998	2,200	9,119	*
21	Russia (Yakutia)	Snow melt	1998	15	51,300	98 m
22	Philippines	Nine typhoons	1998	500	5,000,000	*
23	Australia	Tropical cyclones	1974	15	*	230 m

Source: Munich Re, International Federation, UN OCHA, WFP, NOAA, ECLAC, CRED, Lloyd's Casualty Week.
** Information not available.*

Czechs and Poles living along the River Oder suffered far higher losses than their German neighbours on the other bank (although Germany got the lion's share of publicity). Poland is poorer, and years of neglect had undermined its dykes and flood defences. Weak government regulation led to flooded factories releasing large amounts of pollution. Very few Poles were insured and the government had few resources spare for either compensation or rebuilding (see chapter 11, *World Disasters Report 1998*).

In the post-flood analysis, lack of cross-border coordination was blamed for making mitigation more difficult and emergency response sluggish. The 1997 floods led to the UN drafting a European Protocol on Flood Prevention and Flood Reduction which should be signed this year. Based on the principles of the 1994 Yokohama World Conference on Disaster Reduction and the conclusions of the Rio Declaration and Agenda 21, it seeks to integrate early warning and response mechanisms across the region and treats disaster reduction as an integral part of wider sustainable development.

Information or education?

Some specialists insist that information is the key to lessening vulnerability. Better coordination of information, especially between the Czech Republic and Poland, might have mitigated the effects of the 1997 floods – it certainly helped in Germany. But information alone is not enough, especially for those in developing countries who cannot improve their standard of living, and who cannot easily flee disaster or rebuild their lives and property after it strikes. Despite the efficiency of, for example, the Bangladesh Meteorological Department, with its accurate satellite forecasting of imminent cyclones and rapid dissemination of storm and flood warnings to the public by radio, television and 30,000 Red Crescent-trained volunteers with loudhailers – all of that may still not be enough to avert tragedy.

In one study of a rural district in Bangladesh, over 90 per cent of the villagers claimed they were informed and understood the storm warnings given. Yet only 50 per cent reacted to them. Why? Some had no clear notion of what they could do; others said they did not believe the warnings. Some were afraid to leave their lands or possessions; and others – in the most poignant responses of all – said the man of the house was away and the women could not decide whether to take drastic measures, like moving livestock, themselves and their children to a place where perhaps they were not known and from where they might never be able to find their husbands and fathers again.

By the pure laws of hydrogeography, the Netherlands should be almost as flood-disaster prone as Bangladesh. Over centuries, a very strong and sophisticated system of dykes, flood barriers and drainage has been built and is constantly maintained. But just as important, according to Dutch experts, is their comprehensive system of educating the entire population. Every individual in a flood area – and especially those where storm surges occur – knows exactly how to react to warnings disseminated in every phase of an impending emergency, from participation in dyke patrols to possible evacuation.

That something similar can be achieved even in a country less wealthy than the Netherlands is demonstrated by Costa Rica. A community-based early-warning flood information system can claim credit for the fact that far less property, and no human lives, were lost in the Atlantic coast floods of 1997, in contrast to the year before when the system was not fully established and largely ignored. The early warning system employs key personnel across widely dispersed communities and broadcasts over local radio in indigenous languages, as well as through Spanish regional and national radio and television.

The great flood of the Mississippi in 1993 prompted more reflections on vulnerability Spring and summer rains over the enormous river basin led to flooding that in many places lasted over two months, with multiple crests at record heights. The impact was considerable: 80,000 square km of land inundated, 54,000 people evacuated, and disruption of river, road and rail traffic over several months. Economic losses were estimated at around US$

20 billion. In this case, the information resources of a highly developed country certainly helped reduce vulnerability – there were fewer than 50 fatalities. The low death toll also illustrates that, while a river can be inexorably destructive, it is relatively slow-moving and predictable in contrast to a flash flood or dam burst. Furthermore, a developed country has the means for strong and effective measures to avoid post-flood epidemics.

This leads us to one bright spot in the recent history of floods. Until very recently, most flood-related deaths were not from drowning or injuries, but, after the waters subsided, from communicable diseases like dysentery, typhoid and cholera. Better sanitation has reversed this trend, and is the main reason why the 1998 floods in Bangladesh, devastating as they were, resulted in only a fraction of the 140,000 lives lost in the 1991 floods. And the Chinese government has claimed that while 90 per cent of the 30 000 deaths from the 1954 floods were attributable to contagious diseases, in 1998 no epidemics were reported, although diarrhoeal diseases still took a heavy toll (especially of children under five).

Flood management and disaster mitigation

Floods are neither totally undesirable nor entirely avoidable. But the damaging effects of floods can be mitigated and managed in order to avoid disaster. Strategies for dealing with damaging floods are divided between structural measures (often to keep floods away from people) and non-structural measures (often to keep people away from floods).

Traditionally, specialists have thought the best way of keeping floods away from people was to multiply structural measures – building more dykes, dams and reservoirs, making them higher and stronger – in effect, throwing more concrete at the problem. Stretches of China's Yangtze River, for example, flow between dykes which tower up to 20 metres above the surrounding land. This strategy has not been entirely abandoned, but it is no longer considered the only, or even the preferred, method of tackling the problem of sustainable water management.

The failure of the post-1988 Bangladesh Flood Action Plan (centred around the construction of a network of embankments) is a case in point. It was quickly discovered that the new embankments would be breached, if not in the year after building, almost certainly in the next big flood. Once that happens the land beyond them fills up with water and the dykes metamorphose into reservoir walls inhibiting proper drainage. According to current thinking on flood control in Bangladesh, dyke-building is best confined to the protection of strategic and vital installations – Dhaka airport, for example, which like many airports is situated on the flood plain.

In the 1993 Mississippi flood, 800 out of 1,400 affected levées (dykes) failed. Experts subsequently suggested that some of them might be better left un-reconstructed. Future floods could then spread over more land in a natural extension of retention areas, providing less scope for damage in the narrower channels, particularly those flowing through towns and cities. Furthermore, the same engineers dared to whisper, this could be beneficial for the natural regeneration of flood-plain land – regardless of whether some buildings might require flood-proofing or should even be abandoned In the climate of supremely technocratic thinking that dominated most of the developed world's hydrological community for many decades, this sounded like heresy.

But not all structural work is necessarily useless. In many parts of rural Bangladesh, villagers have built, often with the help of non-governmental organizations (NGOs), raised-earth flood mounds the size of football pitches. They have planted trees on top of the mounds for fuel, dug and stocked fish ponds for food, and sunk wells to provide drinking water uncontaminated by flooding. During emergencies, whole communities can decamp, move to this higher ground, and live reasonably comfortably for weeks at a time. On larger mounds, fodder grasses are grown so that valuable animals can also find refuge atop these 'flood shelters'.

Installations to reduce the speed of water or mitigate flood peaks are usually regarded as beneficial even by so-called 'naturalists'. However, here too the idea that small is beautiful is gathering strength. Huge flood control reservoirs, once highly recommended, now elicit considerable criticism. They are expensive, flood large stretches of landscape and often require relocation of farms and towns. They can destroy scenic land and the habitats of endangered species. And big dams can break.

There are over 20,000 so-called 'large dams' in the world and since 1950 over 100 have burst. Failures of the Brazilian dam at Oros in 1960, and the two Indian dams at Panshet in 1961 and Machi in 1979, claimed over 1,000 lives each. China has thousands of big dams, but reports of a dam failure on the Huai River, said to have killed 230,000 people in 1975, remain unconfirmed. Most failures occur while the dam is being built. For dams higher than 30 metres, construction usually requires more than a year, so exposing the unfinished structure to at least one flood season.

More recent good practice is to construct several smaller, cheaper reservoirs upstream on the main river or on tributaries. Some hydrologists go one step further by suggesting whole constellations of 'farm dams' near the headwaters. To be effective, such a network of micro-dams would need to be very extensive, including non-farming areas and forests, and with the full participation of local inhabitants. The idea appears to have many advantages but has not so far been extensively tested.

Flood-retention basins, also known as balancing basins, reduce the effect of rapid run-off from built-up areas, making it possible to release water more slowly into nearby streams. Cheap to build and often very effective, they are usually quite small. But China is an exception: in the lower valley of the Yellow River, huge retention basins have been designated to protect the rest of the plain. People live inside these areas (250,000 in one, a million in another) and must be evacuated each time a large flood is expected.

'River training' is the collective name for techniques used to modify the river channel in order to make faster and deeper evacuation of flood waters possible. Diversion channels can be

Box 2.2 Letter from Bangladesh - 3 September 1998

For the last two weeks, it has rained very little in Dhaka, the capital of Bangladesh where I live and work for the International Federation. But the flood waters which have affected up to two-thirds of the country for the last 50 days have nevertheless been increasing. Now the comfortable residential colony in which I live close to Dhaka's diplomatic area is full of stinking, stagnant water full of floating plastic bags, a gift of 'progress' which clogs the ways through which water should drain away. Small boats provide a taxi service in my road.

Of course I am lucky: the phone, electricity, running water and gas are still available, but two million people in the capital alone have been driven out of their homes by the flood waters. The foul, very slow-moving water all over Dhaka city and district is potentially lethal, so much sewage has flowed into it.

At the end of a tiring day's work which has usually been at least 14 hours long, I feel a bit guilty having my shower. The waste goes into the already overflowing sewage system and I am acutely aware that millions of people are wading through this dirty water every day. I see tankers of drinking water going through axle-deep floods - that brings the comparison into sharp perspective. I have also seen the horrific sanitary conditions being faced by thousands camping in the flood shelters.

Torrential rains continue to lash India's Uttar Pradesh, Bihar and West Bengal, and most of that water finds its outlet to the sea through Bangladesh. It will be the end of September before farmers can think of finding enough dry soil in which to plant seeds.

A landless agricultural labourer would normally at this time of the year be earning 60 to 70 *taka* a day transplanting paddy (rice) seedlings. Now that paddy land may be under three metres of water. If he owns any animals, he may be passing his days collecting water hyacinth with which to feed them, as the cost of fodder has doubled in the last few weeks. The fruit trees that his wife tends will have been destroyed by the length of this year's floods. And rather than go in search of elusive government and NGO relief supplies, these people may have decided to borrow money with which to survive, even if the interest is as high as eight per cent a month.

dug and natural meanders stabilized. Flood alleviation work is often combined with improvements in navigation through deepening, straightening and stabilizing channels. Dykes and ditches may also form an important and useful part of the total scheme. But major structural solutions can mean difficult political decisions: 'Duff's Ditch', a flood-diversion canal around the city of Winnipeg in Canada, was built in the face of intense public opposition and derision. In fact, the local council hesitated so long over the canal that the provincial government stepped in to make the final decision (see box 2.3).

Non-structural measures

Non-structural measures are the 'software' to the structural engineers' 'hardware'. They will not reduce flooding, but can reduce the damage floods inflict. Some initiatives which could be taken at community, national and international levels are examined below.

A first group of measures involves regulation of the flood plain itself: zoning, urban planning and enforcement of building codes – decisions which may have to be made on a regional or national level. But even at a local level, in poor or overcrowded countries, efforts can be made to discourage building on the most exposed sites and to promote building techniques capable of withstanding some flooding. At its simplest, this means constructing high platforms in houses, or building houses on stilts. Clearer definition of land rights can encourage threatened populations to leave when necessary, knowing they will be able to return to the same land they left. The most drastic measure of all is permanent evacuation.

Box 2.3 **Duff's Ditch**

Winnipeg, capital of the Canadian province of Manitoba, is situated at the confluence of the Red and Assiniboinne rivers, on flat prairie that was once the bed of glacial Lake Agaziz, in the midst of one of the world's most flood-prone regions.

In 1950, the city was completely inundated by what was referred to at the time as a 100-year flood. Almost half its 400,000 citizens were evacuated and thousands lost homes and livelihoods. For the next decade, city fathers debated the options for flood protection, but resisted the notions that either a protective embankment be constructed or that a diversionary channel be dug around the city. Costs for either were seen as unrealistic.

However, Manitoba's provincial premier Duff Roblin had faith in the engineers who opted for a diversionary channel, despite vitriolic political opposition. The decision may have cost Roblin his re-election. Digging the floodway was the largest earth-moving venture undertaken since the construction of the Suez Canal. Cynics, referring to it as Duff's Ditch, maintained the money could have been better invested at a time when the economy was in dire need of financial infusions.

The floodway was completed in 1967, for the opening of the Pan-American Games, where it was used to stage the rowing events. It continued to be used for recreational activities, but remained untested until 1979 when flood waters equivalent to those of 1950 were diverted around the city.

In 1997, however, Duff's Ditch really came into its own. The Red River flood of 1997 was considerably larger than that of 1950, with a peak flow of 167,000 cubic feet per second (cfs) compared to the 1950 peak of 108,000 cfs. From southern North Dakota to Lake Winnipeg, the Red River valley was flooded. The city of Grand Forks, some 150 kilometres south of Winnipeg, was totally underwater, as were all smaller towns and villages in between.

Winnipeg was not affected, except for some low-lying riverside properties. Without the 'ditch', at least half the city would have been flooded under a metre and a half of water.

Potential flood damage to the city has been estimated at several billions of dollars, compared to the US$ 63 million it cost in the mid-1960s to build the diversion channel. The city was saved 30 years later by a far-sighted, albeit highly unpopular decision: to commit the required resources to an investment with no guaranteed time for, or measure of, when it would pay off.

Winnipeg's floodway, like the Dutch delta works with which it has been compared, are clear examples of why disaster mitigation needs to be seen as a long-term intervention, where costs are recouped over generations and where benefits may only be inherited by the children and grandchildren of those who first acted with courage and foresight.

Spreading flood awareness and education is a crucial task of those responsible for flood mitigation. To disseminate flood information and warnings in developing countries, volunteers are best mobilized on a local level although, as in Costa Rica, they may be trained through a system of national courses. In more developed countries such as China, national television and radio networks may be used for mass communication of flood warnings.

But mitigation means more than simply spreading awareness. The Bangladesh Red Crescent Society (BDRCS) has put disaster preparedness (DP) at the heart of its strategy, the aim of which is "to enable vulnerable communities to develop self-sufficiency to withstand or prevent disasters by collective participation." In 1997 BDRCS, through its countrywide network of local branches, began recruiting volunteers, at least a third of whom are women and many who are themselves at risk of losing their lives or property whenever the rains come. After receiving training in disaster prevention, mitigation, awareness raising and emergency response skills, these volunteers helped hundreds of thousands of people during last year's devastating floods (the worst this century). Their help included warning local people that the floods were likely to continue rising, advising them to prepare for disaster, assessing the needs of the worst-affected, moving flooded families onto higher ground, providing health and hygiene education, giving first aid, assisting in food distributions and fund-raising locally for cash or goods in kind. They also collected a cup of rice from each 'well-off' family, to be stored and distributed later to those who had lost everything in the deluge.

Dry seed storage and seed pooling are crucial local measures which ensure families have enough to eat during the emergency and enough seeds to replant when the flood waters subside. Boats to rescue and transport people trapped by high floods can be provided by

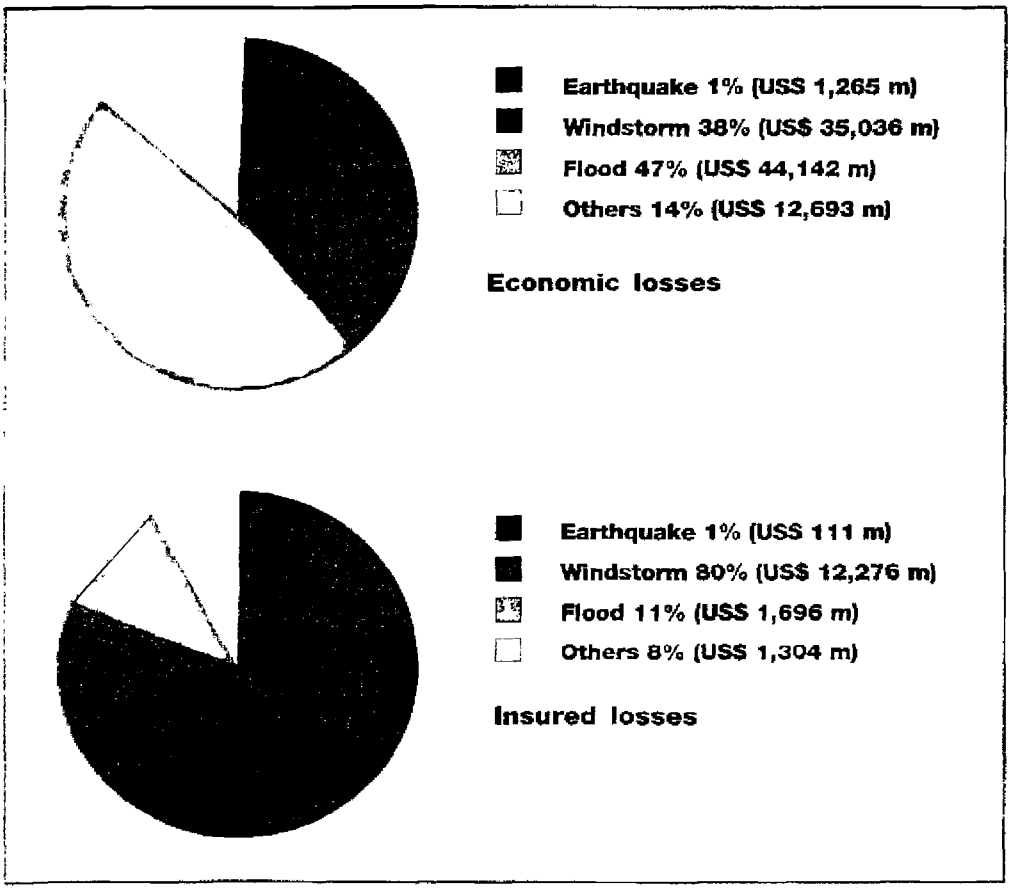


Figure 2.1 Economic losses far outstrip insurance losses. It is the poor who live in the path of known hazards and they cannot afford insurance cover. Indeed, for many increasingly disaster-prone areas, insurance companies are refusing to provide cover. *Source: Munich Re, 1999*

local councils or bought through local cooperatives. First aid is best taught and initiated by members of the local community – they are best placed to identify those in need, and can act as guides or interpreters if outside agencies come to help.

All these initiatives must be taken or at least put in place before the floods arrive. Some measures may be unpopular, or require political will to achieve, such as the definition of land rights. And it may be difficult to keep on promoting or enforcing measures between floods, especially if these are rare events

Much river management cannot be decided even at a national level – over 200 of the world's river basins encompass two or more countries, requiring complex international treaties to govern their use and management. A number of leading international institutions, such as the WMO and the UN's International Decade for Natural Disaster Reduction (IDNDR), have encouraged exchanges of information between the scientific and humanitarian aid communities. But far more cross-sectoral work needs to be done: linking international meteorological forecasts with aid agencies, governments and local networks; sharing new flood-management technologies and expertise between developed and developing countries; and ensuring international trade agreements and practices – whether for the importing of bananas from Central America, or the sale of Western lab-generated high-yield variety seeds – do not disadvantage the world's poorest in their attempts to recover from disastrous floods.

Response and recovery

When a flood hits, the emergency response will be much like that for any other natural or man-made disaster Key actors are much the same: civil-defence teams, police, health authorities and the military. Except for flash-floods and dam failures, most floods can be forecast in time to warn the population Any system will be necessarily complex: not only must it be well organized, but well rehearsed too. This can be by simulated exercises or, as in the Netherlands with its sophisticated system of multi-level storm-surge warnings, by frequently calling a first alert. Ordinary citizens must not only know what to do but also be convinced, even coerced, into doing it And that is not always easy to achieve.

Once the flood has subsided and the injured cared for, much work remains to be done. Cleaning away silt, rotting vegetation and carcasses of drowned animals comes first At this stage, people are at great risk from dysentery, cholera and typhoid – fortunately no longer the inevitable corollary of floods they once were – and, especially for relief workers, tetanus. Disposal of flood-damaged objects and repairs to structures come next After the Christmas 1993 flood on Europe's River Rhine, municipal authorities reckoned the volume of bulky refuse was equivalent to that usually collected in six months. Rich and poor countries alike will be faced with the problem of repairing damaged buildings and demolishing those beyond repair. Many everyday services – sewage, electricity, telephone and water supply – will have been damaged in a major flood and will need restoring.

As well as physical injuries, some people suffer serious psychological damage linked to a sense of loss and insecurity. Poor countries rarely have the resources to offer psychological counselling, but the 1997 central European floods provided a case study for the stress floods can cause. Poland had a spate of suicides and children in particular showed serious stress symptoms, with repeated nightmares and other signs of insecurity.

The last phase of recovery is a post-flood review. Part of this is physical – checking the strength of remaining dykes, dams and other structures. But the post-flood period, when memories are fresh, also offers a valuable opportunity for all the actors – forecasters, rescue workers, journalists, information officers and others – to reflect on how they handled their part of the emergency and what could be done better next time.

Why do 90 per cent of natural disasters, and 96 per cent of deaths from such catastrophes, take place in the developing world, where the risk of death from disaster is 12 times greater

than in industrialized countries? Developing economies lack the resources to invest in robust infrastructure and disaster prevention measures and, as a result, fall foul of the effects of natural hazards. Floods, like other disasters, can shatter fragile economies and breed uncertainty for the future, prompting rapid and vast withdrawals of international capital and deterring potential investors. Added to which, post-flood recovery places huge financial and administrative burdens on sometimes weak or fledgling governments. after the 1997 floods in Poland, estimates put the total cost of rebuilding at nearly one per cent of gross domestic product, equivalent to two or three per cent of the government's budget for the next two years.

Nor is globalization a process likely to strengthen developing nations' resilience to natural hazards As Mark Duffield of Birmingham University, UK, argued in a recent paper: "Rather than the anticipated virtuous circles of growth and prosperity leading to orderliness, globalization tends to encourage new and durable forms of division, inequality and instability."

And the situation is not predicted to improve. According to the IDNDR, by the year 2025, 80 per cent of the world's population will be living in developing countries, and up to 60 per

Box 2.4 Lake Sarez – a disaster waiting to happen

Lake Sarez was created in 1911 when an enormous landslide, caused by an earthquake in the Pamir mountain range of Tajikistan, blocked the Murghab River valley with a dam of debris

The river rose to form a lake about 60 km long containing nearly 17 cubic km of water, about half the volume of Lake Geneva. The natural dam, named 'Usoi', lies at 3,200 metres – higher than any other natural or human-made dam in the world. Usoi is 600 metres high, four kilometres wide and very unstable. It is a 'disaster-waiting-to-happen', for a number of key reasons:

• The Usoi dam was severely weakened by an earthquake in 1968 which toppled one of the riparian cliffs into the lake, sending enormous waves over the top of the dam. The entire right bank of the lake is now in danger of collapsing. If it does, scientists estimate that waves 150 metres high could sweep over the dam and wash it away. The flood unleashed would be devastating for the five million people living in its projected path down the connecting river valleys.

• The lake is located in a highly-seismic area. The earthquakes which shook Afghanistan in February and May 1998 were just across the border. According to reports in the Tajik press, the quakes may have further damaged the already weakened Usoi dam.

• Water is filtering through the dam, due partly to the enormous pressure the lake exerts on the dam wall. This filtration process is good and bad. Although it relieves pressure on the dam wall and keeps the lake's waters at a constant level, filtration continues to degrade the dam's structural integrity.

• The early warning systems created by the Soviet Union in 1984 are inadequate New systems are urgently needed to monitor the unstable riparian cliffs forming the lake's right bank, the very fragile rear part of the dam, and the water level of the lake. Any early warning system must be linked with clearly-defined alert procedures and evacuation plans for those living downstream.

• The impact of any disaster would affect not just Tajikistan but northern Afghanistan, Uzbekistan, Turkmenistan and Kazakhstan.

The IDNDR secretariat is currently organizing a disaster-impact assessment mission, scheduled for June 1999, to Lake Sarez to assess the threat it poses and to propose immediate disaster prevention measures

The mission will examine possibilities for improving the early warning and monitoring systems around the lake and produce a video to draw the attention of the international community to the urgency and scale of the situation. Immediate action is likely to involve (a) lowering the level of the lake by pumping out water or diverting it through channels and tunnels; (b) strengthening the structural integrity of the dam and raising its lowest section by 50 metres; and (c) improving the early warning systems around the lake and helping those in the path of potential disaster to prepare better. This means resettling thousands of people living immediately downstream and creating or improving alert and evacuation procedures

Few people would argue that the threat posed by Lake Sarez is enormous. Failure to prevent the complete collapse of debris dams has often resulted in unnecessary deaths, for example the Cerr Condor Sencca landslide dam failure in Peru in 1945 and the breach of the landslide dam supporting Lake Yashinkul in south-central USSR in 1966

It would be a human tragedy of catastrophic proportions if Lake Sarez were to go the same way.

cent of them will be 'highly vulnerable' to floods, severe storms and earthquakes. Increasingly, poor countries find themselves threatened by the lifestyles of richer nations. The warming of the earth's atmosphere with greenhouse gases – thought to be responsible for sea-level rise and even El Niño with its accompanying storms and floods – is largely due to the high emission levels of developed and rapidly developed nations. But due to powerful commercial lobbies and domestic pressures, major conferences on environmental issues such as Kyoto (1996) and Buenos Aires (1998) have been unable to reach binding agreements.

The IDNDR has been working with the US Federal Emergency Management Agency to explore ways of nurturing linkages between corporate crisis management and natural disaster reduction. But while emergency management is a core activity for a few specific public sector and NGOs, it is only one of many functions for most corporations, and certainly not their primary strategic role. Yet until environmental factors are accounted for in commercial cost-benefit analyses, sustainable development leading to a safer, less disastrous planet looks a long way off.

The role of the private sector

The role of private and public enterprise in flood preparedness and responsibility was debated at length in the US during and after the 1993 great flood on the Mississippi. The flood plains along the rivers were supposed to be protected by levées, some built privately, others by government agencies including the US Corps of Engineers. About 80 per cent of the privately-built levées failed while most of the 'public' ones – designed to withstand a 100-year flood – held fast.

Of all private enterprise sectors, the insurance industry is most directly involved in crisis management. Cover for flood losses is minimal compared to that for other types of natural catastrophe: in 1998, floods accounted for just 11 per cent of insured losses, versus 80 per cent for windstorms. When the Yellow and Yangtze rivers swamped China from May to September 1998, it cost the country an estimated US$ 30 billion in economic losses, of which only one billion dollars' worth was insured. In some parts of the world, insurance against flood losses is simply not available, but even where it is many potential policy-holders underestimate the hazard

Yet flood losses can be so enormous that almost all countries where flood insurance is available have arrangements for a mix of private and public coverage. Even in the US, private and commercial flood insurance comes through a state-run pool under the National Flood Insurance Program which works with both public and private insurers. In Spain, insurance is provided by a public *Consorcio de Compensación de Seguros*, with private companies acting as fronting agents, collecting premiums, reporting and settling claims, which are then paid out of the *Consorcio's* funds. Many other variations exist, but practically all involve pooling premiums and risks, with major claims prompting the intervention of the large re-insurance companies.

Since insurance companies must minimize financial losses, they actively encourage clients to take maximum precautions against flood damage. And the best way, whether for private individuals or huge corporations, is for insurers to offer premium reductions to those who take concrete steps to minimize potential loss. For the same reasons, some insurance companies are enthusiastic participants in education campaigns. Since not all factors can be controlled by individual policy-holders, insurance companies have also been actively involved in lobbying governments to take public measures to reduce risks.

Nineteen ninety-eight was a year of almost unprecedented flood disasters. But there is no point playing ostrich, sticking our head in the sand and hoping the crisis will pass. The coming years will inevitably bring more floods at least as bad as those of 1998, or even worse, if we subscribe to some global warming models They cannot be stopped, but they can be tamed and channelled. Above all, the people in the way of flood waters can be helped to survive, to minimize the damage and to rebuild their lives. That is the challenge of the future.

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