International Strategy for Disaster Reduction

ISDR

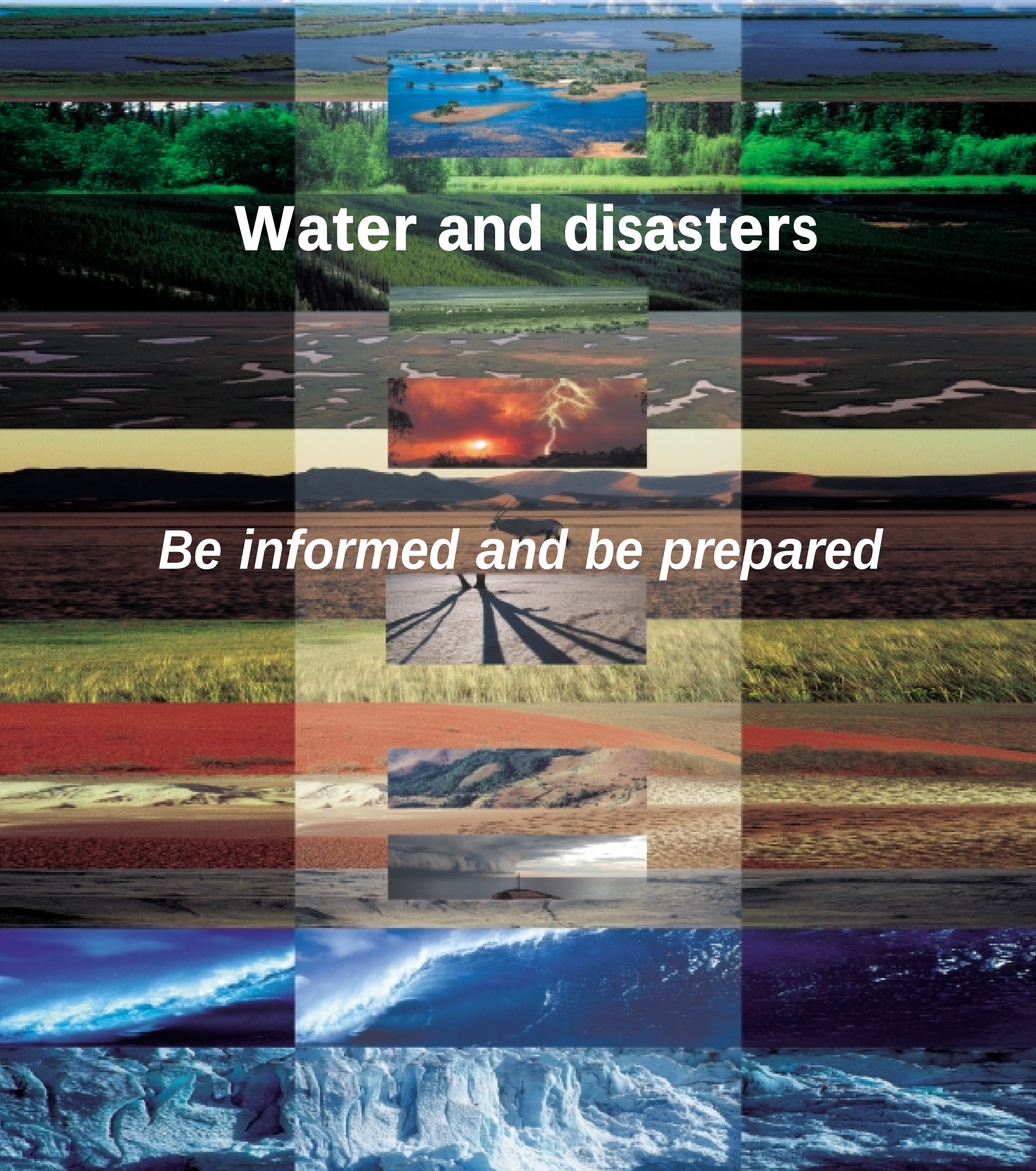
United Nations

World Meteorological Organization

Weather • Climate • Water

Water and disasters

Be informed and be prepared



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Geneva, Switzerland
2004

WMO-No. 971

ISBN 92-63-10971-0

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Foreword

In recent decades, people throughout the world have become increasingly alarmed over extreme weather events, which seem to be growing in frequency and adverse impact. Cyclones, storm surges, floods, droughts, avalanches, landslides or mudflows — all the water-related hazards pose an enormous risk to the millions who live in their path. Poor communities are particularly vulnerable: for them, natural hazards can swiftly lead to human catastrophes. It is now increasingly recognized that reducing this risk is a vital step towards meeting the Millennium Development Goals, and towards sustainable development itself.

Of course, we cannot yet control the forces of nature. We cannot prevent a tropical cyclone from forming. However, we are able to contain rivers, stem tides and build structures that give considerable, if not total, resistance to the forces of nature. And since natural phenomena will continue to occur, the problems they present have to be faced — through prevention, mitigation and preparedness.

Prevention is essential, from identifying the natural hazards and assessing threats to life and property to adopting measures to reduce those threats and making the right decisions on land-use planning and design. For instance, good building codes and standards for development activities in areas prone to natural disasters can hugely reduce vulnerability, and thereby risk. Disaster prevention measures are complex: they relate not merely to the disasters themselves but also reflect the interaction between development and the environment on the one hand and between social and economic interests on the other.

Mitigation measures are key in lessening the impact of a disaster, should it strike. Community awareness campaigns, instruction in how to deal with disasters, levee and dam construction to lessen the impact of flooding — all can cut both the human and the financial cost. Forecasts and early warnings based on scientific monitoring of meteorological and hydrological hazards are a pre-requisite for any disaster preparedness planning. The interrelation and coordination between the various institutions involved in early warning, dissemination of information and disaster response is imporant. The outreach and effectiveness of the early warnings determines the success of disaster response mechanism.

Underlying all these measures must be a strong knowledge base and a clear understanding of how and why natural hazards happen, and how they can escalate into disasters. There is much information to draw on in systematic studies of meteorological phenomena and observations related to cyclones, severe storms, floods, landslides and mudflows and their impact on human activities. Knowing how strong winds can affect the stability of a structure, how building a railway line on a natural drainage system will affect flooding in the area and how urbanization might alter downstream river discharges are all crucial pieces in vulnerability assessment. Authoritative information is at the core of prevention, and is vital for its success.

This principle is central to observing World Water Day. During this annual event, the United Nations agencies dealing with various facets of water focus on a water-related issue affecting sustainable development, and help generate public awareness of it at the local, national, regional and international levels. Among others, countries participate by publishing and disseminating documentaries, and organizing conferences, round tables, seminars and exhibitions related to the conservation and development of water resources and the implementation of the recommendations of the Johannesburg Implementation Pan.

This year, the World Water Day theme is "Water and disasters". WMO has collaborated with the ISDR secretariat, World Health Organization, Swedish Water House and the Swiss Centre of Hydrogeology in the preparation of this booklet. Here you will find information on the science behind floods, droughts, hurricanes and other natural disasters, the impact they may have and what can be done throughout society to build the capability to deal with them. Timely warnings and action ensure preparedness and empowerment of society, the nation and humanity to address water-related hazards.

To reduce the risk due to water-related disasters, the watchword is to "*be informed and be prepared*". Information must flow between global and local, between traditional and modern, between the village and the boardroom, between scientists and decision makers. This booklet is an attempt in that direction, and it is hoped that national governments and all those concerned by the issue will find it useful and informative.

M. Jarraud
(Secretary-General)

Introduction

Every day, hundreds of natural water-related hazards loom over the world. A cyclone may be stirring near Malaysia while the first tentative signs of severe drought may be creeping in over a sub-Saharan savannah. Avalanches may be ready to go in the Alps and mudslides to pour down the hills of Venezuela. And all these hazards are potential disasters for the unsuspecting and unprepared.

The trend in economic impacts of natural disasters, and particularly the water-related ones, has continued to increase during the past half century (Figure 1). The International Federation of Red Cross and Red Crescent Societies, for instance, keeps records of the type and number of reported disasters, the numbers of people reported killed and affected by disasters and damage estimates by country. Their data reveal clearly that, in recent times, 89 per cent of natural disasters are weather and climate related and have been the most pervasive during the last ten years. Drought and famine accounted for 82 per cent of all those affected by disasters in Africa, 48 per cent in Oceania and 35 per cent in the Americas, whereas floods accounted for 69 per cent of those affected in Asia (Figure 2). Similarly the death toll for hydrometeorological disasters has accounted for 71 per cent of all deaths. Over the last 30 years, the number of lives lost to natural disasters has declined and levelled off at about 80 000 per year, but the numbers of people affected and estimated economic losses have been steadily increasing (Figure 3).

Losses caused by natural disasters are, in particular, depriving countries of resources which could otherwise be used for economic and social development. The impact of this is most severe and tragic in the least developed and developing countries and has set back their development goals by decades (Figure 4).

The Intergovernmental Panel on Climate Change indicated in a recent report that climate change and a warmer world will result in more natural disasters. At the same time, it should not be forgotten that mankind has always lived with climatic shifts, and that humans have developed a remarkable array of strategies to survive them. History contains fascinating glimpses into how our ancestors coped with extreme weather, and today's traditional societies have their own repositories of knowledge. People have thus managed catastrophes by anticipating potential hazards based on their experience of them, and by investing in protective measures. There is, however, considerable scope for informing and advising people about these hazards.

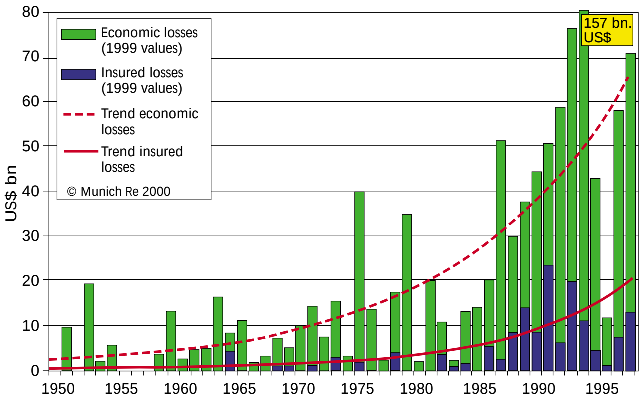


Figure 1 — Economic and insured losses with trends, February 2002 (Munich Re Group, E&F/Geo)

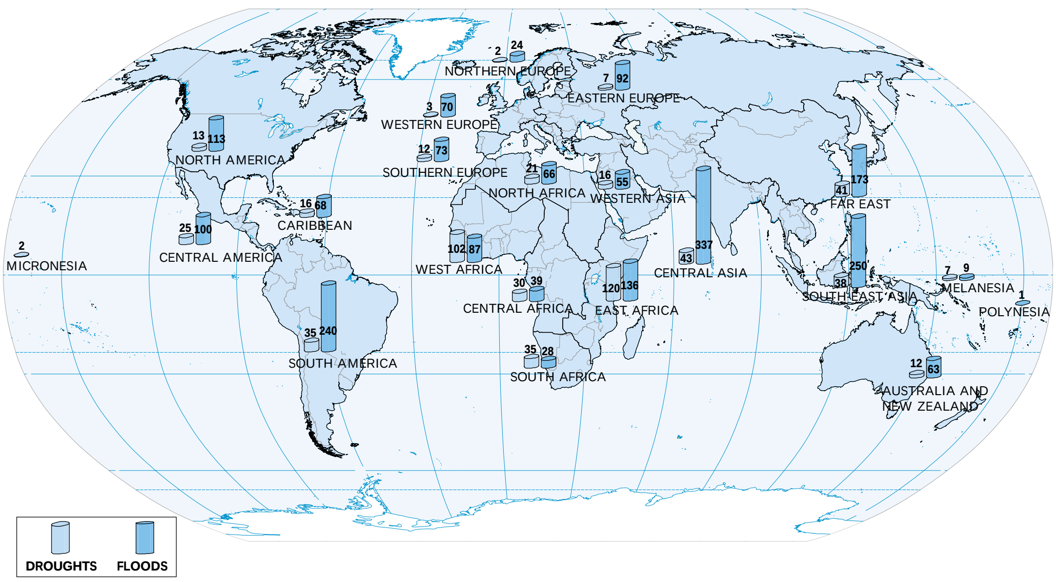


Figure 2 — The occurrence of droughts and floods: a geographical overview for the last 30 years (1973–2002)

NOTE: Includes disasters that meet one of the following CRED criteria; ten or more people reported killed; 100 people reported affected; a call for international assitance, and or a declaration of state of emergency

Data: EM-DAT, CRED International Disaster Database, Université de Louvain, 2003

Base map: Robinson Projection, Standard parallels 38°N and 38°S, Perry-Casteñeda Library, University of Texas, Austin

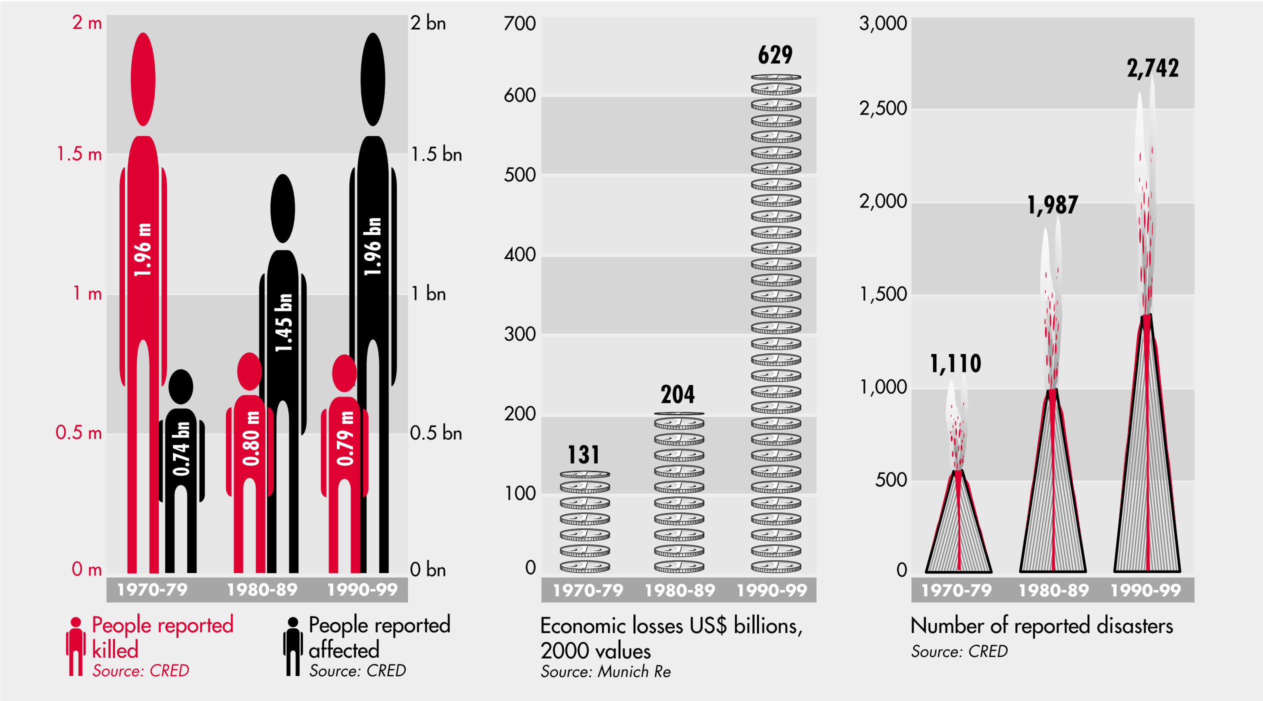


Figure 3 — Thirty years of "natural" disasters
(World Disasters Report 2002, International Federation of the Red Cross)

Governments, public organizations, educational institutions, community leaders and a broad range of professional and commercial bodies are beginning to recognize the essential public value of reducing the cost of natural hazards to health, society, the economy and the environment. If people are properly informed at all stages of the disaster management cycle, and in language they fully understand, they will be less vulnerable and better able to participate effectively in any mitigation measures. Early warnings that quickly reach those at risk and that are effectively acted upon are essential elements of disaster reduction strategies and action plans at all levels. National Hydrological and Meteorological Services all over the world play a crucial role in providing vital information on the vulnerability of society to water-related disasters and provide early warning of impending disasters.

There has recently been a welcome shift from the monitoring and warning of hazards toward disaster risk reduction and early warning bearing in mind the socio-economic aspects of vulnerability. Another positive development is that risk management is integrated more frequently within overall long-term sustainable development planning. Agenda 21 and the Hague Ministerial Declaration of March 2000 both highlighted the need to manage risks to provide security from flooding, for instance. The 2002 World Summit on Sustainable Development (WSSD) also underlined a shift in flood management through the "improved use of climate and weather information and forecasts, early warning systems, land and natural resource management, agricultural practices and ecosystem conservation".

A number of welcome initiatives on disaster issues have also advanced public understanding of disaster risk reduction. Among the many high-quality offerings are the International Federation of Red Cross and Red Crescent Societies' World Disasters Report, the United Nations Environment Programme's Global Environment Outlook and the United Nations Development Programme's Disasters and Development Report. The International Strategy for Disaster Reduction's Living with Risk: A global review of disaster reduction initiatives is another. Specialised information centres such as the South African Research and Documentation Centre (SARDC), Regional Disaster Information Centre (CRID) for Latin America, Asian Disaster Reduction Centre (ADRC), Kobe, Japan and the Asian Disaster Reduction Centre, Bangkok, Thailand are the regional resource centres dedicated to disaster reduction for safer communities and sustainable development.

Water-related disasters are a consequence of the interaction of extreme hydrometeorological events and vulnerable human economic activities

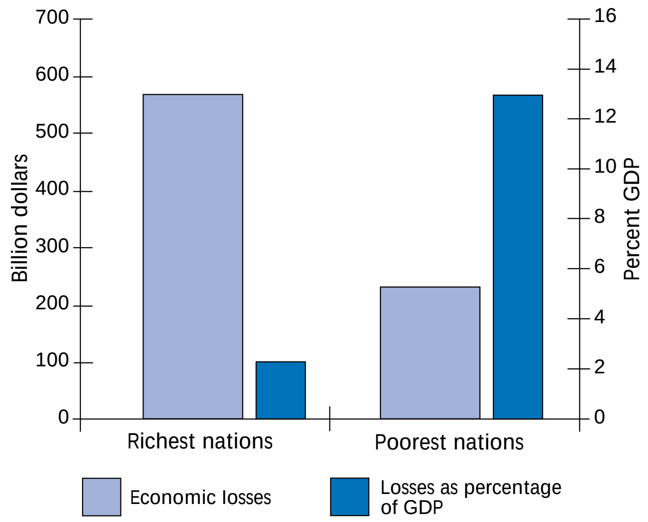


Figure 4 — Disaster losses, total and expressed as share of GDP in the richest and poorest nations (1985–1999) (Adapted from Munich Re and J. Abramovitz, 2001)

in the impact area of such events. Sometimes these hydrometeorological events combine with geological conditions or events to create a complex natural hazard. Such hazards are tropical cyclones (hurricanes, typhoons, etc.) and storm surges; floods; landslides and mudflows; avalanches; and droughts (caused lack of water). Water being fundamental to the existence of all life forms on earth, any kind of water pollution caused by a direct or indirect release of toxic material into watercourses as a result of technological or other disasters poses grave risks to health and wellbeing.

Most water-related natural hazards exist in areas that also present opportunities for human activities and have a large potential to turn into disasters if development activities are pursued without taking them into account or adopting prevention and mitigation measures. Creation of a “safety culture” demands the involvement of local communities so that information and experience is shared through all forms of modern communication means, education and professional training. As a result, communities will be able to be informed and be prepared.

Tropical cyclones

Hurricanes, typhoons or intense vertical storms — no matter what you call them, tropical cyclones are the most devastating of all natural hazards. Every year cyclones wreak havoc when they move inland from the sea, their fierce winds and heavy rainfall blazing a trail of destruction. Among the worst in recent years was Hurricane Mitch. Striking Nicaragua, Honduras and Guatemala in October 1998, Mitch claimed over 11 000 lives, wrecked buildings, destroyed crops and left widespread flooding in its wake (see Figure 1).

Tropical cyclones are areas of low atmospheric pressure that form over warm tropical or sub-tropical waters, eventually building up into a huge, circulating mass of wind and thunderstorms up to hundreds of kilometres in diameter (see Figure 2). Surface winds can reach speeds of 200 kilometres an hour, although the "eye" at the centre, usually just a few dozen kilometres in diameter, is relatively calm.

Figure 1 — Hurricane Mitch, 26 October 1998 (US National Oceanogaphic and Atmospheric Administration)

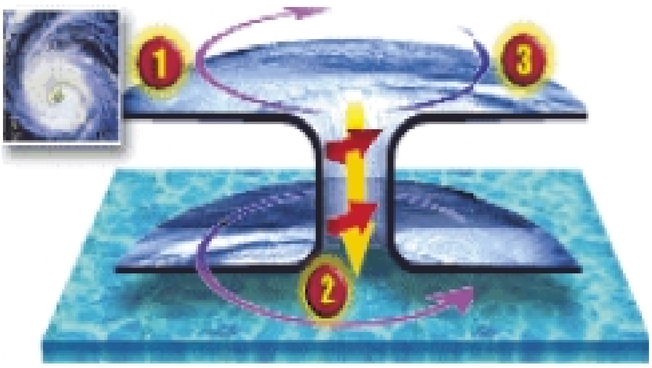


Figure 2 — Anatomy of a tropical cyclone in the Northern Hemisphere

1. *Air spirals outward clockwise at high altitude*
2. *Horizontal inflow at the surface is forced to rise upwards. The ascending air spirals upwards in the "eyewall"*
3. *Sinking air inside the "eye" inhibits clouds and rain. USA Today*

About 80 tropical cyclones form every year in certain regions of the tropics. They are known by different generic names depending on where they form: typhoons in the Western Pacific and South China Sea; hurricanes in the North Atlantic, Caribbean and Gulf of Mexico, and in the Eastern North and Central Pacific Ocean; and tropical cyclones in the Indian Ocean and South-West Pacific region.

Tropical cyclones are also given short, distinctive, individual names or tags, ideally suited for use in emergency communications and weather advisories. In most ocean basins they are given names: Fabian, for instance, was a major hurricane in 2003 in the Atlantic. In the Bay of Bengal and the Arabian Sea, the storms are identified according to a geographic indicator and the time they formed. For example, the third tropical cyclone of 2004 in the Bay of Bengal will be called BOB 0403.

Be informed

Not all tropical cyclones move onto land from the sea, but when they do they can cause disasters of varying severity hundred of kilometres inland. The heavy rainfall may last for days, and frequently causes flooding, or flash floods when the cyclone moves over land. Storm surges — bulges of ocean water formed by the cyclone — can ride on top of tides; when they move up riverine estuaries, they too can start large-scale flooding (see page 11 for a detailed discussion of storm surges).

As with Mitch, some major tropical cyclones become human disasters on a grand scale, resulting in death and suffering, destruction of property, severe disruption of normal activities and serious socioeconomic setbacks. Built-up coastal areas are the most vulnerable, while the greatest loss of life will occur in communities in countries where mitigation arrangements are weakest.

Despite the advances of science, we cannot stop tropical cyclones in their tracks. But our scientific understanding of them has progressed along with our ability to warn those under threat from them. As a result, organized warning systems for cyclones are in place around the world, allowing an unusual degree of preparedness against the ravages of this formidable phenomenon.

An efficient early warning system delivers accurate information dependably and fast. To do that, it must have:

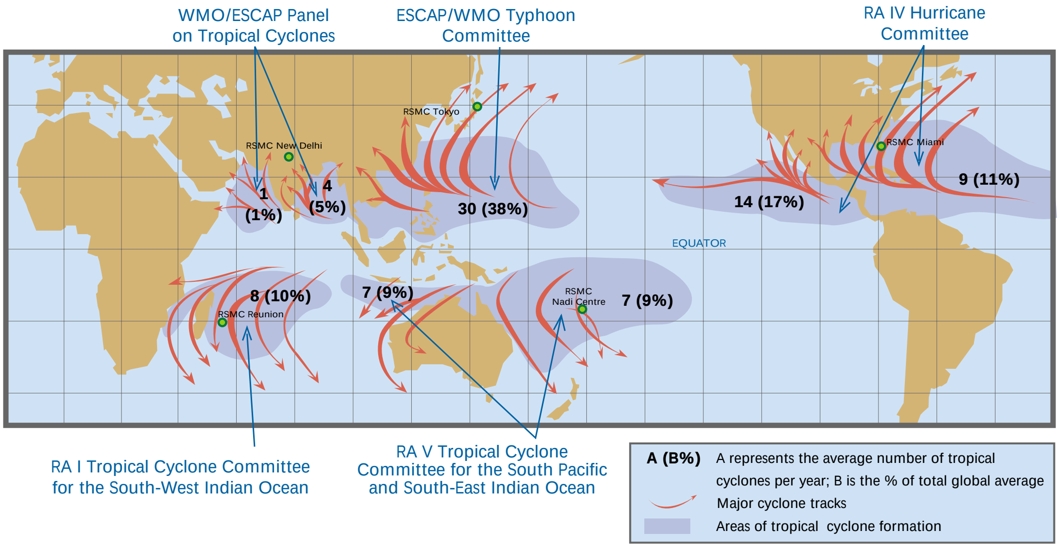


Figure 3 — WMO's Regional Specialized Meteorological Centres, and areas of responsibility

- Advance, accurate, detailed forecasts of dangerous conditions,
- Rapid, dependable distribution system for forecasts, advisories and warnings to all interested parties and
- Prompt, effective response to warnings from both government and public.

Satellites, weather radars and computers are now making short work of monitoring tropical cyclones around the globe from the early stages of their formation.

Getting the message to where it counts demands an extensive distribution system. The World Meteorological Organization has formally designated six centres — in Honolulu, La Réunion, Miami, Nadi (Fiji), New Delhi and Tokyo — as Regional Specialized Meteorological Centres (RSMCs) for tropical cyclone analysis, tracking and forecasting (see Figure 3). At the global and regional levels, activities are coordinated through WMO's World Weather Watch and Tropical Cyclone Programme (TCP). The TCP in turn advises National Meteorological and Hydrological Services (NMHSs), which are responsible for providing warnings of tropical cyclones and associated natural phenomena on their own territory and coastal waters. Taken as a whole, the system is a remarkable example of global cooperation.

Be prepared

Monitoring and early warning aside, there is much that can be done to avoid or alleviate cyclone damage in vulnerable areas. Prevention can include identifying hazards such as storm surges, assessing the threats to life and property, and helping reduce potential loss of life and property damage. Sensible land use planning and measures such as ensuring all new housing is hurricane-resistant are essential.

Mitigation measures to limit the impact of tropical cyclones can range from community awareness campaigns on how to deal with disasters, to building levees against flooding. All such measures are important, as they not only reduce the cost of disasters to the community, but also help save lives.

Beyond a good early warning system, a preparedness plan should cover the protection of buildings, emergency shelter, secure and reliable communications, evacuation and transport arrangements, safety and security measures and coordination between various agencies. Getting the warnings out in time to a population aware of the dangers and poised to act makes a real contribution to the global cyclone disaster mitigation system.

Post-storm preparedness is just as vital, and must include the provision of medical aid, the prompt disposal of dead bodies and animal carcasses, preventive measures against epidemics such as cholera, supply of food and safe drinking water, repair of water stores, distribution of building materials for repairs and supplying cattle fodder. Each year, this comprehensive approach to disaster prevention can and does save lives and communities from devastation by tropical cyclones somewhere in the world.

Storm surges

Storm surges, a by-product of tropical cyclones, can be just as lethal. If these “walls of water” reach land, they can pour in from the sea with immense force and wash away everything in their path. One of the most dramatic examples on record occurred in 1970, when a massive storm surge left 300 000 people dead after it swept in over the coastal wetlands of Bangladesh.

A storm surge forms when tropical cyclones move over a continental shelf. A combination of strong onshore winds and low atmospheric pressure creates the surge — a giant dome of seawater some 60 to 80 kilometres across and 2 to 5 metres high. If the cyclone reaches the coast, the strong winds whip up the sea and push the dome of water inland, usually to extremely destructive effect.

The huge, fast-moving waves known as tsunamis are quite different from storm surges, except in their capacity to destroy. Generated by earthquakes, volcanic eruptions or shifts in the sea bottom, these waves travel faster than 1 000 kilometres an hour on the open sea, but are so long they are barely noticeable. When they reach coastlines, however, contact with the seafloor builds them up to tremendous heights. Tsunamis are a particular threat to the coastline around the Pacific Ocean.

Be informed

Unsurprisingly, storm surges are more of a risk the higher they are. A number of factors determine their height:

- The intensity of the cyclone system — the stronger the winds, the higher the surge,
- The speed of the cyclone — the faster it crosses the coast, the higher the surge,
- The angle at which the cyclone crosses the coast — a right-angle crossing will increase the surge,
- Landfall point and time,
- The radius of the maximum wind,
- The shape of the seafloor — the gentler the slope, the greater the surge and
- Local features such as bays, headlands or islands, which can “funnel” the surge and make it higher.

A surge will usually carry waves stirred up by the cyclone, which intensify its destructive power. It will also combine with ocean tides, riding on top of them. If the cyclone crosses the coast at high tide, the combined height of tide and surge can create a wall of water 6 metres high. These “storm tides” can move inland swiftly, damaging buildings and cutting off escape routes (see Figure 1).

In confined harbours, storm tides, waves and currents can wreck ships, marinas and pleasure boats. The huge rise in water level may cause severe flooding in coastal areas, especially if these are densely populated and lie less than about 3 metres above mean sea level. Coastal communities in areas with a steeper continental shelf (see Figure 2, left) will not see as much inundation from storm tides because the shelf will act like an underwater seawall. Large breaking waves can still present major problems, however.

Currents created by a storm tide combine with the action of the waves to severely erode beaches and coastal highways. This can eventually destroy buildings in the area by undermining their foundations, and so making them more likely to succumb to hurricane-force winds. A surge may also generate a tidal wave, which can run along major rivers and cause flooding up to 15 kilometres upstream. The inundation of croplands with saltwater inflicts irreparable loss on the coastal economy, and endangers public health, for instance by contaminating drinking water.

Storm surges are a major natural hazard in many vulnerable coastal and island regions around the world, and large ones regularly cause tremendous destruction in the Pacific, Atlantic and Indian Oceans, the Bay of Bengal and the Gulf of Mexico. But surges can form beyond the tropics: the low-lying countries around the North Sea have

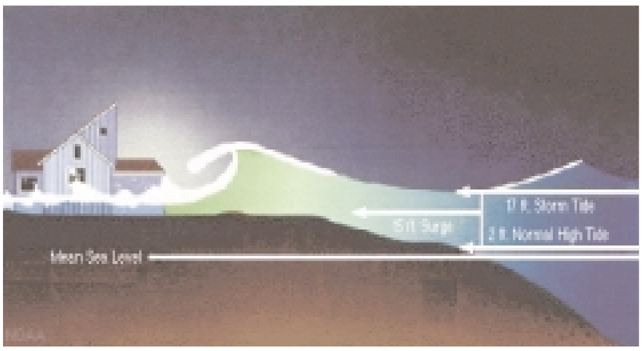


Figure 1 — A storm tide
(US National Oceanic and Atmospheric Administration)

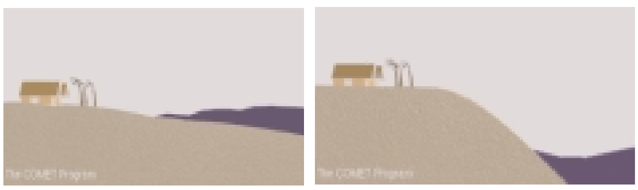


Figure 2 — Behaviour of storm surges with different angles of continental shelf
(US National Oceanic and Atmospheric Administration)

High storm surges cause flooding in large coastal areas (simulated surge)

periodically been flooded by severe storm tides over the past several decades.

In the future, the rise in sea level associated with global warming, paired with land subsidence along fragile coastlines, may mean bigger storm surges and more vulnerability to them. There is also concern that a rise in sea-surface temperatures may increase the number of tropical cyclones reaching coastlines, and thus the number of surges.

Be prepared

Risk assessments and zoning, land use and development planning are all important tasks in preventing storm surges. Mitigation and preparedness involve a combination of measures, from initiatives to protect vulnerable communities to early warning of impending surges caused by tropical cyclones and evacuation plans for people living in exposed, low-lying areas.

Construction projects figure large in most plans to mitigate storm surges. Building seawalls, barrages and dykes all help reduce communities' vulnerability. Coastal embankments are invaluable, and should be designed to withstand the expected storm surge water heights and forces, the combined action of wind and waves, and overtopping from storm surge water. In river deltas, coastal embankment projects must be planned in conjunction with other development projects, such as highways and harbours.

Providing timely early warnings of storm surges and publicizing evacuation plans as widely as possible are both crucial to reducing risk. Inevitably, given their interconnectedness, early warning of surges will depend heavily on early warning of cyclones (see page 10 for a discussion of this comprehensive global system). A system for surges using mathematical models of coastal areas, and incorporating both timely warnings and public education, is fortunately already in place. So far, it has resulted in a decline in deaths from storm surges from thousands to a few hundred a year.

For the future, a major challenge for the early warning community is reducing the number of false alarms that cause unnecessary evacuations in the most vulnerable regions. Predictions of the location and magnitude of surges must also be pinpointed with much greater accuracy. But such changes demand substantial investment in research to improve prediction methods. In the meantime, public awareness and education campaigns, those essential components of preparedness and mitigation, need continuing support.

Floods

Some 1.5 billion people were affected by floods in the decade up to the millennium. Two years later, in the summer of 2002, vast swathes of Europe from the United Kingdom to Bulgaria and Romania suffered serious flooding. Flooding is on the rise, and part of the blame lies with climate change, which has triggered heavier precipitation in parts of the Northern Hemisphere.

But the increase in numbers of people affected by flooding is not only down to climate change. More and more people are putting themselves at risk by settling in floodplains, and these regions need careful, comprehensive management to protect both human habitation and the environment.

Be informed

Flooding happens when rainwater or snowmelt accumulates faster than soils can absorb it or rivers carry it away. Floods come in all sorts of forms, from small flash floods to sheets of water covering huge areas of land, and can be triggered by severe thunderstorms, tornadoes, tropical cyclones, the El Niño phenomenon (where warm water in part of the Pacific sets off extreme weather elsewhere in the world), monsoons, ice jams or melting snow. In coastal areas, storm surges caused by tropical cyclones, tsunamis, or rivers swollen by exceptionally high tides can cause flooding, while large lakes can flood when the rivers feeding them are carrying a lot of snowmelt. Dam breaks can also cause catastrophic flooding. An interdisciplinary approach to understanding floods is therefore essential, as they arise from so many different causes.

Floods can threaten human life and property, but they also replenish wetlands, fisheries and irrigation systems. And floodplains have immense development potential: their proximity to rivers guarantees rich soils, abundant water supplies and transport. In areas such as the Nile Valley, the annual flooding is welcomed, as it re-fertilizes the fields. But building and farming in floodplains inevitably increases the risk of damage by flooding. The ever-increasing spread of human settlement into these areas is attracting the attention of experts from various disciplines, policy makers and the public. Relief and support organizations who monitor and mitigate the effects of flooding are also watching this development with concern.

Be prepared

Forecasting floods can be tricky, depending on the type and nature of the phenomenon that triggers the flooding. For example, widespread flash floods are often started off by heavy rain falling in one area within a larger area of lighter rain, a confusing situation that makes it difficult to forecast where the worst flood will occur. Forecasting floods caused by the heavy rain or storm surges that can sweep inland as part of a tropical cyclone can also be a complex job, as predictions have to include where they will land, the stage of their evolution and the physical characteristics of the coast.

To make predictions as accurate as possible, National Hydrological Services (NHSs) and National Meteorological Services (NMSs) under the auspices of WMO undertake flood forecasting based on quantitative precipitation forecasts (QPFs), which have become more accurate in recent years, especially for light and moderate amounts of precipitation, although high amounts and rare events are still difficult to predict. So setting up forecasting systems that combine predictions for weather with those for water-related events is paving the way for a truly integrated approach.

Forecasting needs also to be a cooperative, multidisciplinary effort. The many issues and the

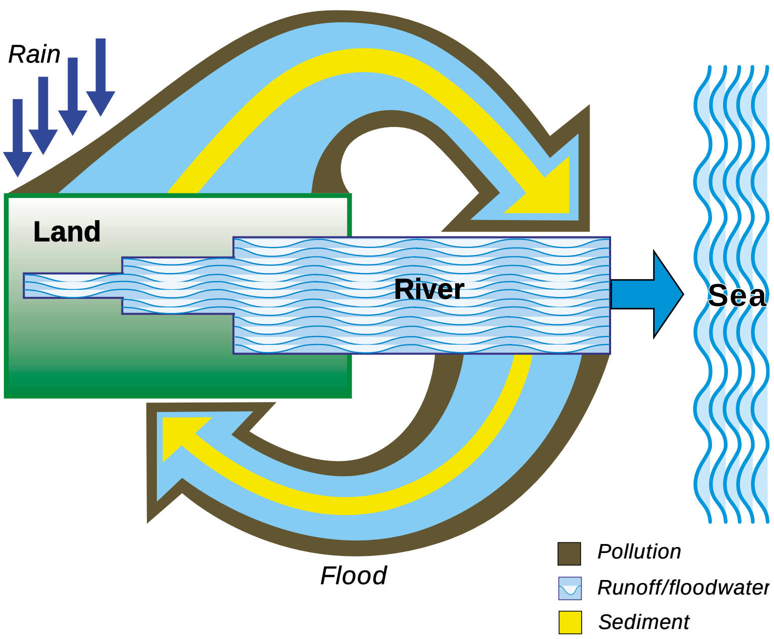


Figure 1 — Interaction between land and water

Table 1 — Strategies and Options for Flood Management

Strategy	*Options*
Reducing flooding	Dams and reservoirs Dikes, levees, and flood embankments High flow diversions Catchment management Channel improvements
Reducing susceptibility to damage	Flood plain regulation Development and redevelopment policies Design and location of facilities Housing and building codes Flood-proofing Flood forecasting and warning
Mitigating the impacts of flooding	Information and education Disaster preparedness Post flood recovery Flood insurance
Preserving the natural resources	Flood plain zoning and regulation of Flood Plains

complexity of factors surrounding floods mean flood managers have to join forces with meteorologists, hydrologists, town planners and civil defence authorities using available integrated models. Determining the socio-economic impacts of floods will mean taking a close look at construction or other activities in and around river channels. Up-to-date, accurate information is essential, through all the available channels: surface observation, remote sensing and satellite technology as well as computer models. Capacity building should therefore be a priority in the developing world in order to take advantage of these advances.

In many countries, flood risk assessment and flood management have been around for decades. But these disciplines are undergoing big changes. Recently, a shift to integrated water resources management, which looks at floods as both risks and resources, has begun. NHSs and NMSs regularly collect the necessary data for formulating flood management strategies through various observation systems like World Weather Watch (WWW) and the World Hydrological Cycle Observation System (WHYCOS). The ideal approach balances conservation and sustainable development of resources with socio-economic aspirations. A good flood management strategy should contribute sustainably to the net economic development of the entire river basin, duly taking into account the land and water resources. This may involve encouraging people to move away from flood-prone areas, especially where there is a lack of resources to develop infrastructure for the protection of life and property.

Figure 2 — Flooding in Mozambique, March 2000
Philip Wijmans, LWF/ACT Mozambique

Usually, the most appropriate management strategy will both reduce impacts and build up capacity to deal with them. Ways of reaching this goal could include the construction of dams and embankments, and flood zoning. It should be remembered that the effects of flooding from the same meteorological conditions can differ hugely given different levels of development, as the flow capacities of rivers can be altered, and the number of buildings increase. So the severity and frequency of floods can increase significantly in certain regions as they develop, and this will need to be factored in to management strategies. These strategies have to inform any overall scheme of disaster mitigation and risk management plans.

Climate change is another element that needs to be included in flood management strategies. Projections of the Intergovernmental Panel on Climate Change show that climate change is linked to higher levels of precipitation as well as sea-level rise, both of which can lead to more flooding.

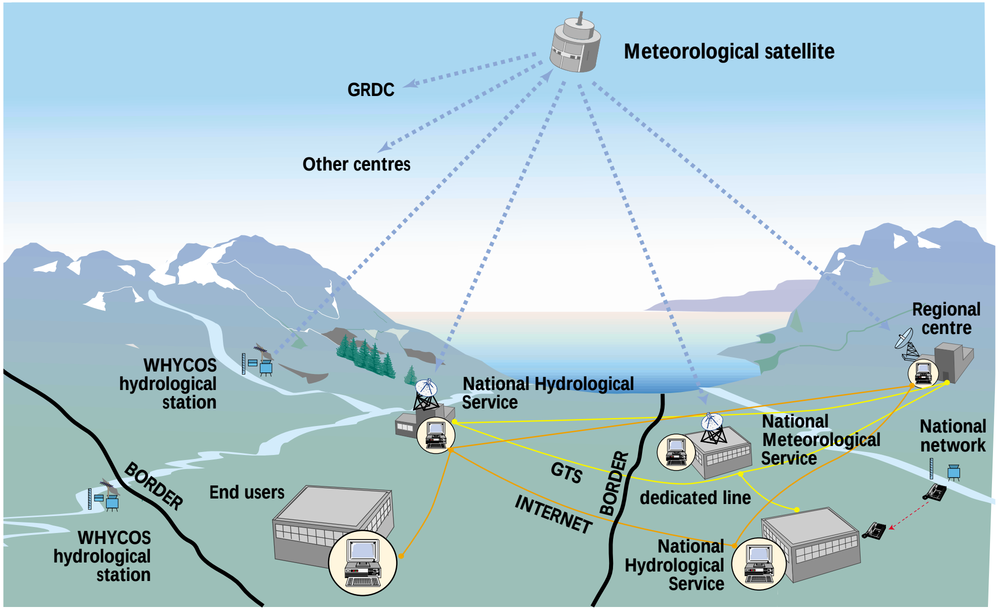


Figure 3 — WMO's WHYCOS: General scheme of data collection and dissemination network

As with forecasting, the array of elements involved in flood management calls for an integrated approach. Inputs from many sources — in this case, local communities and experts in various fields — are needed to make it work. It needs to be informed not only by science, but by local, indigenous knowledge; by the tried and tested, and by any promising innovations. Regional cooperation arrangements will be needed where rivers span two national boundaries.

Finally, when floods reach disaster proportions, preparedness comes into play: evacuation plans, emergency relief and reconstruction all need to be in place. In short, prevention and mitigation plans for floods need to be as comprehensive as every other aspect of our approach to them.

Landslides and mudflows

Towards the end of 1999, the worst natural disaster in Venezuelan history occurred. Two weeks of continuous rain had saturated the soil to such a degree that thousands of landslides and mudflows shot down Avila Mountain in the state of Vargas, washing away towns, killing an estimated 15 000 people and costing almost US$ 2 billion.

This is an extreme example, but landslides and mudflows are undeniably highly dangerous hazards causing billions of dollars in damage and thousands of deaths and injuries every year around the world. Landslides happen when heavy rain or rapid snowmelt sends large amounts of earth, rock, sand or mud flowing swiftly down mountain slopes, especially if bare or burnt by forest or brush fires. They tend to worsen the effects of any floods stemming from the same extreme weather. Earthquakes or volcanoes can also set them off, but the most common culprit is water seepage.

Mudflows and the coarser debris flows are essentially wet, fast-moving landslides that form when masses of loose, wet debris or volcanic deposits become unstable due to saturation from rainfall, melting snow or ice, or an overflowing crater lake. The result is a flowing river of mud or “slurry”. Mudflows usually start on steep hillsides as shallow landslides and can reach speeds of over 50 kilometres an hour. On their way they can pick up large quantities of sediment, boulders, trees and even cars, massive debris that will hit anything in its path with a tremendous impact. Mudflows from many different sources can combine in channels, increasing their destructive power. When the flows reach relatively level ground, the mud and debris spread over a broad area, sometimes accumulating in thick deposits that can wreak havoc in built-up areas.

Be informed

Landslides and mudflows can bury, crush or carry away people, objects and buildings. Because of their relatively high density and viscosity, debris flows can move and even convey objects as large as bridges or train carriages. These are formidable hazards, and landslide-prone areas will need highly effective disaster management strategies.

Hazard maps are one of the first steps towards formulating such strategies. These are essentially topographical maps showing the potential level of danger from landslides, flash floods, debris flows and mudflows in an area, based on data detailing the frequency and intensity of actual events. Planning agencies can use hazard maps to develop new land-use policies and design emergency plans in developed areas. When development goes ahead, a colour-coded zoning system should be used to guide the building, aided by hazard maps that will show features to avoid, including steep slopes, streams and rivers, intermittently dry streambeds and the mouths of mountain channels.

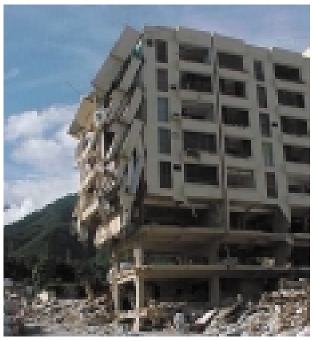
People living in vulnerable areas can promote safety by understanding the hazard potential in the area, taking steps to reduce the risk and practising using preparedness plans. Information on landslides and mudflows that have happened in the area can be sought from elderly local residents, officials, state geological surveys or departments of natural resources. Landslides tend to occur where they have before, in places such as the bases of steep slopes and of drainage channels, and developed hillsides where leach-field septic systems are used.

Before buying a home or building in a high-risk area, it is important to look for telltale signs of ground movement such as trees tilting down-slope, water seepage and breaks in the ground. The patterns of storm-water drainage should be watched on nearby slopes, especially where runoff water converges.

Be prepared

Landslide and mudflows usually strike without warning, and the force of rocks, soil, or other debris moving down a slope can devastate anything in its path. Prevention, mitigation and preparedness have to involve all levels of society, from the national to the individual.

Mitigation strategies for landslides, mudflows and debris flows can include the construction of

Damage by debris flows in two buildings on the alluvial fan of San Julian River (right picture is a closer view of the building in the background in left picture) hydraulic structures to control the flows, sediment control dams, and afforestation, as trees hold soil in place and can also act as barriers against flows. Other measures include monitoring meteorological, hydrological, and hydraulic and sediment variables in the slopes, developing hazard and risk mapping, implementing warning systems and designing contingency plans.

For communities or individuals at risk, evacuation plans are essential. Routes need working out, rescue centres need to be designated, and roles decided on. The people involved should always be actively involved in the planning.

Since landslides and mudflows are not likely to encompass large areas, it is useful to involve the neighbouring communities lying beyond the hazard zone in disaster preparedness plans. In communities, villages and districts prone to landslides, special sections can be printed in the local newspapers, with emergency information such as the phone numbers of local emergency service offices and hospitals. These sections can also report on what city and county governments are doing to reduce the possibility of landslides in the area and the state of the local land-use zoning regulations.

Householders can plant ground cover on slopes and build retaining walls in mudflow areas. Channels or deflection walls can be constructed to direct the flow around buildings. Consulting a competent company specializing in geotechnical, structural or civil engineering for opinions and advice on landslide problems and what to do about them can be highly useful.

People travelling through a hazard zone susceptible to landslides and debris flows need to remember that driving during an intense storm can be hazardous in these areas. Embankments along roadsides are particularly susceptible to landslides. It is vital to be alert to any sudden increase or decrease in water flow in streams and channels, and to any changes from clear to muddy water. Unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together, should be heeded. A trickle of flowing or falling mud or debris may precede larger landslides upstream.

When a landslide begins, the tops and bases of cliffs and embankments and rock overhangs should all be avoided. Keeping clear of banks, trees, power lines and poles is important, as is avoiding valley bottoms in favour of valley sides and other safe higher ground. People who are indoors should shelter at the least-affected end of the building under a strong cover like a table, bench or cot. The second storey is safer. Listening to emergency bulletins on the radio or to television is essential, as even when a mudflow has finished, floods may follow if heavy rain persists. If people have been evacuated, they need to know when to return as there may be the danger of additional slides. The building foundation, chimney and surrounding land will need to be checked for damage, and damaged ground replanted as soon as possible, since erosion caused by loss of ground cover can lead to flash flooding.

There is much that can be done to head off the worst effects of landslides and mudflows, but as with all prevention, mitigation and preparedness strategies, a thorough and coordinated approach is essential.

Avalanches*

In sheer size and speed, avalanches are one of the most terrifying of natural hazards. They can also be one of the deadliest in effect. In Europe during the winter of 1998/99 — one of the snowiest for 50 years — a series of massive avalanches struck villages and resorts throughout the region's high mountains. More than 200 died, and many local economies were devastated. But while dramatic and extremely widespread, numbering in the hundreds of thousands a year, avalanches actually kill fewer than 500 people a year worldwide. They rank this low on the natural hazard fatality scale because most of them happen in remote areas with sparse or no human habitation.

An avalanche is a large mass of snow and ice that moves rapidly down the steeper slopes of mountains or hills, at speeds of up to hundreds of kilometres an hour. They are one of the greatest hazards to persons living in, travelling through or holidaying in mountainous terrain during winter and spring, when snowfall is heaviest. Unusual numbers of avalanches, or exceptionally severe ones, can have serious socio-economic consequences. In the mountainous areas of the developing world, pressure for development such as leisure activities, road building and housing and services for communities can increase the region's vulnerability to damage from avalanches.

Be informed

Avalanches can be broadly classified by the conditions that set them off: recreational or natural. With recreational avalanches — the most common — skiers, hikers or other winter sports enthusiasts will trigger the avalanche, burying themselves or others beneath the snow. These accidents are often fatal: about 50 per cent of avalanche burial victims die unless they are rescued within half an hour. An average of up to 220 recreational deaths a year occur in industrialized countries with mountainous areas (see Figure 1).

Natural avalanches are the result of extreme weather conditions. If snowfall is exceptionally heavy, for instance, massive amounts of snow will lie loosely on the slopes — ideal avalanche conditions. It is in fact not unusual for more recreational accidents to occur under such conditions, but the significant factor is still seen as meteorological.

Avalanches are also classified by the condition of the snow they contain. Most experts agree on two principal types — loose snow and slab (see Figure 2, right and left respectively). A loose snow avalanche behaves like a coarse-grained sand or powder: once a small amount is disturbed, the rest pours swiftly after at up to 400 kilometres an hour. Most specialists consider the slab type more hazardous, however. These are extremely dense, layered masses, with a typical volume of tens of thousands of square metres. After suddenly breaking off, they will shoot downhill at up to 300 kilometres an hour.

Most avalanches start during or after large snowstorms, when the snow is unstable and relatively loose. The spring is particularly risky because of prolonged thaws. When the snow is ready to go, it can be set off by one of four primary triggers: a steep slope of 25 to 50 degrees; heavy snow cover; instability from weakness in a layer; or impact, such as someone stepping or jumping on the snow.

Be prepared

In regions vulnerable to avalanches, prevention should include identification of the hazard, whether recreational or natural, and assessing the threat to

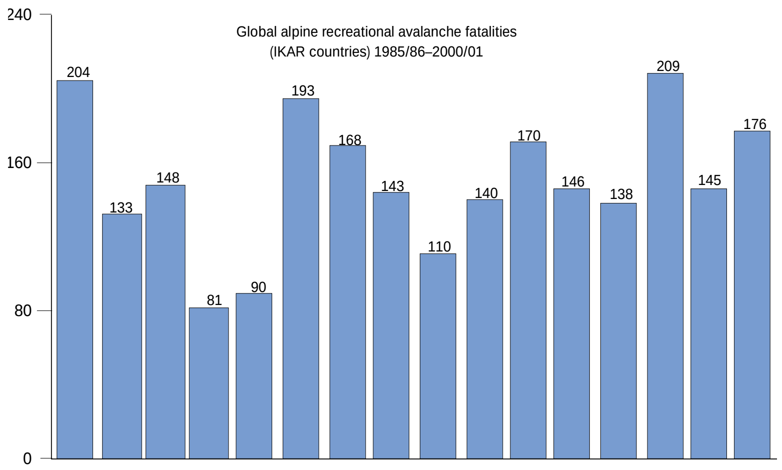


Figure 1 — Avalanche fatalities, 1985 to 2001
(1992–2001 International Commission for Alpine Rescue (IKAR) Statistics for Europe and North America)

* Contributed by Dr Keith Gordon Kennedy of the Swiss Centre of Hydrogeology, University of Neuchâtel and other colleagues from the Swiss Agency for the Environment, Forests and Landscape

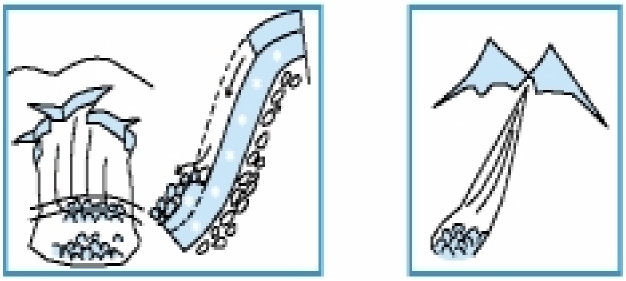


Figure 2 — The two principal types of avalanche (Swiss Federal Institute for Snow and Avalanche Research)

life and resources. As for mitigating the potential impacts of avalanches, avoidance is vital — for instance, by never placing houses or services in potential avalanche pathways. Capacity building and community awareness programmes, where established skills and technical know-how can be shared, are a step towards this goal. The development of community and regional planning strategies, along with realistic, cost-effective tactics for putting them into practice in avalanche-prone areas, are also critical tools for mitigating impact.

Access to winter sports and other recreational areas also needs to be made safer in such regions, and here good public education programmes can go some way towards sensitizing visitors to the dangers of avalanches. Most mountain sports regions already offer them. Early warning techniques are also becoming more sophisticated with the use of linked meteorological data stations and network-based forecasting, methods that align regional storm patterns to avalanche risk predictions in areas of potentially dangerous impacts. In most developed countries, dedicated radio and internet sites routinely broadcast avalanche warnings and encourage people to follow updates on local websites. At the avalanche sites themselves, internationally standardized notices warning of the degree of danger are posted (see table below).

Preparedness for catastrophes, such as readiness for large-scale evacuations, is more problematic. For instance, many countries are highly reluctant to make the decision to relocate communities — a dramatic but in some cases logical solution. But the larger challenge may arise from the global rise in land development, which is leading to more demands on resources in remote regions. Conveying the importance of avalanche

AVALANCHE HAZARD POSTING AND RELEVANT INFORMATION		
Degree (colour)	*Snowpack*	*Avalanche probability*
LOW (green)	Generally well bonded and stable	Triggering is possible only with high additional loads on a few very steep extreme slopes. Only a few small natural avalanches (sluffs) are possible.
MODERATE (yellow)	Moderately well bonded on some steep slopes, otherwise generally well bonded	Triggering is possible with high additional loads, particularly on the steep slopes indicated in the bulletin. Large natural avalanches are not likely.
CONSIDERABLE (ochre)	Moderately to weakly bonded on many steep slopes	Triggering is possible, sometimes even with low additional loads. The bulletin may indicate many slopes which are particularly affected. In certain conditions, medium and occasionally large sized natural avalanches may occur.
HIGH (orange)	Weakly bonded in most places	Triggering is probable even with low additional loads on many steep slopes. In some conditions, frequent medium or large sized natural avalanches are likely.
EXTREME (red)	Generally weakly bonded and largely unstable	Numerous large natural avalanches are likely, even on moderately steep terrain.

awareness to developing countries as they establish or expand villages and towns and transportation routes in mountainous regions will confer vital socio-economic benefits.

There is no international coordinating body or agency for tracking or predicting avalanches, although some national agencies have developed particular skills in mountainous regions, including the Alps, Andes, Himalayas, Rockies and Urals. In some avalanche-prone countries, there are strong associations working closely together to protect public safety and reduce economic costs. Increasingly, networks of such experts are helping establish trends and sharing research results to allow all affected countries to become more aware of, and knowledgeable about avalanches, and mitigate the risks.

Internet sites in many regions offer bulletins on local snow and avalanche conditions. Many also publish links to regions and states which maintain similar sites (see below). The USA, Canada and Europe all have closely connected alpine centres working with adjacent regions to quickly broadcast information on emergency conditions to the public.

Drought

Drought stands alone among water-related disasters. It is caused by too little water, not too much. It takes place over a relatively long time, not moments like an avalanche or flash flood. And it can happen almost anywhere. Although we often associate drought with the arid regions of Africa, particularly the Sahel, in recent years droughts have also struck India and parts of China, as well as the Middle East, Australia, parts of North America, Mexico and Europe.

Drought is actually a normal, periodic feature of climate, the result of a natural reduction in precipitation over time. When rainfall becomes relatively scant or infrequent, it can disrupt the normal balance between precipitation and the evapotranspiration process, and drought can begin. And it can be highly destructive, particularly when accompanied by high temperature, strong winds and low relative humidity. Crops and livestock can die, thirst and malnutrition take over, and the human, economic and environmental costs mount up rapidly. As it is now thought that climate change is fuelling a rise in the intensity and frequency of drought in Africa and Asia, the problem is very much with us.

Inevitably it is the arid, semi-arid and sub-humid drylands of the world, with their fragile ecologies and marginal economies, that are most vulnerable. As they cover some 40 per cent of the Earth's land surface and are home to many people and unique species of of plants and animals, they present a huge challenge for the future.

Be informed

To deal with a drought effectively it is crucial to determine when it started, how severe it is and when it is likely to endl. A look at how drought affects different systems, whether meteorological, hydrological, agricultural or socio-economic, can help with the task.

Meteorologically, drought is generally defined by degree of dryness compared to an average amount, usually over the last 30 years, and the duration of the dry period. A hydrologist measuring drought will instead look at how inadequate rainfall plays out in reservoirs, lakes and groundwater by measuring streamflow and levels of water. Hydrological drought will usually be out of phase with meteorological and agricultural drought, because it takes longer for deficiencies to show up in lakes and streams. Agricultural drought is itself determined using a composite approach, first examining levels of moisture in plants, then factoring in elements such as sparse rainfall or low levels of groundwater. Finally, there is socio-economic drought, where the demand for an economic good exceeds supply because of a weather-related shortfall in water supply.

No matter which system is being measured, drought can be difficult to detect at first. Drought is sometimes called a "creeping phenomenon" because it can be both pervasive and covert, moving slowly but steadily into an entire region and lingering for long periods of time. As it is insidious rather than sudden, responses to drought tend to be late and uncoordinated — crisis management rather than risk management.

The impacts of drought, whether economic, environmental or social, are greater than those from any other natural hazard. Agriculture, forestry and fisheries all depend heavily on water, and any

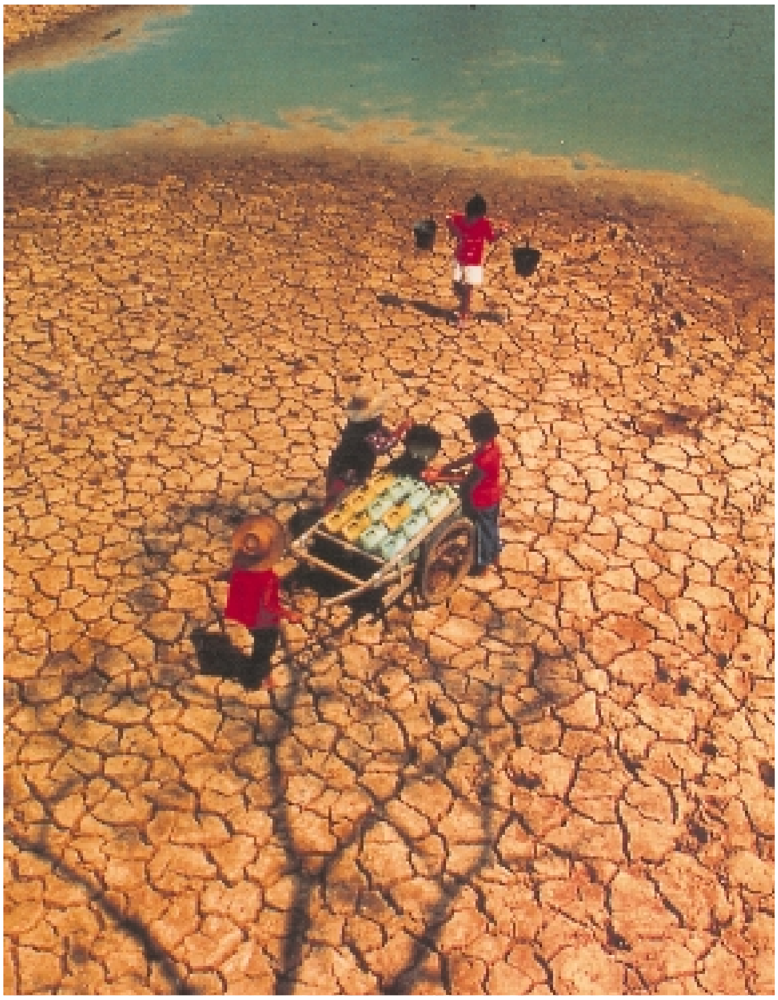


Photo: D. Juntawonsup (UNEP/Select)

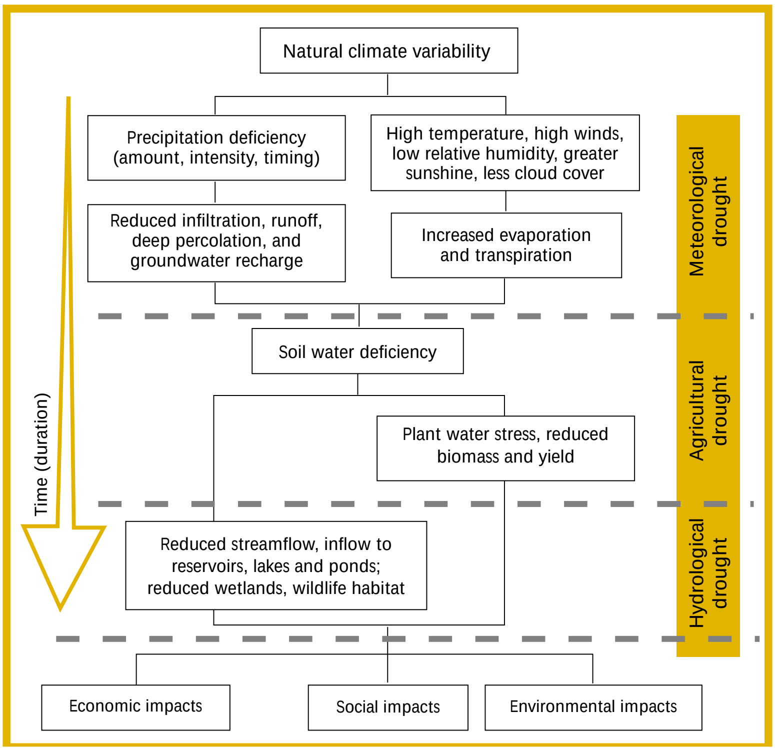
losses in crop yields or livestock production, or increase in insect infestations, wind erosion or forest fires through drought will be a blow to the economy. Local retailers who supply farmers will suffer, too, from the knock-on effect.

The environment is at great risk from drought. Plants, animals and their habitats, and air and water quality, are all affected. There is often a loss of biodiversity. Land can become degraded and soil eroded, sometimes permanently. In sensitive dryland ecosystems, a combination of extreme and persistent drought with human overexploitation such as overgrazing and deforestation can even result in desertification.

Drought is also a tremendous disruption to the normal workings of society. It can endanger public safety, health and quality of life, and is a notorious cause of malnutrition and famine in many parts of Africa, and other countries as well. It can lead to conflict among water users. Migration can become a significant problem, as people will flee drought to find areas with more available food and water, even to adjacent countries. Large numbers of displaced persons or refugees will open up new problems to do with housing, health and livelihood. Another problem is that, with increased pressure on farmland, people may move into marginal, less productive areas where soil is more easily depleted and life is generally harder. So the impacts of drought on humankind in the future are likely to be heavier than those in the past.

Early warning systems can reduce impacts by providing timely information about the onset of drought. Conventional surface observing stations within National Meteorological Services are one link in the chain, providing essential benchmark data and time series necessary for improved monitoring of the climate and hydrological system. Tracking certain indicators such as streamflow or soil moisture can help in formulating drought index values — typically single numbers, far more useful than raw data for decision making. Soil moisture, for example, can be tracked through remote sensing via satellites.

Various WMO programmes monitor extreme climate events associated with drought, such as El Niño, while four monitoring centres — two in Africa, one in China and the Global Information and Early Warning System — provide weather advisories and one and three-month climate summaries. Among other African early warning



Impacts of drought

systems, the Southern Africa Development Community (SADC) monitors the crop and food situation in the region and issues alerts during periods of impending crisis. Such networks can be the backbone of drought contingency planning, coordinated plans for dealing with drought when it comes.

Be prepared

The main aim of drought management plans is to reduce human suffering and improve human welfare, through a variety of ways.

Drought resilience policies, designed to head off the effects of drought, can include boosting water supplies, introducing water conservation programmes and insuring crops. Basic water management strategies need to be improved to cope with more frequent or severe drought resulting from climate change. Irrigation should be seen as a tool to reduce the adverse impacts of droughts, not a guarantee of drought-proofing. There is also considerable scope for improved efficiency in water use and recycling in cities.

Using statistical techniques, governments can look at drought data, particularly rainfall, to find any systematic patterns — trends, persistence or cycles. This kind of information can then be used to develop land-use systems and management practices that will minimize the impacts of drought.

Finally, drought mitigation measures and relief and rehabilitation will minimise the impact on production systems and livelihoods. These can range from providing emergency water supplies and cattle fodder, to giving credit to farmers. Crisis management like this will be inevitable with drought, but properly managing the risk means it will be kept to the minimum. And while we know that it is impossible to forecast drought with pinpoint accuracy, we also know that millions around the world need to brace themselves for thirsty times ahead.

Industrial accidents and water*

Chemicals are a mainstay of industry, whether they are used in the production process or emerge as end products themselves. But many are highly toxic, and can cause serious or even catastrophic pollution problems if they end up in watercourses or lakes as a result of industrial accident or continuous discharges.

In 1986, one of the most spectacular chemical pollution accidents on record happened at the works of the pharmaceutical company Sandoz in Basel, Switzerland. A warehouse fire resulted in the flushing of enormous quantities of chemicals, as well as burnt residues, into the Rhine. For 1000 kilometres downstream the river was biologically dead and unfit for processing into drinking water. In another notorious incident in 2000, a massive cyanide spill from a gold production works at Baia Mare, Romania, reached the Danube, contaminated the drinking water of 2.5 million people and left huge numbers of fish dead.

Such accidental discharges can consist of concentrated chemicals or mixtures of chemicals and water, and can be either production-related or caused by natural disasters such as flooding or earthquakes.

Be informed

The risks of accidental water pollution at an industrial plant depend on the properties and quantities of the chemicals stored and used, the production process employed, and the location.

Industries have to keep records of the chemicals stored and used at their sites. These inventories will include a variety of data on the chemicals, which are classified according to qualities such as their toxicity to humans, the environmental hazard they pose or whether they will harm aquatic organisms, for instance. Other measurements of effects on the aquatic environment include biodegradability, and solubility in water and fat. Combinations of these properties can have different effects; for instance, chemicals with low water solubility and high fat solubility may damage waterbirds or accumulate in aquatic organisms over time. As was seen at Basel, stored chemicals give off other chemicals when burning, so these potential substances must also be accounted for.

Industrial processes that involve numerous storage tanks, production reactors and extensive pipeline systems under pressure pose major hazards. There are a number of guidelines for their construction. Pipelines, for instance, must be of the correct dimensions and must withstand mechanical, thermal, chemical and biological loads. If they are used for transporting explosive chemicals, they must not carry electrostatic charges.

After treatment, chemicals are discharged in wastewater into rivers, lakes or the sea. The acute

Investigations following the accident in Baia Mare, 2000

Untreated wastewater from a chemical factory, Linhe, China

* *Contributed by the Swedish Environment Research Institute, Stockholm with financial support from the Swedish Water House*

Sheep grazing in an irrigation area with untreated wastewater, Bionàr, China

effects of an accidental discharge depend on the human and aquatic toxicity, the amount, and the initial distribution of discharge in the water. This can be fairly localised in a lake if caught early enough, but rivers, as we have seen, transport chemicals downstream fast, affecting water quality far below the discharge point.

Be prepared

One of the prime preventive measures against this kind of pollution is a strong legal framework governing safety. In Europe, since the 1970s, accidents have been one of the main reasons for the tightening of legislation concerning industrial hazards. An accident at a pesticide and herbicide plant in Seveso, Italy, in 1976 led to the 1982 Seveso Directive, which aimed to prevent major accidents involving dangerous chemicals. After the catastrophic accidents at the Union Carbide factory at Bhopal, India, in 1984 and at Basel in 1986, the directive was amended twice, thus broadening its scope to include the storage of dangerous substances.

The European Commission has adopted an amended proposal of the Seveso II Directive. Now all operators of plants coming under the scope of the directive must notify the authorities and establish a major accident prevention policy, a safety report, a safety management system and an emergency plan. Management factors have proven to be significant in over 90 per cent of accidents in the European Union since 1982.

In the United States, the Environmental Protection Agency has published regulations and guidance for chemical accident prevention at facilities using extremely hazardous substances. Companies of all sizes that use certain flammable and toxic substances are required to develop a risk management programme to reduce chemical accident risks at the local level, covering hazard assessment, a prevention programme including safety precautions, and an emergency response programme. The information aims to help local fire, police, and emergency response personnel — who are at the front line when it comes to such incidents — respond to accidents, and can also be used as a tool for public education on chemical hazards in communities.

Beyond the legal framework, planning of preventive measures should involve the police, fire and transport services, civil defence, public health, environmental professionals and the media. This group should develop an emergency plan, and provide information to the general public. The plan should be reviewed at least annually, and will need to cover the location of plants, storage areas and transport routes; emergency procedures on and off site; the designation of emergency coordinators; emergency notification procedures; where to find information about toxic chemicals; how to determine the probable affected area and population; a description of local emergency equipment and facilities; evacuation plans; and emergency training programmes.

Preparedness plans will also need to be drawn up and should include the issuing of a notification detailing the chemical's name; how hazardous it is; how much was released, and when and where; any acute or chronic health risks associated with it, and advice on medical care; and evacuation plans and designated shelters.

The toxic nature and often lingering or widespread action of so many industrial chemicals makes careful preparedness plans essential; and as with all water-related disasters, a coordinated response is crucial if lives are to be saved.

Health and water-related disasters*

Natural hazards all too often become health disasters. One cyclone can kill and injure hundreds, thousands or even hundreds of thousands of people, and given the number of water-related disasters that happen around the world every year, the human toll is high. To put this into perspective, a third of the planet's population was affected by natural disasters in the last decade of the 20th century — an overwhelming majority by floods or droughts. This vast figure includes not just immediate victims, but survivors whose lives have been shattered — the disabled, the chronically ill and the newly impoverished.

Be informed

The best way to confront natural hazards is to create a "culture of safety" by boosting the capacity of people living in vulnerable areas. Preparedness is key in helping communities handle the inevitable when it hits, whether it involves building a seawall or devising an evacuation plan. But if local health services are unable to cope with the grim aftermath of a disaster, many more lives will be needlessly lost.

This is where the World Health Organization comes in. The WHO oversees health issues associated with disasters worldwide. With the goal of reducing "avoidable loss of life, burden of disease and disability in emergencies and post-crisis transitions", the WHO is defining an integrated health policy for preparedness and emergency response to help national health services cope with disasters and link up effectively with relief organizations. Because of its long-term presence in many countries, solid knowledge of dealing with disasters and strong ties with communities and national authorities, it can move fast in difficult situations.

WHO works with local health systems to identify the top health and nutrition-related issues in an area, and ensure that these are properly addressed using an integrated primary health care approach. WHO also strengthens health and nutrition surveillance systems to monitor changes, provide early warning of any deterioration in the situation, and enable health teams to take immediate life-saving action; endeavours to control preventable ill health, particularly communicable and vaccine-preventable diseases, and to ensure basic, good-quality preventive and curative care, including essential drugs; and minimizes risks such as those caused by lack of safe water or sanitation. An important element in WHO's work is to ensure that any lessons learnt in a crisis are used to improve the health sector's preparedness for future disasters.

Be prepared

Water-related hazards can deeply affect our physical, mental and emotional health. Those who escape death or injury can be left traumatised by the loss of relatives, friends, and their homes and belongings, particularly if they are already marginalized by poverty.

A look at four major water hazards — floods, cyclones, landslides and drought — in the health context shows just how devastating they can be. All can destroy crops and livestock, setting the stage for possible famine, and can disrupt or disable basic services such as water supply. But each also poses very different challenges in terms of injuries and risks associated with the aftermath.

Drowning is the leading cause of death from flooding, which can range from small flash floods to massive flooding from dam breaks, snowmelt-swollen rivers or coastal storm surges. Search and rescue teams will be needed, along with medical assistance and help with evacuation. Education about the risks associated with cleanups, such as contamination from inundated industrial sites, sewage works or refuse dumps, and about ways to reduce exposure to water-borne diseases, is vital. In tropical countries, flood water can become a breeding ground for mosquitoes, creating an increased risk of malaria and dengue fever.


Photo: ISDR

* Contributed by the World Health Organization

Tropical cyclones can cover huge areas, their ferocious winds causing death and injury as they destroy buildings and blow lethal debris through the air. But the greatest danger is from associated events such as storm surges, landslides, and coastal and riverine flooding. Search and rescue and triage teams, who treat the most seriously injured first, are likely to be needed.

Often defined as geological events, landslides and mudflows can be a secondary effect of heavy storms and flooding as well as earthquakes and volcanic eruptions. They are often lethal, causing few injuries but many deaths by impact or suffocation, and have been known to bury entire villages. Search and rescue teams and effective management of mass casualties will be needed, and fast: frequently, people trapped in collapsed buildings must be rescued in the first 24 to 48 hours to survive.

Drought can be the most intractable of all. Often there will be mass displacement of people desperate to find food and water, and the length of many droughts can mean it will take people much longer to recover from the effects. If drought takes place before harvest, it can hit much harder in lean times, or in primarily agrarian areas. Malnutrition from a lack of protein is a big problem, as are deficiencies in vitamins A, C and some Bs as well as iron, leading to conditions such as anaemia, scurvy, beriberi and pellagra. Cholera, typhoid fever, diarrhoea and other infectious diseases can be rife. Well-handled food aid will be a central focus of drought relief, and may have to include intensive feeding of severely malnourished children, and ensuring water supplies and water quality control. Because of the strain of simply trying to survive for a long time in horrendous conditions, many people will be depressed and traumatised, and thus more vulnerable to disease.

All this highlights a cruel irony, and one of the biggest challenges for the global health community, namely that many of the poorest countries are also prone to the worst natural disasters. Building up beleaguered national and local health services worldwide may seem a tall order, but it is necessary if all countries are to participate, on as equal a footing as possible, in sustainable development.

The implications of climate change

Climate change is a monumental challenge to human adaptability. Shifts in the global climate have triggered some of the extreme weather we are now seeing — droughts in Africa and Asia, and the torrential rains and heavy snows that are afflicting parts of the Northern Hemisphere. Our understanding of this trend is growing year by year, but is still far from complete. What does seem clear is the need for stronger, more coordinated responses worldwide in the coming decades.

Earth's climate may be changing, but it is a marvel of equilibrium involving a host of interactions and processes between the atmosphere, oceans, land surfaces, ice sheets and biosphere (Figure 1). This system is driven by energy from the sun, and its overall energy budget is naturally balanced, as the Earth eventually re-emits solar energy back to space. But not all at once: in the process known as the greenhouse effect, certain gases such as carbon dioxide hold some of the energy back for a time, warming the planet and making life possible. The problem now is that during the last half-century, land clearance and emissions from industry, cars and other sources have overloaded the atmosphere with greenhouse gases and effectively turned up the heat. This disruption to the natural climatic balance is fuelling some extreme weather events.

Even in a stable climate, however, the temperature, wind, cloudiness, and precipitation are in constant flux. Floods, droughts, storms, heat waves and cold snaps as well as related events such as bush fires, avalanches and landslides, are all natural facets of climate variability. They may last minutes, as with flash floods, or months in the case of droughts, but all are potentially risky and can have serious impacts.

Be informed

The impacts from floods and drought can be costly in both human and environmental terms, so it is important to discover just how much these events will rise as climate change really begins to bite. Governments and a number of major agencies have already been tallying statistics over many years on the nature and impact of such events, particularly the extreme ones that become disasters.

What do the trends in the type, numbers and effects of disasters indicate? First, it should be noted that these data are not comprehensive: generally, only the more devastating events are taken into account. It is also hard to estimate losses when disasters strike predominantly poor areas — few lives and little property will be insured and in some places, such as shantytowns, local governments may not even have accurate figures of the numbers of people affected.

Given that, do the data prove that extreme weather and climate events are becoming more frequent, or more intense? Scientists around the world have recently focused attention on these issues in the latest report of the Intergovernmental Panel on Climate Change (IPCC), established by

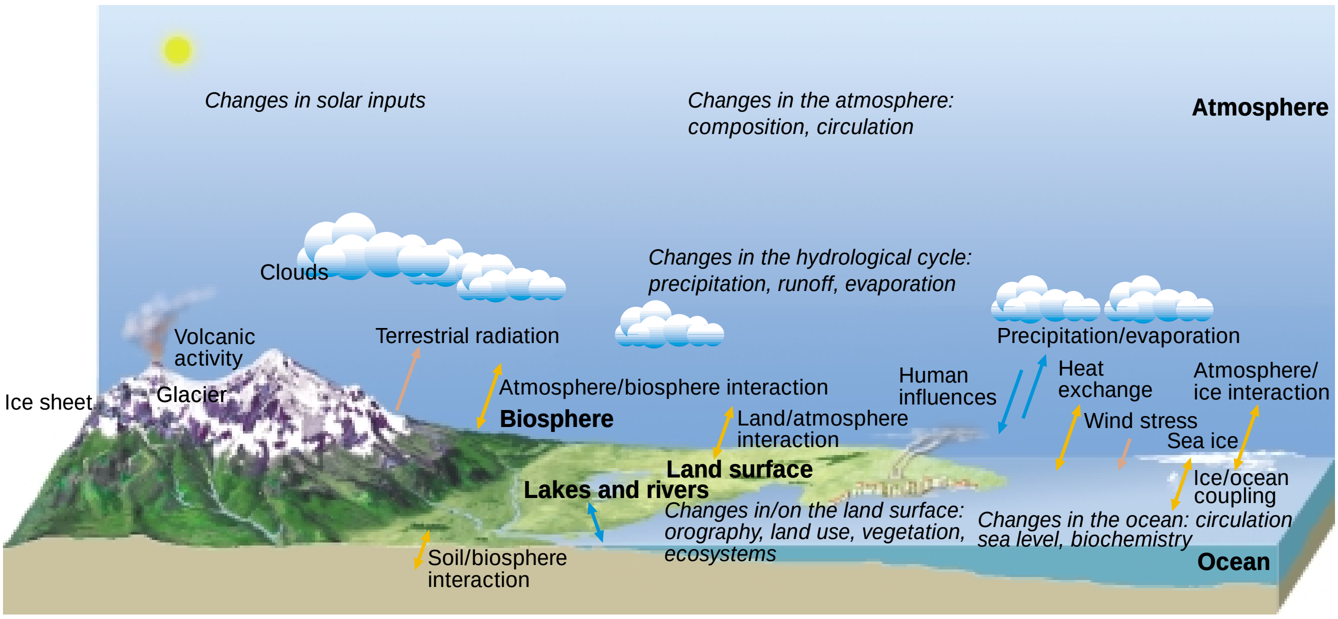
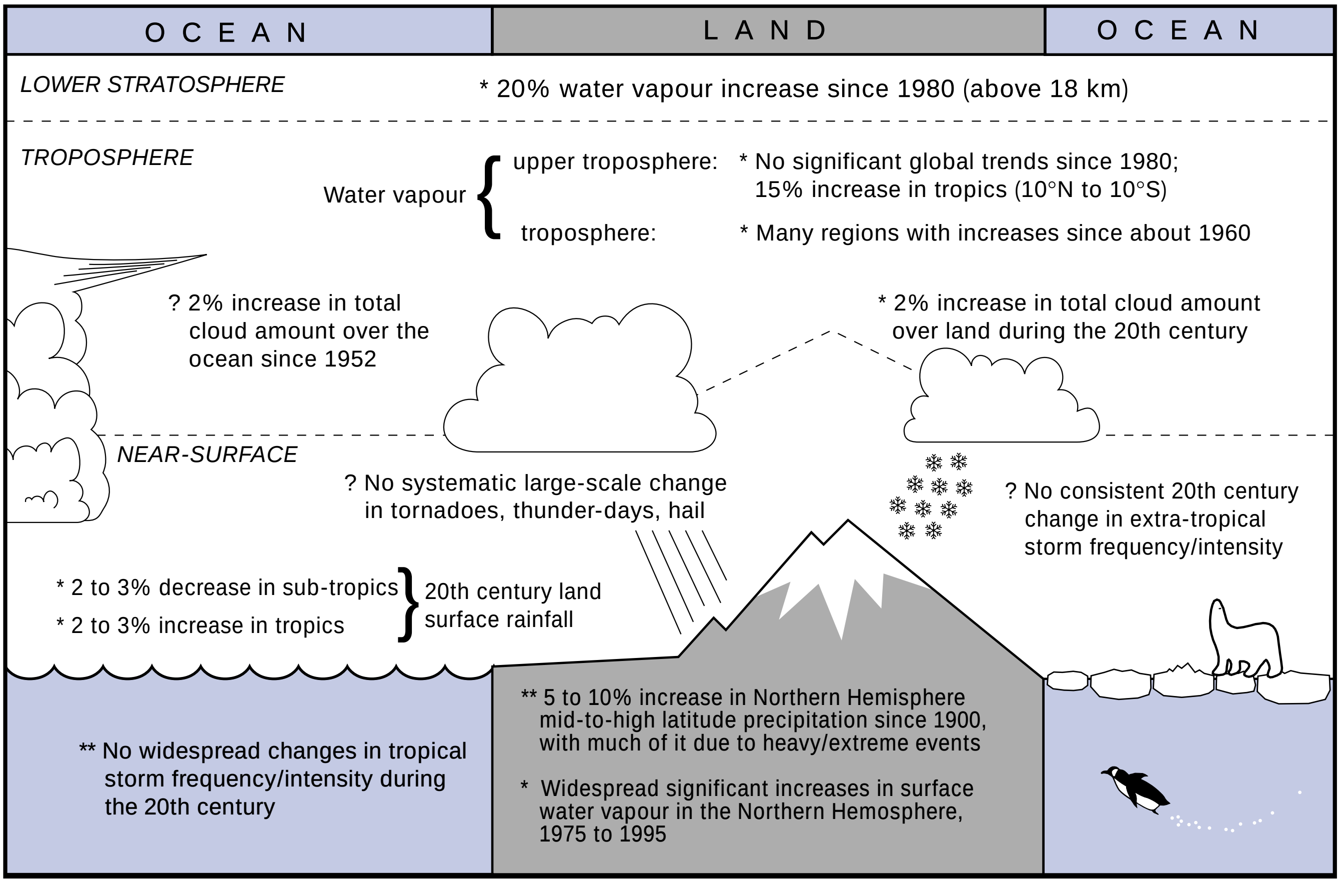


Figure 1 — The climate system is the sum total of the processes and interactions of the Earth's atmosphere, oceans, land surfaces, ice sheets, and its flora and fauna that are driven by the incoming radiation from the Sun, which in turn is balanced by heat radiated back to space

(b) Hydrological and storm-related Indicators



Likelihood:
- *** Virtually certain (probability > 99%)
- ** Very likely (probability ≥ 90% but ≤ 99%)
- * Likely (probability > 66% but < 90%)
- ? Medium likelihood (probability ≥ 33% but ≤ 66%)

Figure 2 — Schematic of observed variations of the hydrological and storm-related indicators (IPCC, Climate Change 2001)

WMO and the United Nations Environment Programme in 1988.

In the report, the IPCC says that while there were probably no widespread changes in the frequency or intensity of tropical storms in the 20th century, it is very likely that precipitation in the mid to high latitudes of the Northern Hemisphere has increased by up to 10 per cent, mainly due to extreme weather (Figure 2). In parts of Africa and Asia, the intensity and frequency of droughts have increased in recent decades. But as to the impacts on people and economies, the IPCC notes that there are other factors to take into account: population growth, increased wealth, demographic shifts, and changes in land use and the value of various goods. So more casualties of extreme weather may simply mean more people are in its way; and bigger economic losses could merely point to greater wealth.

Given the definite trend towards extreme weather, we can predict likely future patterns in a warmer world, using basic principles of atmospheric and oceanic behaviour, factors that influence the climate and sophisticated global climate computer models. There are, of course, a number of natural causes driving climate change, including variations in the amount of energy from the sun, volcanic eruptions, asteroid impacts and slow shifts in the circulation and temperature of the oceans. But projections for future climates also need to include reliable estimates of the human input: future levels of carbon dioxide and other greenhouse gases, based on population growth and choices regarding renewable energy, the modernization of industry and other issues.

Based on these results, a future global scenario is emerging. A warmer world means a wetter one, so the northern part of the Northern Hemisphere will probably see even more storms, and some continental areas might have drier summers and more risk of drought. Sea level could rise, in part fed by meltwater from glaciers and ice caps. Along with this, extreme high-water levels may occur with increasing frequency. Higher sea levels could cause flooding of coastal lowlands, and erode sand dunes. All in all, it is a bleak picture, but not insurmountable.

Be prepared

WMO and the National Meteorological and Hydrological Services of its Member countries have observed, documented and shared data on climate variables for many years. These records are an important step towards knowing what the climate system is capable of, and support prediction, planning and response efforts around the world. Using this ever-increasing knowledge and technological capacity, and in collaboration with governments, agencies and the media, WMO and its Members have helped build resilience, and save lives that might otherwise have been lost in climate-related disasters. This kind of data can improve water management and operations, and inform the overall response to climate variability, including the coping strategies used by every level of society, from households to governments.

Apropos of this, it should not be forgotten that some cultures have evolved their own coping strategies through long experience. People living in agrarian, rain-dependent communities in the semi-arid tropics, regions which have seen their share of extreme weather, have over the centuries amassed knowledge on how to survive drought and floods. With climatic "surprises" expected to increase, this venerable store of knowledge is sure to be called on when new challenges arise. And likewise, as weather forecasts continue to improve, the dialogue between meteorologists and water resources managers has to keep pace to ensure that the knowledge is shared to benefit all.

Managing risk*

We live in a world of risk. Periodically we have to confront all sorts of hazards that may have more or less serious effects, depending on our vulnerability to them. If the phenomena are intense enough, hazards can become disasters — unless we can reduce our vulnerability. This is what managing and reducing risk are all about. So while cyclones, drought and other water-related hazards may present one of the major risks of our time, there is much we can do to sidestep their effects.

Take two coastal villages, side-by-side in a tropical cyclone zone. One has hurricane-proof housing and a population drilled in evacuation procedures; the other, traditional bamboo houses and a few emergency phone numbers tacked up in the local post office. All else being equal, it is not hard to see which community is at greater risk from the next hurricane.

Reducing the risk of water-related hazards means, on the one hand, developing our capacity to monitor their magnitude, duration, timing and location, and on the other, assessing and reducing our vulnerability to them.

Monitoring hazards is a vital part of the equation. Our understanding of floods, droughts, landslides and cyclones, for instance, has been enhanced through the work of National Meteorological and Hydrological Services. As the availability of hydrological data in Africa has even decreased over the last decade, there is a clear need to maintain adequate networks for observing water- and weather-related hazards.

But tackling our vulnerability is the real key to reducing risk. Planning control, legislation and land use, environmental management and financial tools such as insurance are important steps towards this goal. All of this needs to be underpinned by an understanding of the factors that make us, and our assets, vulnerable. Over the past 30 years there has been a significant development in this direction, and vulnerability is now viewed comprehensively, as a reflection of the individual and collective physical, social, economic and environmental conditions that are shaped continually by a myriad of influences, whether behavioural, cultural, socio-economic or political, from the individual level to the national.

The organizations working to reduce disaster risk globally are striving to add to our understanding of vulnerability and disaster risk within the framework of the International Strategy for Disaster Reduction (ISDR). The ISDR has identified four broad types of vulnerability:

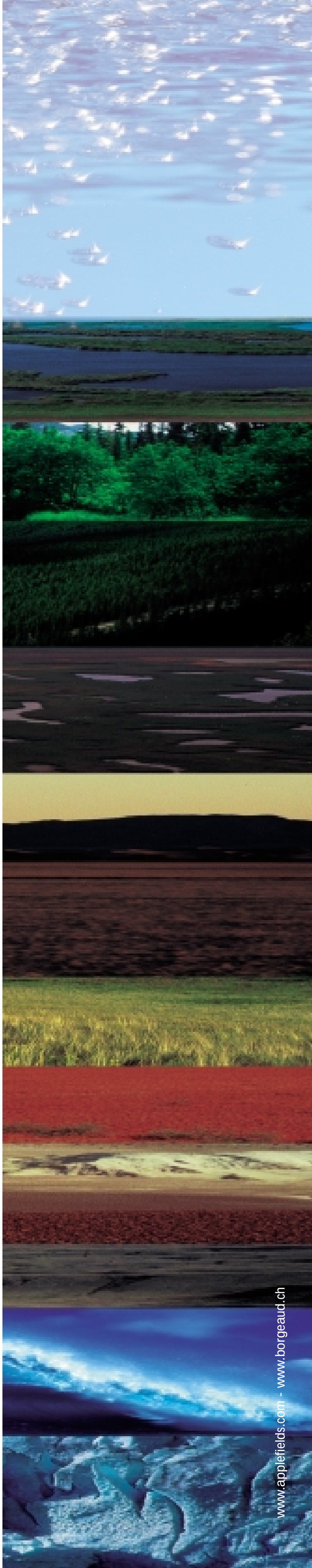
- Physical, referring mainly to location and to the built-up environment;
- Social, linked to the level of wellbeing of individuals, communities and society. Included are aspects related to literacy and education, peace and security, access to basic human rights, systems of good governance, social equity, positive traditional values, knowledge structures, customs and ideological beliefs, and overall collective organizational systems;
- Economic, as the poor are generally far more vulnerable to risk than the rich, and tend to lose more and recover slower when a disaster strikes. The links between eradicating poverty, the impact of poverty on recovery from natural disasters, and the state of the environmental resource base upon which both depend, are crucial;
- Ecological, covering a broad range of issues, such as the depletion and degradation of natural resources, the loss of resilience in ecological systems and in biodiversity, and the level of exposure to toxic and hazardous pollutants.

* *Contributed by the ISDR Secretariat*

Another important factor in disaster risk reduction is the level of awareness of risk, which largely depends on the quantity and quality of the available information, and on how individuals, communities, agencies and governments perceive risk. People are more vulnerable when they are not aware of hazards.

The United Nations Development Programme (UNDP) and the ISDR are now developing a collective framework to encourage and spread appropriate and effective disaster risk reduction practices. This is a starting point — a core set of principles and goals for understanding, guiding and monitoring disaster risk reduction that will pave the way for a 2005–2015 action plan, due to be presented in 2005 at the Second World Conference for Disaster Reduction (WCDR2) in Kobe, Japan.

It is a timely move: with climate change ensuring that water-related hazards will not be abating soon, disaster risk reduction will be relied on more and more to build up our capacity to cope.



The photographers that graciously contributed their work: Martin Harvey, Rolf Hogan, Les Molloy, David Sheppard, and Jim Thorsell. There are four photos for which we do not have the names of the photographers, although much effort was made to find them. We have included their photos in the belief that the photographers would also want to share their work for the cover of this booklet.

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