


Preventing and mitigating natural disasters

Working together for a safer world



World Meteorological Organization

Weather • Climate • Water

WMO-No. 993

Weather • Climate • Water

Preventing and mitigating natural disasters

WMO-No. 993

ISBN 92-63-10993-1

CONTENTS

Michel Jarraud,
Secretary-General of
WMO

FOREWORD

Every day, we hear and read of death, injury and destruction caused by, or related to, weather, climate and water events. In this day and age, with advances in technology, computer capability and communication—especially the tools developed for watching, understanding, predicting and communicating the world's weather and associated early warnings—how and why does this still happen? Is there something more that can be done?

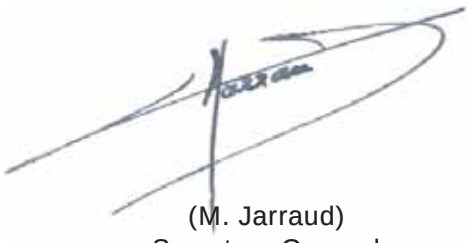
At the highest levels of government, there have been repeated calls to address natural disasters that hamper sustainable development and accentuate poverty among the most vulnerable nations and sectors of society. These have been echoed at recent international conferences, including the World Summit on Sustainable Development (Johannesburg, South Africa 2002), the UN Conference on SIDS (Mauritius, 2005), the World Conference on Disaster Reduction (Hyogo, Japan, 2005) and the UN World Summit (New York, 2005).

WMO and the National Meteorological and Hydrological Services (NMHSs) of its 187 Members have been at the forefront of disaster mitigation through the operation of a 24-hour, seven-day a week, year-round system for monitoring and predicting the weather and for disseminating the forecasts and warnings of phenomena such as tropical cyclones, flood, drought, tornadoes, lightning and associated events such as mudslides, locust development and invasion, and impacts on health. In order to focus global attention and promote disaster preparedness and prevention, WMO has dedicated Word Meteorological Day 2006 to disaster mitigation. This Day is celebrated on 23 March each year to commemorate the entry-into-force of the WMO Convention on that date in 1950.

One of the major goals of WMO, NMHSs, and their systems, programmes and activities and their partners in disaster-prevention and mitigation communities is to reduce the number of deaths, injuries and damage caused by severe weather, climate and water events. They give individuals, decision-makers and other partners the information they need for awareness building, planning, preparedness and, when necessary, for recovery and rehabilitation efforts. In this way, WMO also promotes partnership in a global effort to save lives and to protect human livelihoods and well-being and the environment.

This year, WMO would like to propose a different story from the ones so often making the headlines—one in which the human element takes centre stage. It is a story of confidence, planning, empowerment, positive action and hope. It is reflected in this booklet, dedicated to make disaster mitigation a reality. I am thankful to Mr Michael Allaby and to various other contributors to the booklet.

I encourage all to become involved, as individuals, families and communities, to work with their respective NMHSs and disaster-prevention and mitigation bodies to be informed, to be prepared—and to be safe.



(M. Jarraud)
Secretary-General

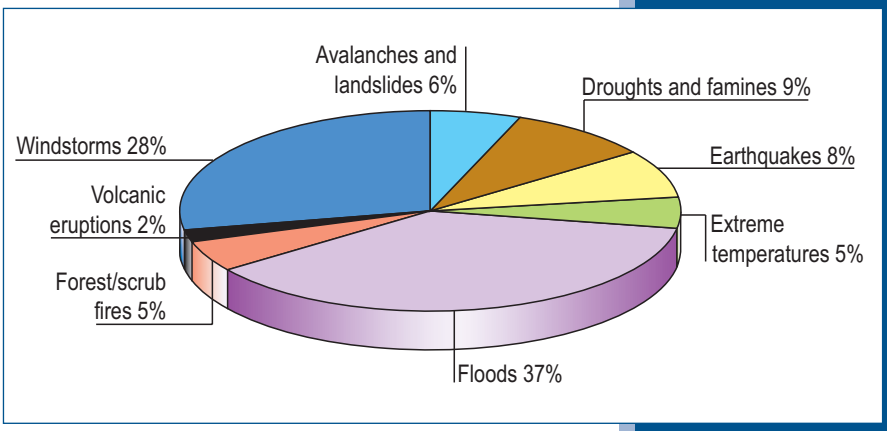
... be informed, be prepared ... be safe

INTRODUCTION

The World Meteorological Organization is well known for its scientific and technical expertise in watching, understanding, predicting and analysing the Earth's weather, climate and water and for communicating this information to every country around the world in near-real time. This vigilance, every hour and day of every year, and the global-scale international cooperation that has developed amongst all countries over decades allows the National Weather Services of WMO's 187 Member countries to generate reliable and timely information on the state and likely evolution of the weather. This information forms the basis of all early warnings for the safety and protection of people and their well-being and the environment.

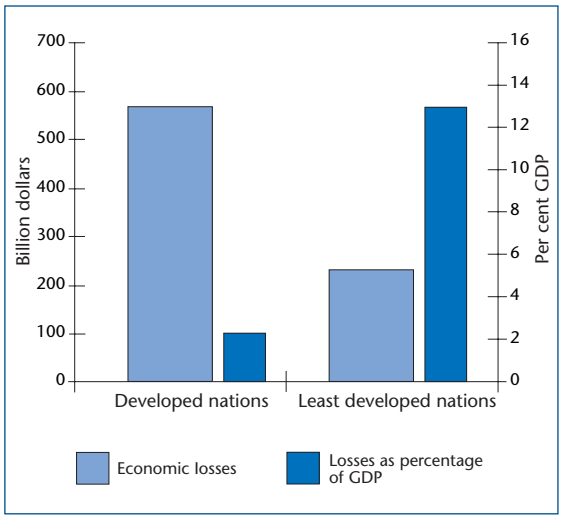
Weather, of course, is part of everyday life, a natural part of the Earth's climate system. While it is often benign, from time to time and in almost any part of the world, it can be violent, in the form of cyclones, high winds, tornadoes, thunderstorms and heavy rain-, snow- or ice storms, or in associated events such as storm surges, floods, mud- or landslides, duststorms, forest fires and avalanches.

The destructive power of such hazards can range from personal injury to large-scale mortality, property and infrastructure damage, to regional-scale socio-economic and environmental impacts: people and communities can and do suffer, physically, economically and emotionally. Over long periods, even non-violent manifestations such as droughts can have extremely serious socio-economic and environmental effects. No part of the world is immune from hydrometeorological hazards of one sort or another. Recent statistics have shown that about nine out of 10 of the many natural disasters experienced around the world are related to weather, climate or water.



Weather, climate and water hazards cause the great majority of natural disasters.

A number of studies suggest that weather-related disasters appear to be growing more frequent. However, the scientific evidence for a significant long-term increase in the frequency or severity of certain hydro-meteorological hazards is not yet clear. There is also the need to recognize the vulnerability of a community, country or region to various hazards. Vulnerability is a factor of preparedness and socio-economic conditions, including population density,



In the last decade, developing countries shouldered a much greater share of the impact on their economies than their developed counterparts (Munich Re).

availability of resources to invest in disaster mitigation and proximity to hazard-prone areas. Vulnerability can change over time, as can the capability to learn of and record disasters in remote areas.

That said, there is little doubt that the social, economic and environmental costs of weather- and climate-related disasters are rising. The burden falls most heavily on the developing and especially the least developed countries, where repair, recovery and rehabilitation divert resources that might otherwise be devoted to national social and economic development.

WMO's mandate includes addressing the challenges of understanding and predicting weather-related hazards. WMO recognizes that saving lives and preventing disasters require partnerships. WMO, through its international activities and through National Weather Services, is reinforcing its outreach to work ever more closely with disaster prevention and mitigation experts, decision-makers, citizens and the media.

The task of WMO and the National Weather Services involves developing and sharing information on natural hazards, ensuring that the disaster-management community, decision-makers and the public understand the risks posed by these hazards and recognize the onset of hazardous weather and its impact on safety and survival procedures.

Research remains a cornerstone for understanding and refining the accuracy of forecasts with longer lead-time for issuing reliable warnings. The Organization is also actively engaged in enhancing the understanding of the potential impacts of climate change.

By working together, positive action to prepare for, respond to and recover from, weather-related hazards will be ensured. This is an upward-spiralling helix: as a community begins to cope with the hazards, to reduce and increasingly to prevent the damage that harms development, the community gains strength, grows and improves its chances to build up resistance and remain safe.

On World Meteorological Day 2006, WMO proposes a story of confidence, planning, empowerment, positive action and hope—a description of how the cycle of information, preparedness, survival and progress should work. This story is set in a tropical village prone to cyclones. The village is confident, informed, organized and ready to face the challenge of the weather. The story could apply to anyone, anywhere in the world, because in this village are local citizens, visiting businessmen, tourists and others who find themselves in the path of violent weather in a place far from home. The vital contributions of WMO and the National Weather Services to all components of this cycle are presented throughout, for a complete and integrated picture.

The story of challenge and survival begins ...

Soon after midnight, the edge of the tropical cyclone came screaming ashore. The community had been following the warnings through the media for the last three days. The villagers and staff and guests in the tourist resort complex a few kilometres down the road, had spent hours reviewing the safety procedures, hoarding food, medicines and other basic necessities, boarding up windows, securing tools, equipment, boats and vehicles, and securing roofs. Livestock were moved upland to enclosures where they would be better protected from falling trees, flying debris and floodwaters. Emergency supplies had been brought into the school where the villagers were riding out the storm. They had worked hard but, even though they were exhausted, the tension of waiting and then the sheer force of the wind and rain made sleep close to impossible.

Driven by wind of more than 180 km/h, sheets of rain and blowing debris lashed the village for hours. The community listened to the weather warnings on the radio and knew when the eye of the cyclone would pass close by, creating a temporary lull in the violent winds and rains. When the storm abated enough and the Weather Service confirmed that the immediate danger had passed, those sheltering in the school rushed out, eager to see how well their property, as well as the staff and visitors at the tourist resort, had weathered the storm.

Inevitably, in a storm of this magnitude, there had been a few minor injuries and some property damage. Crops were flattened as they had borne the brunt of easterly winds and then, after a couple of hours after the passage of the eye, the winds from the west. However, most of the livestock were safe; the tools and equipment with which the villagers earned their living were undamaged; there were stores of food and water to use during the clean-up process; and no one had died or been seriously injured.

Life could go on.

This story shows the steps that carried this village through the hazard of the cyclone with such security. The role of WMO and the National Weather Services in each stage of the process will be described, as will those of our partners, including the citizens themselves.

While this story has a tropical setting, and the hazard in this case is a cyclone, the full suite of weather-related hazards that have the potential to cause serious socio-economic damage somewhere in the world will be touched upon. Where a person lives (or visits for work or recreation) will determine which of these hazards will be faced. While specific details of preparation, recovery, response and planning will vary, according to the location and the nature of the hazard (tropical cyclone, tornado or drought) the steps described are good general guidance for coping with hazards of any sort.

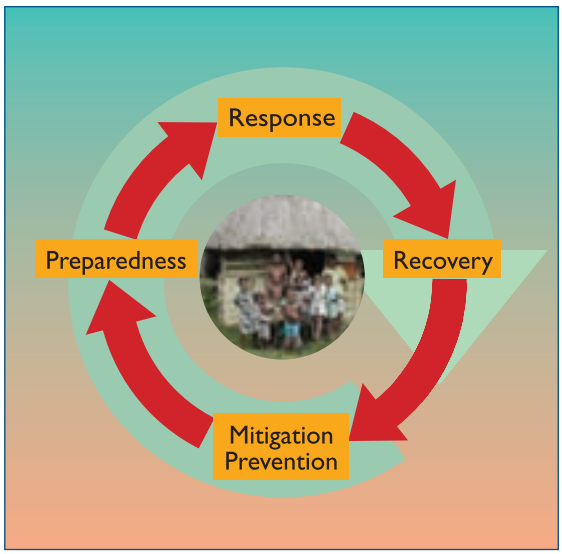
Natural hazards pose a threat to communties worldwide. Much can be done, however, as this booklet sets out to describe, to ensure that their inhabitants will be able to ride out the storm in safety and return to their peaceful, everyday lives.

COPING WITH NATURAL HAZARDS: FOUR-PHASE NATIONAL ACTION PLANS

Emergency planning and response requires collaboration and coordination from international and national to local levels. National Weather Services identify and monitor potential hazards and issue warnings and thus play a critical role in preventing a hazard from developing into a disaster. This, however, is but one component of the much larger "system" that must be in place to prevent and reduce disasters.

The details of such systems vary somewhat from one country to another but, when they are organized efficiently, the emergency plan is clear and unambiguous, the warnings arrive in time and are reliable; people are informed and ready for action; lives and livelihoods can be protected.

Implementing a plan for dealing with an emergency involves government departments and agencies at every level, from the national government in the capital to local communities, from local police to fire and health and social services. It is essential to the success of the plan that each of these bodies has clearly defined authority and responsibility. Ideally, the plan and these responsibilities should be defined by legislation in order to remove all possible ambiguities and to impose on each body an enforceable duty to play its part.



The four phases of a National Action Plan with the community as the focus of all actions

National Action Plans should have four components: mitigation; preparedness; response; and recovery with the National Weather Service playing a crucial role:

- *Mitigation* involves identifying the vulnerability of every part of the country to particular types of hazards, and identification of steps that should be taken to minimize the risks. These steps can include modifying building codes to ensure that buildings can withstand high winds, forbidding building on land that is prone to flooding and identification of evacuation procedures. Once enacted, regulations must be strictly enforced. Mitigation, in essence, is long-term planning and involves government at many levels including NMHSs, emergency services and the military, but also relief agencies such as the International Federation of Red Cross and Red Crescent Societies. In the mitigation phase, all partners in the National Action Plan will determine what tools and personnel they will require, what training to offer, what outreach products must be prepared and distributed to the communities in the country.

- *Preparedness* also involves the wider community. Citizens must be educated about the nature of the hazards they face and how to recognize and respond safely to them. They will become familiar with the way in which their National Weather Service and emergency services communicate information on, and

HOW WMO CONTRIBUTES TO NATIONAL ACTION PLANS FOR COPING WITH NATURAL HAZARDS

Through the internationally coordinated network of the National Meteorological and Hydrological Services (NMHSs), WMO:

- Monitors the weather over land and oceans, including potentially severe conditions, and predicts the evolution of all weather systems;
- Uses its specialized communications systems to ensure relevant information (data, satellite images, forecasts, warnings and other products) reaches all NMHSs in a timely manner;
- Ensures consistent data quality and data accessibility across national boundaries for the purpose of improving risk management capabilities within a regional and subregional framework, including development and coordination of global observing systems;
- Provides expert advice and technical support to vulnerability assessment, risk-mapping and formulating action plans on managing disaster risk;
- Collaborates in and sets standards for the training of NMHS staff to make sure they are able to address effectively the needs of their countries for weather, water and climate information;
- Provides a wide range of educational products and services to increase public awareness of the causes and consequences of natural hazards. In partnership with emergency services, health and social services, relief agencies, etc., WMO contributes to development of information and advice on how to prevent and mitigate the impacts of weather-, climate- and water-related hazards.

warnings of, severe weather. Individuals and families will have personal action plans, lists of emergency supplies to have on hand and a clear understanding of coordinating their own safety.

Citizens must also know how best to cooperate with each other and with the emergency services. Carrying out exercises and drills will expose any sources of confusion or deficiencies in the way that information is disseminated. Each community will refine its local plan according to its particular circumstances and will consider contingency plans in case any aspect of the emergency plan fails for some unforeseen reason (e.g. a fuel shortage just prior to a storm may leave emergency vehicles stranded). NMHSs, emergency services, health and social services, relief agencies, etc., all have a role to play in ensuring a community is prepared to face a hazard.

- The *response* phase of the plan involves the implementation of the measures developed during the mitigation and preparedness phases. The National Weather Service will provide up-to-the-minute weather advisories and warnings. Emergency, health and social services, volunteers and citizens will all have their own parts of the overall plan to enact, and will systematically and calmly set about ensuring the safety of the community.

Access to a radio through a programme such as RANET can save many lives.

RANET is an international collaboration, guided and supported by National Weather Services. Its mission is to make weather, climate, and related information more accessible to remote and resource-poor populations.

This information aids these populations in making day-to-day resource decisions and in preparing against natural hazards.

RANET combines modern technologies with appropriate applications and partnerships at the community level.

- *Recovery* comprises the steps taken after the event to repair the damage and reconstruct communities. All partners in the Action Plan will assess how well the plan worked, its strengths and weaknesses and will also begin the process of revising the plan for greater success the next time. The National Weather Service will continue to provide its usual services—the hazard may have passed this community, but will now likely be affecting a neighbouring area whose inhabitants are enacting their own Action Plans.

Preparedness phase of an effective action plan

The villagers had survived a tropical cyclone. Also known in different parts of the world as hurricanes or typhoons, they are the biggest and amongst the most violent of all storms. They develop in the tropics and subtropics over warm ocean waters, but they move with the circulation of the atmosphere and can bring gales and torrential rain to places as far from the tropics as Canada and northern Europe.

The villagers survived the cyclone because they were prepared. They had an emergency plan. Everyone knew what to do. And because their National Weather Service forecast the storm and warned that it was coming, the villagers had time to take appropriate action.

Several days before the cyclone arrived, the media broadcast weather advisories from the National Weather Service on the probability of a major storm for the region, and gave advice for personal and community protection. "Make sure you know the emergency plan," the broadcasts urged.

LEVELS OF WARNINGS OF APPROACHING HAZARDS

The precise nature or scale of warning used varies from country to country. Generally, the following three levels are common:

- An ***advisory*** informs people within a designated area of probable weather or hydrological conditions that could lead to hazardous situations, but they are not yet severe enough to move to the next stage of alert. People should take note of an advisory and be aware of any change in conditions.

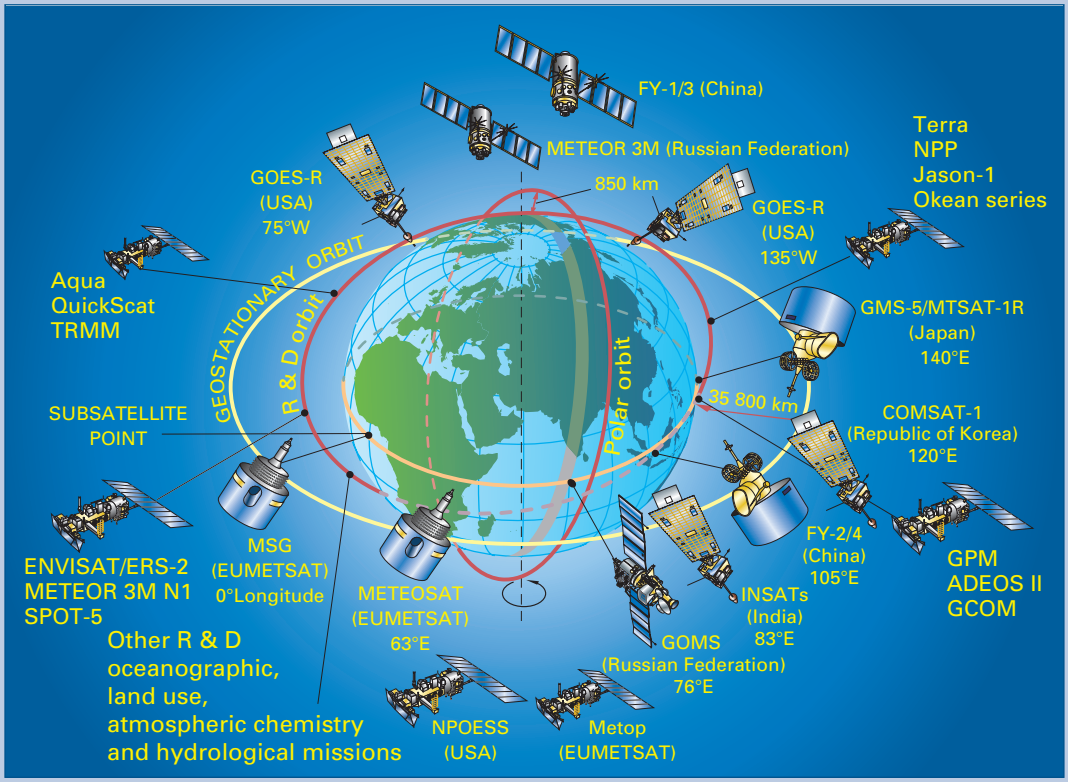
- A ***watch*** alerts the public of the possibility of a particular hazard and provides as much information as is available on its intensity and direction. Such forecasts are issued well in advance of a weather event such as a cyclone, when conditions are suitable for the development of severe conditions. When a watch is announced, people should take steps to prepare to protect their lives and property. Depending on the circumstances, they may need to prepare for evacuation.

- A ***warning*** is a forecast of a particular hazard or imminent danger issued when extreme conditions have developed and are occurring, or have been detected. It is time to take appropriate action.

WMO'S SPACE-BASED SURVEILLANCE

A ring of geostationary satellites above the Equator provides regular images of the globe between latitudes 65°N and 65°S, at more or less 30-minute intervals. The space-based constellation also includes polar-orbiting satellites and a number of research-and-development environmental satellites.

This array of operational and research satellites provides almost continuous observations of many aspects of the Earth's weather and a picture of the evolution of climate—the march of the seasons and the development of anomalies that lead to drought, floods and heat waves.



"Everyone has a part to play. Be prepared and you will survive."

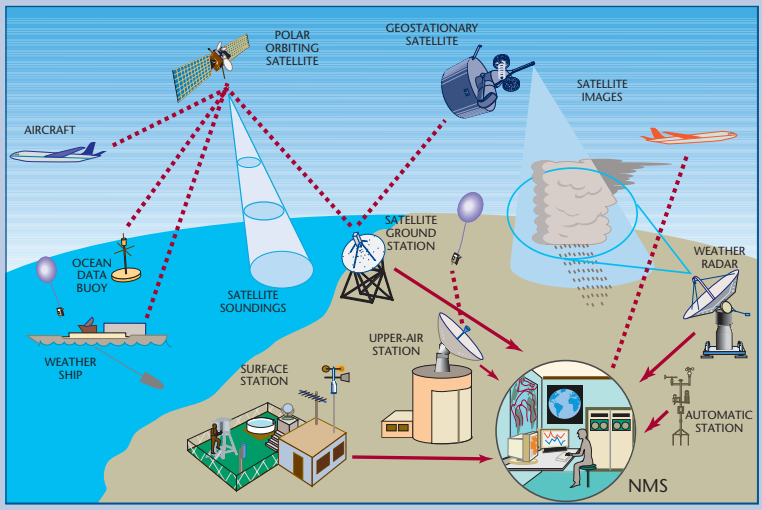
When the warning reached its next level—a cyclone "watch"—people in the village began to act, gathering their emergency supplies (food and water, medical supplies, blankets, radios, flashlights, etc.), making sure they had the materials needed to secure their property. Then, a weather warning was issued for the area: the cyclone was on its way, and would be dangerous. Regular activities were abandoned and school lessons ended. Since the school had been selected as the emergency shelter, desks and other school equipment were pushed to one side to make space for people and supplies. The school's windows were boarded up and the roof secured against the coming winds. Local authorities and volunteers alerted the community and visitors, ensuring that everyone was aware

WMO GLOBAL OBSERVING SYSTEM

The Global Observing System is a fundamental component of WMO programmes and services. Data are collected from 16 satellites, hundreds of ocean buoys, aircraft, ships and some 10 000 land-based stations. Within countries, the National Weather Service makes observations using manned and automatic instruments of temperature, precipitation, wind speed and direction, atmospheric pressure and other characteristics of the "weather". The observations, forecasts and products developed from these data are sent around the world every day, using the Global Telecommunication System.

The data are processed, and forecasts are made at World Data Centres (WDCs), and at 40 Regional Specialized Meteorological Centres. The WMO Global Data-processing and Forecasting System ensures the cooperation of these and national centres to routinely provide analyses and forecasts, particularly those warning of severe weather, to National Weather Services all over the world via the Global Telecommunication System.

Every day, WMO distributes more than 50 000 weather reports, several thousand weather charts, and many other products on time scales of minutes to seasons ahead in digital form. Weather Services then develop and provide early warnings adapted to local conditions and needs for their countries.



of the warning, the danger and the emergency plan. Lists were made of who would need to take refuge in the school, as well as at the tourist resort and other public locations during the storm.

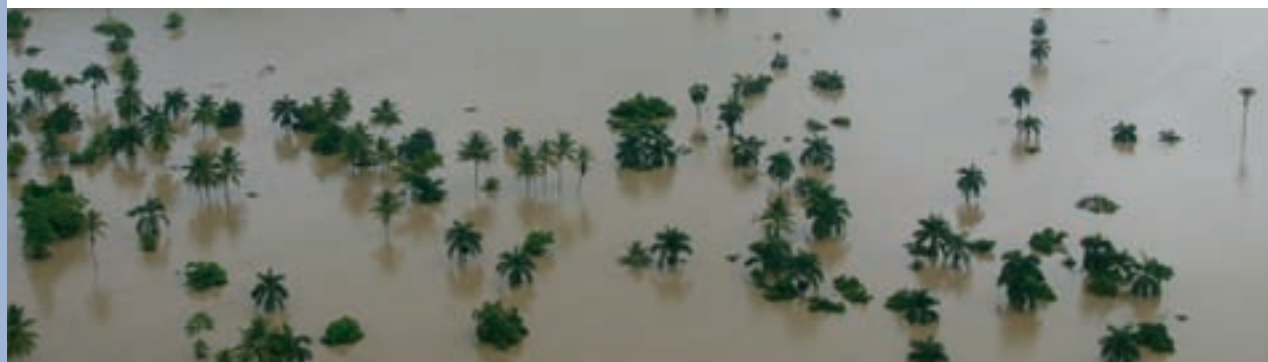
Finally, when all was ready, the designated members of the community at risk headed for the school with their emergency supplies. The head teacher stood at the school door and marked off the names as each person entered, so that when the doors were closed and barred, no one who needed shelter had been left outside at the mercy of the storm.

The emergency action plan the villagers used provided detailed instructions that were simple to understand and practical for their preparations against the storm. A critical part of the effectiveness of this part of their plan was the series of weather forecasts issued by the Weather Service. These forecasts were accurate, clear, readily understandable and timely. The villagers relied on them as they came from the official source, the National Weather Service.

The weather forecasts issued by the National Weather Service are a vital element of a national preparedness plan.

What warnings are provided to help in the preparedness phase?

In the case of dangerous storms such as tropical cyclones, meteorologists first issue an advisory when it seems probable that severe conditions will develop. A storm



"watch" is put in place a day or two before the Weather Service expects the storm to arrive. This allows individuals and communities to prepare, by checking the availability of emergency supplies and other items they may need to protect their lives and property.

When a severe storm is no more than 24 hours away, the Weather Service generally issues a more precise warning for the areas that will be at risk. At this stage, people are urged to secure their property and to move their families and emergency provisions into the place where they will wait for the storm to pass.

While the warning is in effect, people are advised to keep their radios and televisions switched on and tuned to the local station, to listen for sirens or street announcements and to watch for flags or other signs used in their community for warnings. In some cases, people may be advised to leave the area completely. They will need to be alert for instructions on evacuation procedures that will come into effect.

How much ahead of time can the community be warned?

The time-scale of warning for tornadoes will be of the order of minutes to hours and for droughts could be months to seasons.

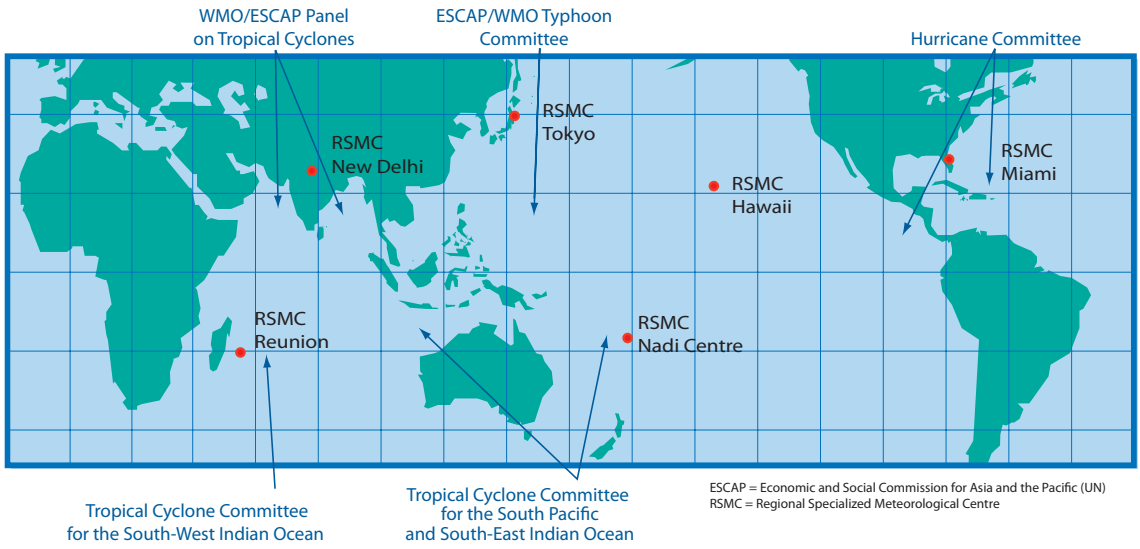
In the case of tropical cyclones, meteorologists can usually predict fairly accurately their arrival 48-72 hours ahead, allowing time for emergency plans to be put in effect. This is due to the fact that large storms are watched from space by satellites as well as tracked through land- and ocean-based observation programmes. Some emergencies, however, develop much more quickly than others and, on occasion, the status of an event can change quickly. These factors affect the amount of advance warning communities can be given, but Weather Services strive continually to provide the longest lead times possible for any weather-related hazard.

How do WMO and Weather Services observe and predict tropical cyclones?

Instruments carried on orbiting weather satellites maintain a continual watch on the whole atmosphere. Every day, their radio transmitters feed huge volumes of data to receiving stations on the ground. The digital images from satellites show cloud formations, which help meteorologists identify weather systems, including isolated storms, storms linked together in squall lines, and local disturbances that may develop into tropical cyclones. Sequences of satellite images indicate the evolution, including the direction and speed, of the moving storm. Data, such as wind speed and direction and moisture profiles are used to indicate the severity of conditions that may be experienced at the Earth's surface.

Meteorologists regularly release weather balloons into the atmosphere (twice a day at many sites around the world). These balloons carry instrument packages that enable the measurements of temperature, humidity, wind speed and direction and atmospheric pressure. Observations of

Meteorologists monitor tropical cylones and forecast track and potential conditions at landfall by satellite, hurricane hunter planes and small, light but robust unmanned aircraft called Aerosondes.



WMO's six regional tropical cyclone warning centres

atmosphere, land and ocean characteristics are also made by surface land stations, ships and ocean buoys.

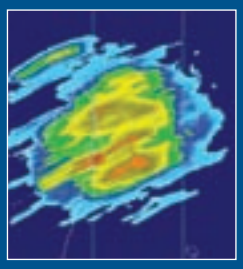
Radar is also used to study storms. Radar scanning produces an image of a weather system, and its distance is calculated from the time that elapses between the transmission of the radar pulse and the receipt of its reflection. Radar images show the amount of moisture clouds contain and the type and intensity of precipitation coming from them.

Specially built research aircraft, with computer workstations for scientists, can provide more detailed information about conditions at different heights inside large storm systems. These aircraft have sufficient range to reach storms in remote regions, and are strong enough to survive severe horizontal and vertical currents, sometimes moving at 150 km/h or more, and the rapid accumulation of ice on the aircraft's surface.

All these observations help meteorologists understand the current behaviour of the atmosphere. The information is fed into global and regional computer models that predict the evolution of the storm systems. WMO coordinates the exchange of information: the observed data from all sources and the output of all forecast centres are exchanged among National Weather Services and specialized centres.

WMO, through National Weather Services, operates six centres that specialize in tropical cyclone forecasting, in Honolulu, La Réunion, Miami, Nadi (Fiji), New Delhi, and Tokyo. Their scientists track the tropical cyclones, forecast their movements, and alert national Weather Services of their approach. The centres issue continually updated bulletins and forecasts of approaching storms and distribute them via the Global Telecommunication System to the National Weather Service of the countries likely to be affected. These Weather Services then have the responsibility to issue warnings to the authorities, the local communities at risk and the public.

Radar is also used to study storms.

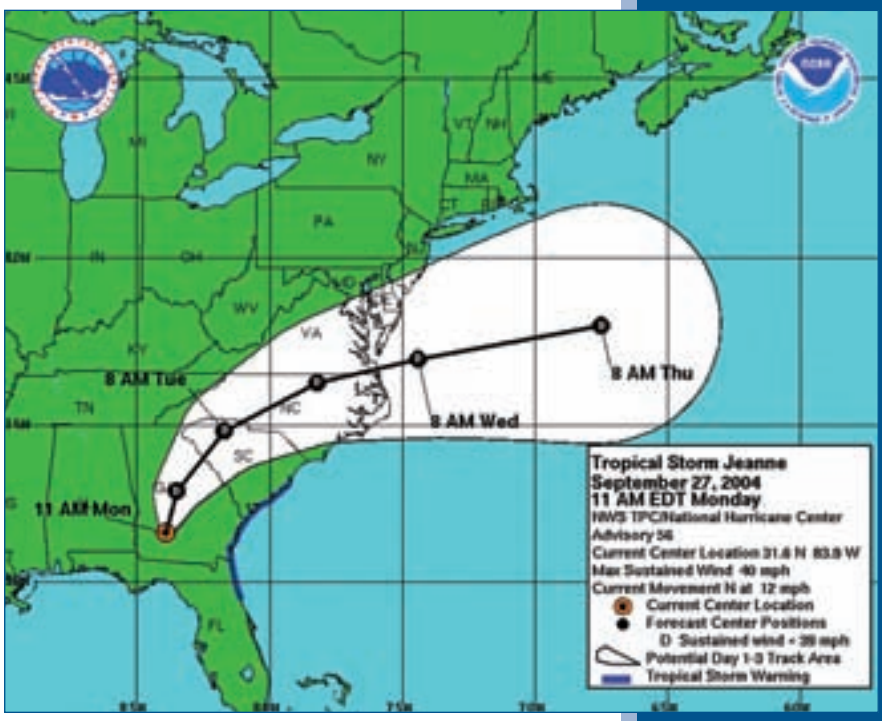


How is the community warned of the danger approaching?

First of all, the Weather Services send vital information quickly to partners in disaster prevention—by phone, fax and Internet—and the Weather Services and their partners together warn the public. Warning information comes from a single official source, the

National Weather Service. In some countries, the dissemination of weather warnings is under the authority of the national Civil Defence or emergency services, but the National Weather Service serves as the unique source of warnings. It is extremely important that all those involved in facing and responding to a natural hazard receive and act on official weather and water information from the Weather Service, to ensure that everyone is using the same information, and that the advice received is the best available.

The media are a vital partner in the communication of advisories, watches and warnings, and broadcasters will interrupt radio and TV programmes to warn of an approaching hazard. Not everyone will have a radio or television, however, and emergency plans have to account for that. In some communities, loudspeaker vans tour the streets, telling people to prepare. In other places, sirens are sounded or signal flags may be raised. Storm cones have been used for centuries in some parts of the world. These are made from canvas and covered in tar to make them rigid. They are raised on flagpoles to warn of an approaching windstorm: the position of the cone indicates the direction and intensity of the wind.



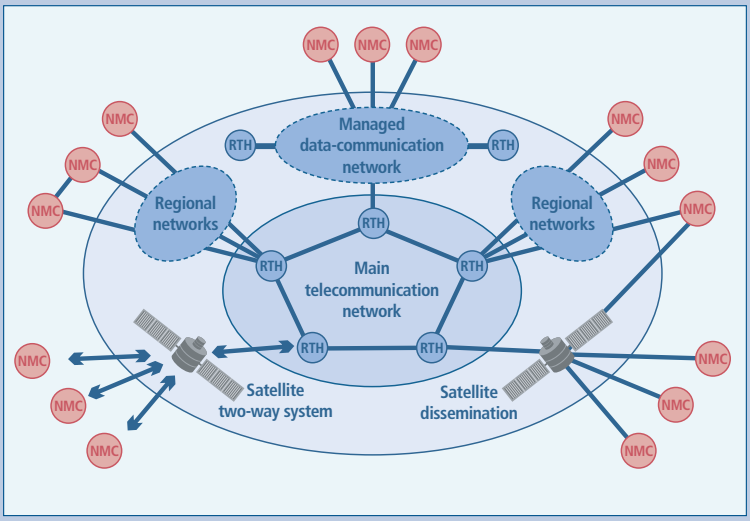
Storms are tracked closely and forecasts are being made with increasing accuracy. It is important that forecasts and warnings are issued by a single official source.

What are the characteristics of an effective forecast or warning?

- ***Accurate:*** the forecast must be accurate regarding the onset and intensity of the weather-related hazard, and the geographic area likely to be most affected, so that the National Weather Service and emergency authorities can judge potential impacts in its path. Since forecasting involves an element of probability, it is important that the forecast information provided to emergency services and government decision-makers includes discussion of any uncertainties, so that they will understand how to deal with them effectively.
- ***Clear and understandable:*** the information in the forecast or warning must be clear, understandable and unambiguous to the extent possible about the expected phenomenon and the risks to person, community and property.
- ***Available to all:*** the forecast or warning must be disseminated to all affected persons and groups, including those unable to receive television, radio or the Internet.
- ***Reliable and timely:*** over time, the Weather Service must work with the users of its services to develop trust in the products and must deliver these services when and as often as needed. The user must be prepared to act when a warning is issued.
- ***Authoritative:*** there must be one clear and recognized authority for official warnings of weather-related hazards; the media and partners participating in addressing the hazard must not create or broadcast conflicting information.

WMO GLOBAL TELECOMMUNICATION SYSTEM

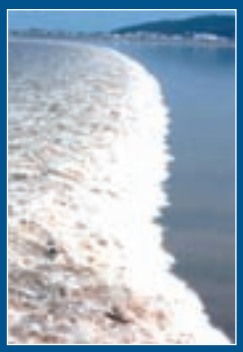
The WMO Global Telecommunication System is a dedicated network of telecommunication facilities and centres, using leased lines, satellite-based systems, the Internet, and data networks, that is implemented and operated by the National Meteorological and Hydrological Services of WMO Member countries all over the world. The Global Telecommunication System interconnects these Services to facilitate the rapid, reliable collection and exchange of all meteorological and related data, and for the distribution of weather, climate and water analyses, forecasts and warnings produced by the Global Producing Centres, Regional Specialized Meteorological Centres and National Meteorological and Hydrological Services. The System also supports the exchange of certain other data, such as seismic data.



Structure of WMO's Global Telecommunication System (NMC = National Meteorological Centre)

The Global Telecommunication System ensures that each country has access to the information it needs to provide effective, weather, climate and water services and warnings to decision-makers and the public. It is regularly upgraded, allowing it to benefit from evolving telecommunications technology, as well as to meet increasing requirements.

Already, the Tsunami Warning System for the Pacific uses the WMO System to collect and exchange tide-gauge data. The Global Telecommunication System is also the backbone for the distribution of Tsunami Warning System bulletins to countries of the Indian Ocean rim and for the Interim Tsunami Advisory Information Service. It makes an important contribution to the collection and exchange of data needed for the Indian Ocean Tsunami Warning System, especially those on sea-level from tide gauges that are acquired through the data-collection services of meteorological satellites.



- ***Collaborative:*** Those receiving and using the forecasts must understand the hazards and the risks they pose. Emergency services must ensure that the official forecasts are the ones consistently used in their planning and action, to reduce confusion. The National Weather Service will see its efforts result in more effective response to, and recovery from, hazards, through development of strong partnerships with all levels of decision-makers involved in disaster prevention and mitigation.

Mitigation phase: long-term planning for the community

The tropical cyclone in this story is not the only one this community has ever seen. In fact, the community has been struck by cyclones a number of times in the past, sometimes a glancing blow, with minor damage and a few injuries. Once, however, several years ago, a cyclone of terrible strength swept through the community and caused great damage and loss of life. It was very hard to recover and move on from this event. The people in the community saw how much this cost them, in terms of the loss and injury of family and friends, damage to or total loss of homes and possessions, and in terms of their ability to make a living in the aftermath.

The planning process

They vowed that such a catastrophe should never happen again if they could help it. The government helped them make a plan that would cope with another dangerous event. Living where they did, experience told them it would be inevitable.

The process began with a visit from a team of meteorologists, hydrologists, civil engineers, coastal zone managers, disaster emergency managers and representatives of relief agencies. The topography and soils around the village were examined and the villagers questioned about what had happened in past storms. The most likely path that water, mud, rocks, trees and other debris would take as torrents of rainwater wash everything downhill was determined.

The teams identified the areas most likely to be safe from such runoff and from falling debris and where buildings and their occupants and their livestock would have the best chance to survive the winds and water of a severe storm. They inspected the buildings, roads, bridges and other infrastructure in and around the community, to assess what needed to be reinforced.

Such decisions are a matter of available resources and also experience. In some cases, "traditional" architecture has proved to better withstand local hazards. In coastal management, mangrove forests in the land-sea interface have proved to provide protection against storm surge and coastal erosion.

Severe storms can bring down power and telephone lines and wash out roads and bridges, cutting communities off from the rest of the world. People must be prepared to survive until communications and transportation are restored. The local community and the emergency experts worked together to list the emergency supplies and equipment that would be needed during, and while recovering from, the crisis. These lists include hand-operated radios and flashlights, blankets or sleeping bags, camping stoves and fuel for cooking and boiling water and the amounts of food and water each person would need. They also reminded those people in need of medication to keep enough on hand to last until regular supply lines were re-established.

Severe storms and storm suge can destroy valuable infrastructure such as this hospital in Niue, South Pacific, which has to be replaced at great cost.

It is vital in the planning process at the community level to identify potential hazards and appropriate safety measures. People should know where they can seek shelter for themselves and for their livestock.

Vital factors in this process are the nature of the hazard itself and vulnerability assessment. It is essential that the community knows what hazards it may face, the associated risks and how they happen. The National Weather Service responsible for this community prepared information on the hazards and their power and what warnings would be provided and by whom. They worked with partners in the emergency services and the government to prepare a booklet and other outreach materials that gave this information, as well as advice on how to maximize safety and information on the local and national services where further advice and information could be found. Every household in the community received this booklet from the government but, as not everyone was able to understand everything from this process alone, a number of public meetings were held.

Formulating the National Action Plan

Scientists from the National Weather Service provided information and advice on the weather, water and climate hazards to which this community could be exposed. Representatives of the emergency services went through the procedures everyone should follow for each type of hazard, described the assistance that would be available and made sure everyone knew where and how to find help.

Government officials explained how the village emergency plan formed part of a much larger national strategy—the National Action Plan. Representatives of non-governmental relief organizations such as the International Federation of Red Cross and Red Crescent Societies also offered advice and explained what they would do to help. The relief organizations were also gathering information for their own use. They needed to know, for example, how they could reach the village; where they could deliver aid if the roads became impassable; and whom to contact during the crisis.

As part of the Action Plan, responsibilities were assigned, so that everyone understood who had authority over each step. Finally, once the villagers were familiar with the plan, they rehearsed it. To ensure that all would run smoothly when the hazard occurred, the community then revised its plan to take into account any problems that had been encountered in the drill.

Response phase: how the community "weathered" the weather hazard

The community has taken refuge in the school. They have done what they could to safeguard their property and to keep themselves safe from the storm. And what a storm! Inside the school, volunteers kept the children busy, looked after the elderly and checked the radio for news. The wind and rain battered the building, flinging branches and other debris at its walls and roof, making a pounding, relentless din. Rainwater rushed through parts of the community, heading for the coastline—a fast-moving river of water, earth and anything found loose in its path. The media kept transmitting news of the storm, and where it would pass. Because this community had been informed, they understood that there could be only a temporary abatement of the winds and rain if the eye passed over the village. It would not be safe to expect that the worst was over because the winds had stopped.

The emergency supplies came in handy—everyone kept warm, had food and water, light and news—small comforts given the conditions, and given the memories of a similar storm a few short years before. The pain was still real for many. This time, though, there was a feeling of hope—and confidence that they would withstand this cyclone.

Of course, the storm eventually died down, The National Weather Service gave the good news that the last band of rains and winds had passed, and the community would be out of danger once the flash flooding had abated. The information provided by the meteorologists and hydrologists had impressed the people about the power of moving water. They knew not to try to walk or drive through it, even if it appeared shallow. Opening the doors, those who had sheltered in the school prepared to take stock of the state of their community in the aftermath and to implement the immediate, short-term and long-term measures in their Action Plan.

The response phase: assessing the damage

Recovery phase: cleaning up, rebuilding, and getting ready for the next one

Life does not generally return to normal at once after a severe weather event. The effects can last for some time and much work is usually needed to repair the damage. A recovery period must be part of the action plan for coping with extreme weather hazards.

When the school doors opened, there was no rush to head for home. A small party had been assigned the responsibility of first of all making sure that the streets and buildings were safe. The storm had been powerful and floodwaters were still coursing through the village. Keeping well away from the flooding, the team began its inspection. They looked for downed power and telephone lines; ruptured water, gas or sewage lines; damage to roads and bridges; broken glass and spilled noxious substances. They looked out for injured people. They also looked for snakes and vermin that might have been dislodged by the storm or floodwaters. The team informed the authorities of their findings.

It was quickly apparent that the vegetation and crops had taken a beating. The livestock had fared better, especially those that had been taken to higher ground. Most of the buildings were still standing, but all were checked for structural damage. No one but skilled workers would be permitted to enter a building declared unsafe.

Trained volunteers checked the local supply of drinking water for signs of contamination. Until it was declared safe, no one would be allowed to collect and use water from any well or from the river that passed through the village. The action plan had accounted for this. The community had set aside enough drinking water to last for several days.

As soon as their homes were declared safe, people returned and began the clean-up. For the unlucky ones, whose homes were not safe, temporary accommodation was organized.

The villagers had had a setback, but not a catastrophe. Implementation of the action plan had kept the people safe. This was much better than before. Thoughts turned quickly to re-building—and to new buildings which would be less vulnerable, stronger, out of the way of possible floods. Next time, things would be even better.

The role of the National Weather Service did not end with the passing of the storm. The storm may have left this place but was still causing havoc elsewhere along its path. The Weather Service continued to forecast the full life span of the cyclone, but also remained vigilant regarding the weather for the villagers entering their recovery period.

The relief teams and citizens, working to get things back to normal as quickly as possible need to know if further weather-related challenges will complicate, obstruct or prevent recovery efforts. In a scenario in which not all citizens have been sheltered from the hazard, as in our story, relief and recovery efforts will begin with a search for survivors and for the dead. Medical and food supplies will have to be moved into the stricken area by road, air or sea. This must all be done as quickly and as safely as possible. Relief teams need to be able to rely on round-the-clock support from the Weather Service until the crisis is over.

Flooding can cut off communities and supply routes for days.

SOME OF THE DANGERS IN THE AFTERMATH OF A DISASTER

Extreme weather events are often responsible for conditions that pose serious threats in the aftermath of a disaster. In collaboration with the National Weather Services, disaster preparedness and mitigation bodies provide information that is useful to the public in thwarting these dangers. A non-exhaustive list is given below:

- **Flash floods:** After heavy rains, floods or flash floods are a common occurrence. Moving water is a powerful force. It can damage roads and bridges and sweep away even heavy vehicles. *Head for higher ground. Do not attempt to drive through, or walk through moving flood waters - even 15 centimetres of moving water can knock adults off their feet. When walking in still water, use a stick to test the ground in front of you.*

- **Falling masonry:** The disaster may have caused serious structural damage to buildings. Walls may collapse without warning and interior floors and stairs may be unsafe. Buildings may have been moved off their foundations and roofs may not be firmly attached to the frame. *Allow damaged buildings to be inspected by experts before going near them.*

- **Electric shock:** Power lines may be down and some of them may be live. It is not only the cables that are dangerous: water can be electrically charged from underground or by downed power lines. *Stay away from downed power lines and do not go near floodwaters—live cables may lie in the water. If safe to do so, shut off power at circuit breakers.*

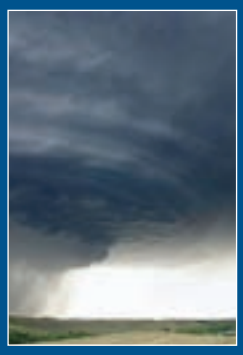
- **Fire and explosion:** Gas pipes and gasoline reservoirs at filling stations may have been ruptured, presenting a serious risk of fire. Gas and gasoline fumes are toxic and can cause asphyxiation, and they can also cause an explosion, if they accumulate in an enclosed space. Escaping gas can be smelled or heard by a hissing sound. *If you smell or hear gas, leave immediately. Shut off the gas at an outside valve if possible. Do not use open flames.*

- **Toxic chemicals:** Floods can wash household and commercial chemicals outdoors into surface water and can carry away drums of chemicals that may rupture. Surface water could be contaminated with oil, gasoline, agricultural chemicals including pesticides, and a wide variety of other substances. *Stay away from floodwaters as they may be contaminated with toxins.*

- **Water-borne disease:** Floods can overwhelm sewers, mixing raw sewage with surface water. There is a risk of disease such as cholera and dysentery. *Wait for the authorities to declare tap water safe and, in the interim, only drink water known to be safe—or boil it for at least three minutes. Always wash hands with soap and clean water after coming into contact with floodwaters.*

- **Wild animals:** Animals, including vermin and venomous snakes that spend much of the time in burrows or crevices may have been driven from their retreats and may be dangerous. *Beware of snakes and vermin that may have been dislodged by the storm.*

Falling masonry represents a danger in the aftermath of a disaster.



PLANNING AND PREPARATION FOR HAZARDS ON DIFFERENT TIME-SCALES

Over the years, this community has learned to plan and prepare for tropical cyclones and associated phenomena, such as floods and landslides. Elsewhere, other communities have to face other hazards which are of different size and occur on completely different time-scales.

Tropical cyclones are large, powerful systems, whose life cycle and behaviour are well known and whose movements are predictable 48-72 hours ahead. Meteorologists can observe and forecast the onset and evolution of both tropical and extra-tropical cyclones, and can track them quite easily. Other hazards, on the other hand, behave quite differently, with each having its own unique features which must be coped with. The planning cycle of mitigation, preparedness, response and recovery will consequently be somewhat different for each hazard. The examples of tornadoes and droughts will highlight certain commonalities and specific differences in recommended responses.

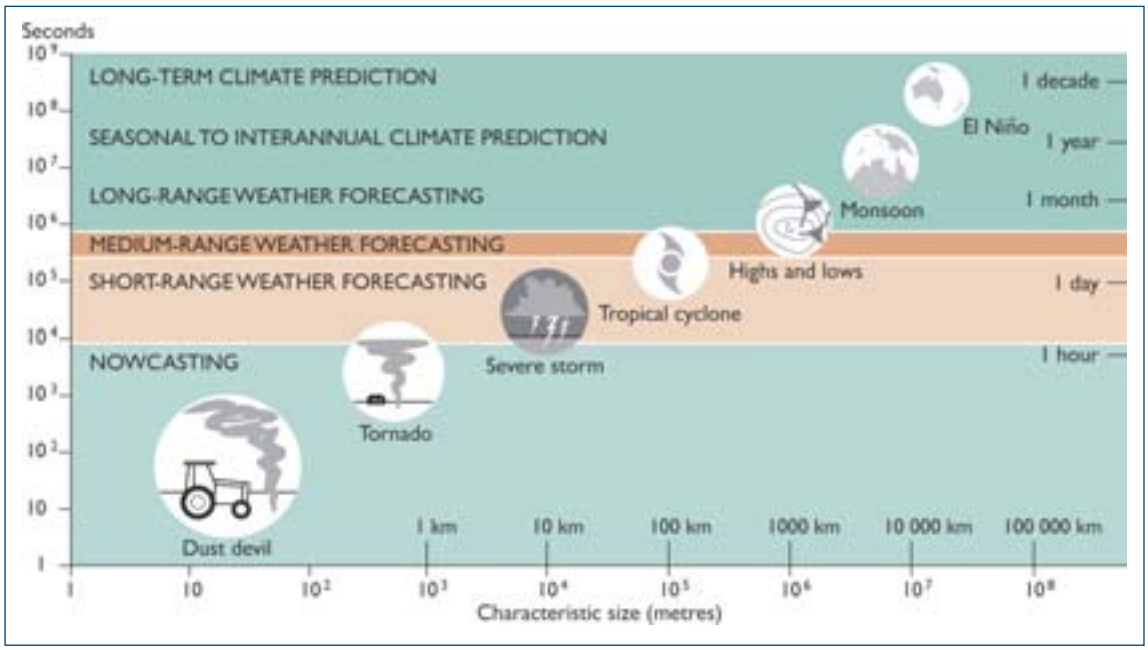
The tornado is the most violent weather phenomenon of all.

Tornadoes

A great deal is known about tornadoes, their awesome power and destructive capability, and in which regions they are most likely to occur. Tornadoes are violent windstorms, characterized most often by a visible, twisting, funnel-shaped cloud that reaches from the thunderstorm cloud base to the ground. Tornados are spawned from severe thunderstorms (they also sometimes result from tropical cyclones) and can be accompanied by lightning and hail, and by heavy rains that can result in flash floods.

A tornado can last from minutes to more than an hour, but most last for 10-20 minutes. This short life-span makes the warning of tornadoes one of the most difficult tasks for National Weather Services, which are the official sources of tornado forecasts. Because tornado development is quite well understood, the conditions likely to cause them can be seen up to a day or two in advance in model output. The Weather Service forecast teams are extremely vigilant, consulting satellite and radar imagery, studying data from wind-profilers, land stations, upper-air balloons, and lightning sensors, for early signs of development. Too many small-scale factors are involved for accurate forecasting several days ahead of convective activity. Also, tornadoes are eccentric during their short lives. Detailed predictions of how many will form or the path along which they will travel are therefore not possible at present.

National Weather Services, specialized prediction centres and research institutes study tornadoes, their occurrence, characteristics and risks, and develop forecasting techniques and warning services that can be of considerable use in mitigation and preparedness phases. Climatological infor-



Examples of the range and scales of natural hazards that are observed, detected, monitored and forecast by WMO networks.

mation is used to strengthen building codes and helps influence structural design for extreme wind situations. In the short-term, the National Weather Service issues watches for and warnings of tornadoes. When a watch is called, people are advised to locate their family members and make sure everyone has access to shelter. As with any other hazard, it is wise to have on hand an emergency kit with a flashlight, radio, first-aid materials, emergency food and water and essential medication.

If a tornado is seen, or if radar shows the characteristic signs of one developing, the Weather Service will immediately issue a warning. People will perhaps have only minutes to take shelter. Experts advise that safe shelter would be a windowless, interior room in a basement, or the lowest place possible in a building—a small inner room like a closet could be safe. It is important to stay away from windows because of breaking glass, and to get out from under wide-span roofs such as in auditoriums. If caught outdoors, people are advised not to take shelter under a bridge, to get out of their cars and to lie low in a ditch (but to beware of flash flooding).

Once the tornado has passed, it is wise to stay tuned to the National Weather Service broadcasts, in case there is more to be braced for. People are advised to stay out of damaged buildings until they are inspected, to avoid downed power lines and to be alert to chemical spills, water contamination, gas leaks and fires.

Droughts

Droughts are normal climate events. They are not at all rare but their characteristics, such as duration and severity, can vary considerably in both time and space. Droughts are caused when, over an extended period of time, a region experiences a deficiency of precipitation or a long-term imbalance between precipitation and evapotranspiration. Droughts can be related to timing of precipitation during a rainy season or the effectiveness of the precipitation. In other words, the amount of rainfall received during a season could be "normal" but it may all occur at the end of the period or come only in short, intense downpours that immediately run off. Human activity and the demand on available freshwater resources

Tornado damage

Australia suffered drought in the 1997/1998 and 1981/1983 El Niño events. (Photo: Australian (Government Department of Foreign Affairs and Trade)

for use by people and livestock, can exacerbate the impacts of a drought.

Droughts can result in loss of agricultural productivity and extensive crop failures, both of which contribute to reduced viability of the economy and to increased health risks for the human population and livestock. Severe droughts can lead to famine and starvation. Drought can cause migration of people and herds, leading sometimes to civil unrest and political issues. Dehydrated vegetation is vulnerable to wildfires and barren land is vulnerable to wind erosion and loss of topsoil. All these factors can contribute to desertification.

WMO and National Weather Services develop climatologies of drought and conduct research into its causes. Together with research institutes, global prediction centres and partners in organizations such as the United Nations Food and Agriculture Organization (FAO), public information and materials for decision-makers are developed and incorporated into long-term mitigation, planning and preparedness efforts. This information—particularly reliable predictions of very dry or very wet seasons or years, can be extremely useful to partner agencies and governments which have to allocate their available resources early in each financial planning cycle.

Droughts develop slowly, and their onset can be masked by a number of factors. Many of the atmospheric and oceanic conditions that could lead to drought are well known, however, and, in many parts of the world, scientists have developed reliable seasonal predictions related to drought. Research shows that the El Niño-Southern Oscillation can be a reasonable predictor for drought in some regions, particularly in the tropics. Regional specialized Drought Monitoring Centres, in Harare, (Zimbabwe) and Nairobi (Kenya) were established to monitor, study and predict droughts and other hazards in Africa. Similar centres exist in other countries.

Seasonal to interannual prediction of hazards

Most people recognize that the weather has certain seasonal characteristics—pronounced warm or cold or wet or dry periods. In addition to these seasonal cycles, meteorological and ocean science researchers have identified a number of oscillations, or cycles, in the way the atmosphere and oceans interact over time to produce varying weather patterns.

The Madden-Julian Oscillation

The Madden-Julian Oscillation, for example, is a roughly periodic behaviour of tropical convection that influences tropical convective rainfall and the formation of tropical cyclones. This cyclic behaviour, coupled with frequent analysis of satellite imagery, allows reasonable prediction of active convection areas, including the movements of the Inter-Tropical Convergence Zone (ITCZ) over Africa and

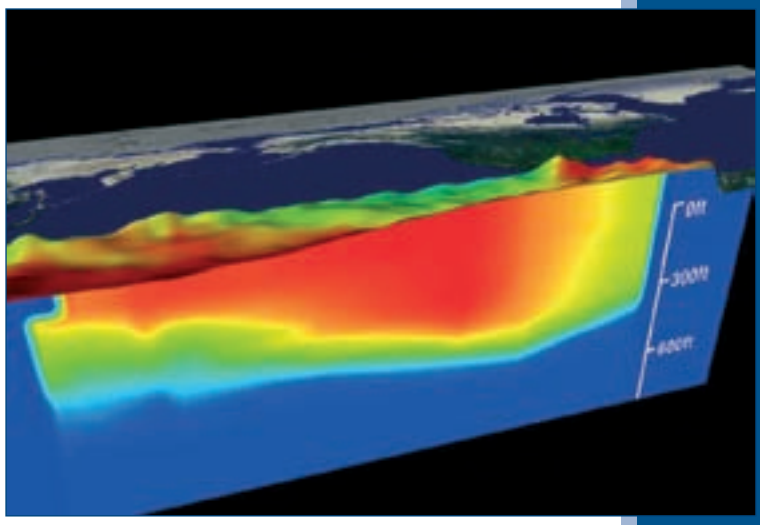
the South Pacific Convergence Zone near Samoa in the Pacific.

El Niño-Southern Oscillation (ENSO)

The best known natural fluctuation of climate is the ENSO phenomenon. The Southern Oscillation is a large-scale atmospheric fluctuation centred in the equatorial Pacific Ocean. It is characterized by a pressure fluctuation between Australasia and the South Pacific that is accompanied by variations in wind strength, ocean currents, sea-surface temperatures and precipitation in the surrounding areas. El Niño is traditionally associated with an extensive warming of sea-surface temperatures across the central and eastern equatorial Pacific Ocean. El Niño events can last for several months to more than one year. The opposite phenomenon, La Niña, is an extensive cooling of sea-surface temperatures in the equatorial Pacific Ocean, lasting from seasons to more than a year. ENSO, therefore, is a feature of the interaction of atmosphere and ocean and links the fluctuating temperatures of the equatorial Pacific Ocean with changing wind, cloud and rainfall patterns in the tropical Indo-Pacific region.

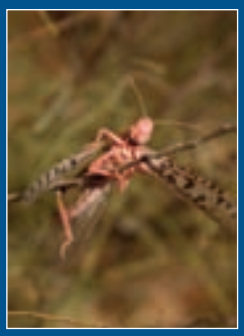
ENSO is a primary reason for climate anomalies that may last a season or more in many parts of the world, particularly (but not exclusive to) the tropics. ENSO-related shifts in tropical convection trigger changes in middle- to high-latitude westerly winds, which, in turn, alter the evolution of storm systems far beyond the tropics. Although no one ENSO event is exactly the same as another, there are certain general characteristic patterns of ENSO impacts on regional and local weather and climate.

ENSO events have been responsible for major socio-economic impacts around the world throughout history. In recent times, the events of 1982/1983 and 1997/1998 have made El Niño a household term. During the 1997/1998 El Niño, believed to have been the strongest of the 20th century, severe drought in Indonesia led to widespread wildfires that cast a pall of smoke over a wide area of South-East Asia. The worst drought of the century, coupled with exceptional cold in the New Guinea highlands led to serious food shortages for 1.2 million people. North-eastern Brazil also experienced drought. At the same time, there were extensive rains in tropical East Africa, and some 15 000 people died as a direct result of floods and ensuing disease. Australia suffered drought (although it was worse in the 1982/1983 event). In 1997, the June-November hurricane season in the Atlantic was the quietest on record up to that point. China and the Philippines also saw reduced storm activity.



The El Niño/Southern Oscillation phenomenon is now well understood and ability to predict it is improving.

ENSO is now well understood and scientists' ability to predict it is improving. With large arrays of instruments monitoring conditions across the oceans, and increasingly sophisticated computer models, meteorologists can detect the early signs that an El Niño is about to develop and predict ENSO conditions three to six months ahead with reasonable skill. This information is shared on a continual basis with National Meteorological and



Weather information facilitates the prediction of the formation and movement of locust swarms, as well as control operations. (Photos: FAO)

PLAGUES OF LOCUSTS

Every few years, unusually high rainfall makes vegetation flourish in a semi-arid region. With abundant food for their offspring, female locusts lay many more eggs than usual. The wingless young, called hoppers, feed peaceably, avoiding contact with one another, until the vegetation becomes sparser with the return of dry weather. The hoppers are crowded more closely together and individuals meet more often.

Then a change comes over them: they no longer avoid one another. When two individuals meet, they tend to stay together, feeding all the time, and when two groups of hoppers meet they merge to form a larger band. The insects continue to grow and when they mature they sprout wings. When the adult locusts have eaten all the vegetation around them they move away in search of more, as a swarm. Despite covering large distances, locusts are weak fliers and swarms drift with the wind, travelling up to 200 km a day.

A locust swarm can comprise as many as 80 million insects and a locust outbreak—a plague—can comprise several swarms. One million locusts will eat nearly two tonnes of food a day: about as much as 10 elephants, 25 camels or 2 500 people.

The National Weather Services of affected countries help track the swarms by monitoring and forecasting meteorological conditions. They work closely with those engaged in locust control. WMO and the United Nations Food and Agriculture Organization advise national weather and locust control services.

Hydrological Services around the world so they can advise citizens and decision-makers of emerging threats.

WMO El Niño updates

WMO regularly coordinates scientific opinion worldwide and, when conditions so warrant, produces "El Niño updates", a consensus-driven assessment of the anticipated development of ENSO for months ahead. These updates are issued to Weather Services and to the public, and have proved to be reliable and useful products.

Monsoons

Another well known and predictable major weather feature is the monsoon. Monsoons occur in Australia, Africa and North and South America, but the best known and most studied are the East Asian and Indian monsoons. Predicting the onset, intensity and cessation of the Indian and East Asian monsoons is of immense value to the peoples of these regions. Late arrival of the Indian monsoon in June or July, or early withdrawal in August or September, for example, can ruin crops and lead to great hardship.

PLANNING FOR ENVIRONMENTAL EMERGENCIES AND CLIMATE CHANGE

Huddled together within the confines of the schoolhouse for the duration of the emergency, the elders of the village recalled their own experiences and those passed on to them by their parents and grandparents. The children listened to their stories about the devastating cyclones and other phenomena—flash floods, tornadoes, lightning and bushfires—that had left a lasting mark on the village and its inhabitants.

The villagers had heard discussions about climate change on the radio and television and read about it in the newspapers. They wondered if their local climate was changing. Most of the villagers earned their living from the land and the sea. They speculated about potential impacts of a changing climate on their livelihoods and on food security. In recent years, the population had been growing and new industries had come to the region. The villagers were becoming concerned about air and water pollution.

They had the idea of requesting the authorities to advise them about climate change and its potential impacts, as well as on environmental emergencies to enable them to take timely preventive and mitigation measures as they were already doing for tropical cyclones.

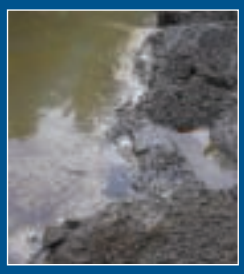
It is the responsibility of National Meteorological and Hydrological Services to detect, observe and forecast extreme events related to weather or water and to warn of impending risks of these natural hazards. WMO's system also allows observation and warning of the movement in the atmosphere and in water of chemical substances, particulate matter and contaminants. Meteorologists monitor chemical substances or living organisms that remain airborne for any length of time, as well as the drift of ash and gases from volcanic eruptions and of pollutants resulting from industrial accidents. Hydrologists track the movement of oil and other contaminants that enter rivers, lakes, seas and oceans.

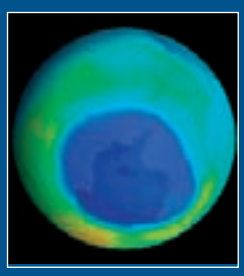
Working through the National Weather Services, WMO helps in these tasks by facilitating the smooth flow of observations, forecasts and other information between countries, The global system that WMO coordinates includes the Emergency Response Activities (ERA).

Based on the capabilities of their National Weather Services, ERA assists countries to respond effectively to environmental emergencies. Emergency Response Activities has been built in collaboration with the International Atomic Energy Agency, the World Health Organization and the United Nations Food and Agriculture Organization. It centres on the round-the-clock services of eight designated Regional Specialized Meteorological Centres (in Beijing, China; Exeter, United Kingdom; Melbourne, Australia; Montreal, Canada; Obninsk, Russian Federation; Tokyo, Japan; Toulouse, France; and Washington, USA). These centres share the responsibility for providing warnings and information, for example on the atmospheric transport and dispersal of pollutants, as part of internationally coordinated response plans.

Initially developed to deal with nuclear accidents, ERA is expanding and enhancing the capabilities of National Meteorological Services to respond to emergencies arising from volcanic eruptions, forest and wildland fires, airborne disease organisms and chemical accidents.

The observational data and forecasts of weather, climate and the atmosphere that are collected through WMO's network of





observing, data-transmitting and forecasting systems are vital inputs to various international environmental conventions on climate change, desertification, air quality, biodiversity and the ozone layer. Policy-makers are thus kept informed of the state of the environment so that they may be in a better position to prevent its further degradation.

Climate change and weather extremes

It is generally agreed that the global mean surface temperature has increased by 0.6° to 0.7°C since 1860, when instrumental records began. Recent years and 2005 in particular have been among the warmest observed over several centuries. At the same time, statistics from centres such as the Center for Research on the Epidemiology of Disasters show that there is an upward trend in the number of extreme weather and climate events. In 2005, the number of hurricanes in the Atlantic basin reached an unprecedented number. The cost of such events to the insurance industry is also growing considerably. In the mind of everybody, the question is whether the patterns in the extreme weather events being observed are the result of a change in climate.

While these questions are the subject of intensive studies and research, scientists are increasingly aware of the implications of potential climate change on extreme weather events. The assessments, based on climate model outputs, of the Intergovernmental Panel on Climate Change (coordinated by WMO and the United Nations Environment Programme) indicate that climate change is likely to result in more intense precipitation and associated flooding over many mid- to high-latitude areas in the northern hemisphere. In other areas, there could be increased summer continental drying and associated risk of drought conditions. There may be an increase of heat waves over land areas; people living in an urban environment are particularly sensitive to such increases. The impact of climate change on tropical cyclones, especially with regard to increases in number, frequency, wind strength and precipitation intensities, is a subject of intense research.

Current projections of El Niño events over the next 100 years show little or no change or a small increase in amplitude. Even with little or no change in El Niño, global warming is likely to lead to greater extremes of dryness and of heavy rainfall and an increase in the risks of droughts and floods that occur with El Niño events around the world.

Monsoons affect various parts of the globe and are vital for the livelihood of the people affected by them. Heavy monsoon rains lead to flooding while weak monsoons

often result in drought conditions. Climate models indicate that global warming may cause an increase of Asian summer monsoon precipitation variability, while confidence in the projections of monsoon mean duration and strength is limited.

For some other small-scale extreme phenomena, such as thunderstorms, tornadoes, hail and lightning, which have significant impacts on the environment and society, there is currently insufficient information to assess recent trends and climate models currently lack the spatial detail required to make confident projections of these phenomena.

Extreme weather and climate events

BEING PREPARED SAVES LIVES

Adapting existing buildings to withstand severe weather events is an investment in safety. Above: proper installation of blocks beneath mobile homes will ensure fewer instances of damage during a flood. Below: a house, originally built in a floodplain, was raised a level to save it from future flooding. (Photos: Dave Gatley/ FEMA News Photo)

The experience of the village community provides lessons for all communities, including those in urban environments. We shall look at the real-life example of Bangladesh, practical advice on how to prepare individually and collectively, the benefits of investing in safety, and the international cooperation that is essential if communities around the world are to achieve and continue to enjoy a high level of safety.

The Bangladesh example

Emergency plans that help people prepare for and respond to natural disasters save lives.

The experience of Bangladesh provides an excellent example of the benefits of planning and preparation. The authorities spent 10 years establishing integrated early warning services to safeguard people from hazards caused by tropical cyclones, storm surges and tidal and river floods. The project has largely succeeded in establishing improved observation and communication systems and close cooperation between the National Meteorological Service and the disaster preparedness community. It has developed nationwide alert mechanisms built on a network of more than 5 000 volunteers, as well as other mechanisms to deliver critical warnings and advisories to communities at risk. These warning systems, combined with programmes based on local cultures, educate and prepare people to respond to emergencies appropriately. This, together with activities such as building shelters in coastal areas, has saved many lives. For example, in 1998, a major storm surge led to nearly 140 deaths. This loss is high but, in a storm of similar magnitude in 1991, 130 000 people lost their lives. In 1970, some 300 000 perished in the storm surge that swept across the deltas of the Ganges and Meghna Rivers.

WMO has supported developments such as those in Bangladesh and recently made a significant contribution in the form of a regional project on flood management at village and household levels that aimed to ensure the effectiveness of public warning messages. The project proved its worth during the severe monsoon rains of 2004. The tsunami alert-and-response mechanism in Bangladesh will be built on the current national alert and response system for storm surges.

Taking responsibility

An emergency action plan involves institutions at many levels, from national government to local councils, but it is not enough to wait for officials and the emergency services to shepherd everyone to safety. Individuals and families should take responsibility for their own safety and that of their homes.

There is much that individuals can do to protect themselves. Those living in areas at risk should lay in supplies of boarding

HOW INDIVIDUALS AND FAMILIES CAN PREPARE

There are steps anyone can take to prepare for a natural emergency. Not all of the advice given here applies everywhere, but much of it does.

- Find out where you can obtain reliable information about potential hazards in your area.
- Learn about the official plan for dealing with an emergency arising from extreme weather, water, and climate conditions.
- Find out whether the area where you live has suffered emergencies in the past, what types of hazard they were, how frequently they occurred, and the type and extent of the damage they caused.
- Study the surrounding area: identify low-lying places that are at risk of flooding and places that are exposed to high winds.
- Identify escape routes from your home and mark them on a map. Remember that a storm may make a route across low ground or bridges impassable, so if you have to evacuate you will need to leave before the storm arrives. Keep the "escape map" in a safe place and make sure everyone in the household knows where and what it is.
- If possible, arrange to stay for the duration of the emergency with friends or relatives outside the affected area.
- Where most people have access to cell phones, ask someone who lives outside the area to act as a contact through which family members can communicate their location and situation should they become separated.
- Obtain supplies of wood, plywood sheeting, polythene sheeting, nails, and rope for boarding up windows and securing external doors.
- Obtain good-quality flashlights or lamps and a reliable battery-powered or hand-cranked radio. Make sure they are in working order and that you have spare batteries.
- Obtain a camping stove and fuel for cooking and heating water.
- Prepare a first-aid box.
- Learn basic first-aid skills.
- Make a list of the supplies you and your household (including pets) will need to survive for two weeks.
- If you are evacuated you may need blankets or sleeping bags.

Building techniques adapted to a region's climate can help save damage and injury from natural hazards.

to cover their windows and doors and rope to secure outdoor items that could be dislodged by wind. Those living in a region prone to tornadoes should prepare a storm shelter where they can take refuge. If there is a risk of flooding from a nearby river, householders can keep a supply of sandbags ready to make exterior doors watertight. Snow shovels and a store of salt and grit will help reduce the impact of ice and heavy snow.

Good house and ground maintenance also helps. Check there are no loose or missing tiles or slates on the roof. The wind will enter through such small gaps and exert an upward force from beneath the roof that may be strong enough to cause serious damage. Make sure gutters and drainpipes are free from obstruction. Remove old or weak trees and branches and shrubs that could blow about in a strong wind.

More generally, there are preparations everyone can make to increase their chances of surviving a severe hazard of any kind (see box on page 29).

The need for worldwide collaboration for monitoring the weather

Continual observation of the world's atmosphere and oceans requires scientific collaboration on a global scale. The village of our story survived—and others can also survive—because, in large measure, the National Meteorological and Hydrological Services receive the information they need from other national, regional and global centres to prepare and issue timely warnings through the WMO communications network.

The modern technology meteorologists use to gather, analyse and communicate information is very costly. Meteorological satellites, for example, are manufactured, owned and operated by those countries or groups of countries that have a space programme. Most countries cannot afford to develop or operate satellites on their own. Nor can they always afford advanced electronic instruments or the supercomputers needed to process vast quantities of atmospheric and oceanic data in real-time. The international collaboration that fosters the transfer of data from ground stations, ocean buoys, ships and aircraft, prediction output from models, satellite data and products, maps and imagery, etc., between major centres and National Weather Services is an important aspect of WMO's philosophy and service.

It is WMO's objective that all essential information is made freely and quickly available so that Weather Services can do their part to ensure the safety and security of people around the world.

Investing in safety

Preventing and mitigating natural disasters call for capital investment and the cost may be high.

Collapsing buildings are responsible for many deaths and injuries during and in the aftermath of severe weather events. Strengthening buildings so that they can withstand hurricane-force winds and torrential rain will reduce the numbers of deaths and injuries from falling masonry. Climate information is a vital part of developing building codes that ensure new or rebuilt structures are able to withstand local hazards.

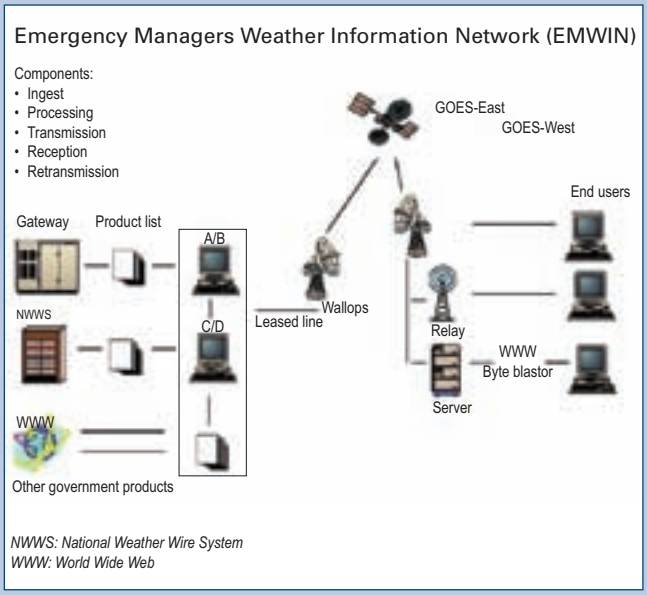
Death, injury and loss of property from flooding and storm surges could be reduced if people could be dissuaded from building their homes on floodplains and along low-lying coasts. Replacing existing buildings and persuading people to abandon homes may be impractical, but building and planning regulations, strictly enforced, will ensure that buildings and developments in future will be safer than those they replace.

Failure of infrastructure arising from floods, winds and extreme temperatures may also endanger life. Strengthening or raising bridges, particularly those that are vital to evacuation plans, would ensure they are better able to withstand flash floods. Once weather conditions improve, relief workers will need to bring essential supplies to the afflicted region. Roads and railroads into the region must be maintained or returned to service as soon as possible after the event.

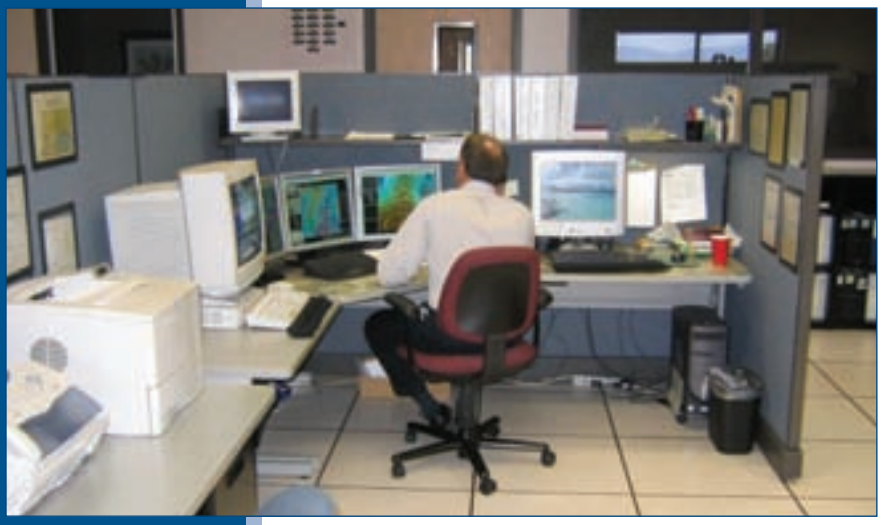
EFFECTIVE AND TIMELY COMMUNICATION: A CRITICAL COMPONENT OF AN EARLY WARNING SYSTEM

Efficient international and national satellite-based data-distribution systems, operated by National Weather Services under the aegis of WMO Programmes, provide timely and reliable access to weather, climate and water information. One example among many is the Emergency Managers Weather Information Network (EMWIN) operated by the USA's National Weather Service.

EMWIN is a wireless, priority-driven computer weather data broadcast system that provides rapid satellite dissemination of alerts/warnings, forecasts, graphics and imagery. It is a free service, using low-cost, readily available technology. EMWIN is of crucial importance for National Weather Services in the Caribbean and the Pacific.



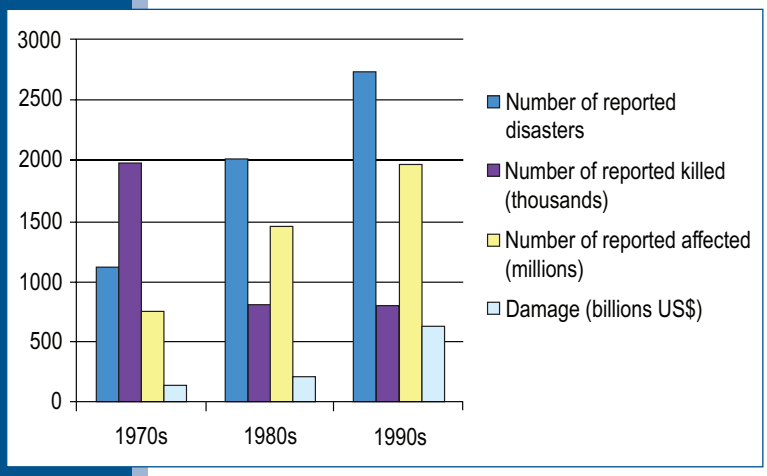
Bridges need to be strengthened to reduce damage, facilitate evacuations and ensure relief operations.



National Meteorological and Hydrological Services are on duty all day, every day of the year. (Photo: NEXRAD)

Getting the warnings out

It is essential to put in place mechanisms for communicating warnings to the people at local level who are in danger and must take action to protect their lives and property. Long-distance communication from an emergency management centre can be by telephone, e-mail or radio, but some communities may not have the necessary equipment. A community that cannot be contacted will have no chance of implementing a prepared plan before a hazard strikes. Access to a radio, such as through the RANET (Radio and InterNET) programme or a computer link to the outside world could save many lives (see page 8).



The economic impact of natural disasters shows a marked upward trend over the last few decades.

Investing in your Weather Service pays off

For an emergency plan to succeed, those who must implement it will need access to reliable and understandable information and forecasts that can be incorporated into the decision-making process leading to appropriate action. The National Weather Services that produce these forecasts are expensive to run, however. Modern meteorologists rely on a wide range of instruments and equipment and, as technology advances, items like computers must be upgraded or replaced at fairly frequent intervals. In addition to the cost of the equipment, life-cycle maintenance of observing instruments, the cost of weather balloons, for example, and communications costs (including access to the Internet and satellite data feeds), have to be considered.

Because atmospheric conditions are constantly changing, National Meteorological Services must remain active and alert for the 24 hours of every day, every day of every year. Meteorologists and technical staff work shifts to ensure that the Service is always vigilant. Meteorologists prepare the routine weather forecasts that are broadcast on radio and television, printed in the press or shared over the Internet, and the more specialized forecasts for sailors, fishermen, farmers and others, who need more detailed information.

One of the most important responsibilities of Weather Services is to detect the approach of weather conditions that may be dangerous, and issue the timely warnings that save lives, at any time of the day or night.

The need to be on permanent watch and to be able to communicate, at any time, atmospheric, ocean and terrestrial data, forecasts and warnings of severe weather-related hazards makes Weather Services a very strong partner for communication of timely information on other types of

hazards as well. In the aftermath of the 2004 tsunami that devastated parts of Asia, WMO is increasingly working in concert with other international agencies, in particular the Intergovernmental Oceanographic Commission (United Nations Educational, Scientific and Cultural Organization) to ensure that its communications and observations capabilities, its expertise in early warnings, and the 24-hour watch responsibility of the Weather Service in each country are part of the global plan to prevent such a disaster from ever happening again.

Government decision-makers need to understand that investment in National Weather Services is needed and that it is worth the expense. It is not easy to determine the socio-economic benefits of weather, climate and water services, but governments and funding agencies increasingly request this information for decision-making. They should be aware that the cost-benefit ratio of effective warning is at least one to seven.

Amongst other considerations is the cost of the impacts of extreme weather, in terms of lives lost and net economic losses. In any disaster, however, not all those affected are affected negatively. In the aftermath of a hurricane, for example, the lumber and construction industries can often find their business prospects much enhanced. In some places, cyclones bring in much needed rain. Innumerable people, however, lose a great deal—sometimes everything—in violent weather. In the world as a whole,

PREVENTING ONE DISASTER FROM FOLLOWING ANOTHER

Although WMO and many National Meteorological and Hydrological Services do not advise on emergency planning relating to hazards such as earthquakes, tsunamis and volcanic eruptions, that are unconnected with weather or water, they can and do help in the aftermath of such disasters. They supply regular local weather forecasts to help relief workers and advice on the siting of facilities such as refugee camps. For instance, they can warn that a particular site, although logistically convenient, is likely to be flooded in the event of heavy rain.

On 28 October 2005, following a huge earthquake, the Pakistan Meteorological Department released a seasonal weather report warning that the region was likely to experience a harsher-than-average winter. Snowfall was expected to exceed the norm both in frequency and quantity. This long-range forecast indicated that temperatures in mountainous areas would remain below freezing throughout January. At night they would sometimes fall to below -20°C. The forecast had a direct bearing on an estimated three million people who survived the earthquake, as well as on the plans of the humanitarian and relief organizations working to save lives throughout the region.

In Niger, in 2005, people were struggling against prolonged drought. Future harvests remained uncertain and many people, especially children, were suffering from malnutrition exacerbated by diseases such as malaria and diarrhoea. Weather forecasts helped those trying to overcome the disaster. The Meteorological Service provided seasonal, ten-day, and seven-day weather forecasts and assessments of accumulated precipitation—important for predicting crop yields.

The Direction de la Météorologie Nationale of Niger and the African Centre of Meteorological Applications for Development were aiding the Food Crisis Management Unit and other organizations in their efforts to tackle the country's food crisis. WMO assisted these institutions in obtaining the relevant data and forecasts.

The costs of purchasing, maintaining and repairing equipment are high but the need is vital and the fruits are tangible.

WMO, through its unique global network operated by the National Meteoroloogical and Hydrological Services, does its utmost to ensure that the world's citizens are kept safe from the adverse impacts of natural hazards. (Photo: ACMAD)

over the last decade, natural disasters arising from extreme weather or climate episodes such as drought cost at least US$ 450 billion. That is a huge amount. It is almost two-thirds of the total cost of losses due to natural disasters of all kinds.

How much could be saved, through provision of weather information and forecasts as part of an effective emergency action plan? WMO is taking steps to help National Weather Services develop the tools and knowledge that will allow them to prepare this kind of information for their governments and partner agencies.

Natural disasters impose costs that go far beyond the repair of homes and the replacement of private property. A country that suffers a disaster of this kind has no choice but to divert some of its resources to restoring essential services. Roads, bridges, rail tracks and power and telephone lines must be repaired so that the country can continue to function. Public buildings such as schools and hospitals must be made safe or rebuilt. Water and sewerage systems must be restored urgently, to prevent outbreaks of disease. The injured must receive medical treatment. All these unavoidable costs must be met from resources that might otherwise have been invested in development projects.

The danger passed

Back in the village, life is starting to return to normal. The damaged buildings are being repaired and those that were destroyed are being rebuilt. The community is grateful to have withstood the cyclone with only minor damage.

They understand that another cyclone will strike—this is part of living in this place. They know that their National Weather Service will make sure it does not strike without warning. And they now know that they have an emergency plan that works. It saved lives and protected their livelihoods. It was worth the effort.

No one is immune from the risks associated with weather, climate and water hazards, but we do not have to wait helplessly while our lives and livelihoods are in danger. WMO collaborates with the National Meteorological and Hydrological Services of each country to help their populations plan and prepare, so that they may survive and recover and build a better future.

Photo credits:

E. Al-Majed, Météo-France, Kyoto News/Japan,
NOAA, FAO/G. Diana, South Australia Metropolitan Fire Service, ICRC, DigitalGlobe, ISDR, Randy Williams.
Despite our efforts, we were unable to identify the photographers of some of the photos.
Their photos have been included in the belief that they would want to share their work with WMO.

For more information, please contact:

World Meteorological Organization

7*bis*, avenue de la Paix - P.O. Box 2300 - CH 1211 Geneva 2 - Switzerland
Tel.: (+41) 22 730 83 14 - 730 83 15 - Fax: (+41) 22 730 80 27
E-mail: cpa@wmo.int - Website: www.wmo.int