5.5 Early warning systems

The ultimate goal of hazard forecasting and early warning systems is to protect lives and property. They therefore constitute one of the key elements of any disaster reduction strategy.

To serve people effectively, systems must be integrated and link all actors in the early warning chain including the scientific and technical community, public authorities and local communities. Accurate, timely, reliable and comprehensible communications are essential. Effective early warning procedures should be part of the national institutional and legislative framework for disaster management. They equally need to have redundancy built into the system.

Early warning must be complemented by professional services, training and capacity-building activities and the allocation of resources to enable timely actions to be taken to avert loss.

This section will start with the current status of early warning thinking. It will then examine the three key prerequisites on which to build effective early warning systems:

- *political responsibility to promote integrated early warning strategies;*
- *human dimensions of early warning; and*
- *international and regional support.*

It will also describe the following components of the early warning chain:

- *technical identification and monitoring of hazards;*
- *communications requirements; and*
- *response to warnings.*

Current status of early warning thinking

Early warning has always been considered a cornerstone of disaster reduction. One goal of the IDNDR was that all countries should, by the year 2000, have ready access to global, regional, national and local warning systems and broad dissemination of warnings.

During the past decade, many activities promoted the benefits and feasibility of early warning, and identified major strengths and weaknesses of related capacities around the world. These included the 1994 *Yokohama Strategy and Plan of Action for a Safer World*, the declaration of the 1998 Potsdam International Early Warning Conference, the Early Warning Programme Action Plan for the Future presented at the IDNDR Programme Forum in 1999 and the recent outcomes of the Second International Conference on Early Warning in 2003.

Specific concerns were also addressed relating to climate phenomena such as El Niño (1998 Guayaquil International Seminar) and to small island developing states (SIDS) (1994 Barbados Global Conference).

Efforts to integrate early warning as an essential component in disaster reduction have always been encouraged by the UN General Assembly. The crucial importance of early warning was again validated by the ISDR Inter-Agency Task Force which identified early warning as a priority area for its work and created a Working Group on early warning from 2000-2003.

Advances in science and technology during the last decade have improved the potential of early warning to reduce human loss. Good estimates of the timing and location of landfall for tropical cyclones now can be made 48 hours ahead. In one decade, warning lead-time of tornadoes has

doubled. Drought warnings are now issued several months in advance.

The development of new information technologies and the rapid spread of global communications have considerably increased the availability of information and early warnings about natural hazards and disasters. These technological advances now enable better monitoring and forecasting of extreme weather conditions.

Significant improvements in global observation systems have also enhanced the early detection of medium-term climatic conditions such as El Niño events, and will contribute to warnings of long-term hazards associated with environmental change. Sophisticated early warning systems will only be effective with the free and unrestricted exchange of meteorological data.

Early warning systems also must be comprehensible and accessible to all users. They must deliver clear and concise messages tailored to respective social and cultural contexts. The ability to deliver vital information to the public at risk has not always been successful. In many cases, local mechanisms for communicating risk and interpreting warnings remain very weak. Sophistication of technical information may be of little use if it is not linked to the local situation's capacities, resources and traditions.

Moreover, detailed information about the adverse impacts of hazards on people and infrastructure, and their vulnerability – necessary for informed decision-making – is often missing. Even where procedures do exist, communities often do not respond appropriately to warnings because of lack of community engagement and lack of planning, training, resources or viable response options. In many documented cases, the perceived threat of looting following evacuations is considered greater than property loss caused by disaster. In the absence of information about what actions to take, warnings can create panic or indifference.

Box 5.31
Elements in the early warning chain

The main elements of the early warning chain are:

- Detecting and forecasting impending extreme events to formulate warnings on the basis of scientific knowledge and monitoring, consideration of factors that affect disaster severity and frequency;
- Disseminating warning information, augmented by information of the possible impacts on people and infrastructure (i.e. vulnerability assessment), to the political authorities for further communication to the threatened population, including appropriate recommendations for urgent actions; and
- Responding to warnings, by the population at risk and local authorities, based on a proper understanding of the information, and subsequent implementation of protective measures.

Early warning is now widely acknowledged as being much more than a scientific or technological issue related to hazard monitoring, forecasting and telecommunications and climatology, volcanology and seismology. Satellite coverage and state of the art surveillance techniques are now well developed. As stated by Sorensen (2000), "better local management and decision-making about the warning process are more critical than promoting more advanced technologies, although both would help".

The dissemination of, and response to, warnings are still areas where knowledge is at an early stage. For example, in 1997, research in the United Kingdom indicated that the performance of its flood warning systems was generally poor. This was seen as primarily due to weak links in the chain that connects forecasts with the public at risk. The study found that only about fifty per cent of warnings were received by intended recipients.

In some places, inhabitants became aware of flood risks through unofficial or informal flood detection and warning processes, with the official warnings being received well after the informal alert. Sometimes warnings were received even after the flood had occurred. People were found to be dissatisfied with poorly targeted systems that did not reach down to those at risk. Unsuitable institutional arrangements were cited as part of the dissemination problem. Areas of concern were the weaknesses in:

- monitoring and evaluating hazard onset situations;
- learning from experience to improve future policies and operational practices;
- the effectiveness of internal communications systems;
- communicating with potential victims and advising them of appropriate actions;

- providing adequate levels of pre-hazard training; and
- mobilizing resources for response activities.

The example of the March 2001 floods in the town of Grafton, New South Wales, Australia illustrates problems associated with the response element of the warning chain. The potential threat was so serious that it was decided to evacuate all 12,000 residents from the flood hazard zone. However, fewer than ten per cent of the residents left the city during the nine-hour evacuation period. A research project was undertaken to enquire into why so many people remained in the danger area.

An examination of recent reviews of flood warning systems in North America and Europe also points to an overall negative assessment of warning performance. However it also shows that substantial progress is being made in many local areas and countries, as well as in steady improvement in the reliability of forecast and communications hardware.

As illustrated by the Mount Pinatubo example, the success of early warning systems depends greatly on human aspects related to public understanding, communication and confidence. The conscious shift of many national meteorological services away from a predominantly science-centred approach to a more user-oriented philosophy is a welcome step toward improving the overall effectiveness of early warning systems.

The basic principles for effective early warning, which are partly the result of several years of work undertaken by the IDNDR Early Warning Programme, are reproduced throughout this section and provide a clear and comprehensive basis for the early warning process. The challenge in coming years is to translate the accepted principles into action and practical procedures that systematically protect people from avoidable harm and loss.

Box 5.32
Principles and responsibilities for effective early warning

The objective of early warning is to empower individuals and communities threatened by hazards to act in sufficient time and in an appropriate manner so as to reduce the possibility of personal injury, loss of life and damage to property or the environment.

Risk assessment provides the starting point for an effective warning system. It identifies potential threats from hazards and establishes the degree of local exposure or vulnerability to hazardous conditions. This knowledge is essential for policy decisions that translate warning information into effective preventive action.

The responsibility for effective early warning spans from local to international levels, each level having essential but partially overlapping functions:

- Vulnerable populations need to be aware of the hazards and the related effects to which they are exposed and be able to take specific actions to minimize the threat of loss or damage.
- Local communities need to have sufficient familiarity with the hazards to which they are exposed. Community leaders must understand the advisory information received, to be able to advise, instruct or engage the population in a manner that increases their safety or reduces the possible loss of resources on which the community depends.
- National governments need to exercise sovereign responsibility to prepare and issue hazard warnings for their national territory in a timely and effective manner. They should ensure that warnings and related protective guidance are directed to those populations determined to be most vulnerable to the hazard risk. The provision of support to local communities to develop knowledge and response capabilities is an essential function to translate early warning knowledge into risk reduction practices.
- Regional institutions need to provide specialized knowledge and advice in support of national efforts to develop or sustain operational capabilities, especially for countries that share a common geographical environment. Regional organizations are crucial to linking international capabilities to the particular needs of individual countries and in facilitating effective early warning practices among adjacent countries.
- International bodies need to provide the means for the exchange of data and knowledge as a basis for the efficient transfer of advisory information as well as the technical, material and organizational support for the development and operational capabilities of national institutions officially designated as responsible for early warning practice.

Box 5.33
Mount Pinatubo, an early warning success story

Early warnings of the 1991 eruptions of the Mount Pinatubo volcano in the Philippines were a notable success. The number of deaths compared to the number of people at risk was small despite the magnitude and violence of the eruption. This was due to a number of factors including:

- timely identification of the hazard and delineation of vulnerable areas;
- successful application of modern monitoring and surveillance techniques;
- accurate prediction of the destructive phases;
- timely issuance and dissemination of easily understood warnings;
- prompt action by key civil defence officials and disaster response workers; and
- timely evacuation of the majority of inhabitants at risk.

The experience highlighted the value of international cooperation based on mutual respect, sustained intensive public education, active involvement of selected scientists as spokespersons for awareness and dissemination purposes, open and speedy communication lines between specialists and civil defence officials, good relationship between scientists and the media.

Source: Punongbayan and Newhall, 1996 and 1998.

Political responsibility to promote integrated early warning strategies

The first prerequisite for an effective early warning system is the recognition of the benefits of early warning in protecting societies. With this recognition, the necessary political engagement and the will to promote early warning as a policy instrument for disaster risk management will evolve. However, political will alone is not sufficient; governments also need to develop and support legislation, administration, contingency planning, operational procedures, including inter-ministerial and inter-agency mechanisms.

Governments must establish and maintain collaborative frameworks essential for the functioning of credible and accountable warning systems. An important aspect in this regard is the necessity to overcome difficulties associated with the inherent uncertainty of hazards and predictions, and to build the understanding and support needed for the implementation of government decisions at times of crisis.

This requires mobilizing the necessary political, human, technical, material and financial resources, including support of community groups best equipped to reach highly vulnerable groups, such as women's organizations, community operated radio stations, and rural support networks.

An understanding of the main indicators of the effectiveness of early warning can be useful in guiding governments to implement appropriate and relevant systems. Such measures of effectiveness may include the following:

- forecast timing and accuracy;
- assessment of each stage of the warning process against specific targets such as proportion of audience reached and time taken to reach them;
- quality of warning system design and operation;
- public understanding of warnings;
- human and economic losses avoided;
- knowledge and implementation of timely and appropriate actions; and
- public satisfaction with the warning service.

The following are examples of successful national early warning systems in use.

Case: Mauritius

The specifications of the Mauritius cyclone warning dissemination system, including roles and responsibilities, are set out in the 1995 natural disasters scheme issued by the office of the Prime Minister. The Central Cyclone Committee, a well-administered and communication-oriented central body, provides leadership to ensure the effectiveness of the warning system. A high degree of legitimization is accorded by the endorsement of the scheme at the highest level of political authority. Furthermore the meteorological office is part of the Prime Minister's office, which provides added authority to the warnings issued by the Director of Meteorological Services.

"The commitment of policy makers is essential for achieving an effective early warning system. By accepting political responsibility to promote integrated early warning strategies, governments take a crucial step towards protecting the interests of communities against a possible disaster.

Effective early warning procedures should be part of national institutional and legislative frameworks, complemented by professional services, training and capacity building activities and the strategic allocation of resources.

The first early warning conference in Potsdam five years ago emphasised the importance of early warning for disaster reduction in the 21st Century. The Second International Conference on Early Warning provided a chance to enhance the early warning dialogue, by bringing together policy makers and practitioners to further integrate activities related to the early warning process.

As a key element of any disaster reduction strategy, early warning will bring us closer to the achievement of the Millennium Development Goals."

Jan Egeland
Under-Secretary-General
for Humanitarian Affairs
& Emergency Relief
Coordinator
United Nations

Box 5.34
Hurricane Michelle, a disaster preparedness success story

In Cuba, the national hurricane preparedness plan and early warning system is practiced and tested every year before the start of the hurricane season. The system is activated at the first information notice by the military authorities and civil defence, involving all actors from official authorities to companies and cooperatives. Planned measures are then activated according to different levels of warning, including an informative phase, a cyclone alert, a hurricane alarm and a concluding rehabilitation phase, if required.

Hurricane Michelle formed in the Gulf of Honduras on 2 November 2001, reached Cuba on 4-5 November with wind speeds of up to 220 kilometres per hour. This was a category four hurricane on the Saffir-Simpson Scale. Michelle was the strongest hurricane to hit Cuba in 50 years.

Upon early notice from the Institute of Meteorology the evacuation plan came into action. Twelve provincial and 150 municipal headquarters for civil defence, involving 87,000 workers were activated. More than 5,000 vehicles were deployed for evacuation.

Over 700,000 people were evacuated, of whom 270,000 were provided with temporary accommodation and basic needs for a longer time. Also, 777,000 animals were moved to safe areas. The hurricane created a major economic setback. Principal damages were to building infrastructure, agriculture and communications facilities. However, only five fatalities and 12 injuries were reported.

Case: Southern Africa

Southern African Development Community (SADC) countries have long focused attention on drought and food security for which early warning mechanisms have been developed over the last 20 years. Recent extreme weather events have encouraged a wider perspective for early warning and more comprehensive disaster preparedness activities.

Additional warning requirements need to be addressed through policies that can provide an integrated regional early warning and disaster preparedness framework, reflecting the relations between hazards, human actions, environmental consideration, management of natural resources and the climate. Toward this end, steps are being taken to develop a framework for a multisector disaster management strategy within SADC supported by UNDP and other international donor interests.

In 2000, following the devastating floods in Southern Africa, SADC governments took another step in institutionalizing early warning systems. A review of the contributions that meteorological and hydrological services provide resulted in recommendations to boost regional early warning strategies. These included the need for SADC countries to create a policy that is more focused on regional requirements for early warning and disaster preparedness. To achieve this, the formulation and progressive implementation of a structured regional approach was proposed.

It was also recommended that adequate funding be provided to national institutions to equip them with the necessary facilities and tools to maintain a satisfactory level of public service. Another recommendation was for plans that integrate early warning systems, disaster preparedness and related mitigation activities into overall national disaster management frameworks.

Case: Viet Nam

With sustained UNDP support, the Viet Nam Disaster Management Unit (DMU) has developed a nationwide information system that provides real-time information to the Central Committee for Flood and Storm Control (CCFSC), the primary government agency responsible for realizing disaster management policy.

The system provides early warning information, updates on emerging disaster situations and related information about damage or need assessments, through a computerized network linking CCFSC, DMU, the national hydrometeorological services and all of the 61 provincial committees for flood and storm control. The system is also able to draw on information supplied by the ministry responsible for agriculture and rural development.

The internet provides new opportunities to disseminate timely warnings to the public, to address emergency requirements and publicize general disaster management information. Since early 2001, the project has benefited from even more advanced technologies because of additional funding from OFDA/USAID. Expanded activities include the design of weather and natural disaster warning systems based on computer graphics for use by Viet Nam television to produce more effective public warnings.

Flood maps for all of the central provinces in Viet Nam are being created with the latest geographic information systems (GIS) technology, accompanied by training that will encourage its effective use by provincial and local authorities. A new warning system is also being designed for the areas most prone to rapid or flash flooding.

Case: India

The India Meteorological Department (IMD) has a well-established organizational arrangement for observing, detecting, tracking and forecasting cyclones in the Bay of Bengal and Arabian Sea and for issuing warnings. A special disaster warning system disseminates simple cyclone warnings in local languages through a satellite to users in isolated places.

Cyclone warning bulletins are issued to All India Radio and national television for broadcasting in different languages throughout India. IMD also issues cyclone advisories to neighbouring countries. Improvements in the forecasting and warning system are ongoing, drawing on past experiences inside and outside of the country and related technological development.

The effectiveness of cyclone forecasting and warning systems was confirmed in several cyclonic events including the super cyclone of Orissa in October 1999. The intensity of this cyclone, the region's worst of the 20th century, caused extensive loss of life and property. However, the timely warning by IMD coupled with the pre-event efforts of the administration saved many human lives.

Human dimensions of early warning

The second prerequisite for effective early warning is the strong recognition of the human dimensions of early warning mechanisms. Early warning messages must reach, be understood, believed and personalized by the public at risk, in order to be acted upon so as to reduce immediate exposure to hazards. Therefore community involvement is essential to the design of locally efficient and socially relevant early warning systems.

Informed communities will be in a better position to overcome weaknesses in transmission systems and fail to fully appreciate risks and take protective actions. Community involvement is essential to identify and satisfy the need for a variety of warning methods and products.

A continuous dialogue between users and authorities is key to clarifying needs, perceptions and priorities before disasters strike and to avoid confusion, contradiction and conflicts at times of crises. An example in this regard, is the consideration of the security of people's belongings during evacuations and responsibility for this property loss. In 2000, when the volcano near Puebla in Mexico was threatening to erupt, people were reluctant to evacuate because a few years earlier their animals had been stolen during a similar evacuation.

Sociological research is important to properly understand the human dimensions of warning generation and use, for example to examine the influence of the mode of warnings, collective interpretation of warnings and risk perception, the natural attachment of people to their home environment and personal properties, family ties or beliefs and superstitions, and existing forecasting and warning methods and coping strategies based on traditional knowledge.

Box 5.35
Principles for the application of early warning

The application of early warning at national and local levels requires attention to the following principles:

- Early warning practices need to comprise a coherent set of linked operational responsibilities established at national and local levels of public administration and authority. To be effective, the early warning systems should themselves be components of a broader programme of national hazard mitigation and vulnerability reduction.
- Within each country, the sole responsibility for the issuance of early warnings for natural and similar disasters should rest with an agency, or agencies, designated by the Government.
- The decision by authorities to act upon receipt of warning information is political in character. Authoritative decision makers should be identified and have locally recognized political responsibility for their decisions. Normally, action resulting from warnings should be based on well-established disaster management procedures of organizations at national and local level.
- In the chain of political responsibility, the initial hazard information is often technically specialized or specific to a single type of hazard authority. To be applied effectively, the warnings derived from this information need to be clearly understandable and operationally relevant to the local agencies that must act upon them.
- Early warning systems must be based upon risk analysis that includes the assessment of the occurrence of hazards, the nature of their effects and prevailing types of vulnerability, at national and local levels of responsibility.
- Locally predominant hazard types and patterns, including small-scale or localized hydrometeorological hazards related to patterns of human, economic or environmental exploitation, must be incorporated if early warning is to be relevant to risk reduction practices.
- The warning process should include demonstrated practices that can communicate warning and advisory information to vulnerable groups of people so that they may take appropriate actions to mitigate loss and damage.
- There is a continuing need to monitor and forecast changes in vulnerability patterns, particularly at local levels, including those arising from social developments such as rapid urbanization, abrupt migration, economic changes, nearby civil conflict or similar elements.
- Considerable responsibility rests at local levels for producing detailed information on risks, acting on the basis of warnings, communicating warnings to those individuals at risk and, ultimately, for facilitating appropriate community actions to prevent loss and damage. This requires detailed knowledge and experience of local factors and risks, decision-making procedures, roles and mandates of authorities, means of public communication and established coping strategies.
- Groups of people experience different types of vulnerability and have different perceptions of risk and various coping strategies. Locally appropriate warning systems need to provide a range of communication methods and to provoke multiple strategies for protection and risk reduction.
- To be sustainable, all aspects of the design and implementation of early warning systems require the substantive involvement of stakeholders at the local and national levels. This includes involvement in the production and verification of information about perceived risks, agreement on the decision-making processes involved, the formulation of standard operational protocols, and especially the selection of appropriate communication media and dissemination strategies for those at risk.

An overview of early warning systems for hydrometeorological hazards in South-East Asia in 2002 showed that communities demonstrate a high level of resilience and act from experience or respond instinctively to survive. This was confirmed by another study carried out by the ILO in India in 2002 which documents the wealth of information existing among tribal people to forecast hazards. This knowledge needs to be compiled and tested for incorporation in local early warning systems.

Communities and NGOs are crucial in operating early warning systems. They must be involved especially in disseminating messages and coping strategies, operating and maintaining warning equipment. They also have important roles in organizing training, public education and conducting regular testing to ensure reliable performance during a crisis. It is important for them to raise awareness about the responsibility people have for their own survival, not least by providing motivation and building confidence for systems in place.

Experience shows that informal and social networks in addition to community awareness and understanding of hazards contribute to more effective early warning systems.

The following examples illustrate public involvement in warning dissemination, strengthening of local capacities, the application of local experiences and public participation in the design of early warning systems.

Box 5.36
Human elements important to the early warning process

- improved understanding of warnings as a complex social process;
- improved understanding of the cognitive processes involved in communicating along the early warning chain;
- improved knowledge of local needs, perceptions and priorities;
- clear identification of those at risk and of intended warning recipients;
- knowledge of key people and resources available at the local level to tailor message contents, dissemination channels and response options;
- collection of empirical knowledge of hazards and local experience and memories, as well as local coping strategies;
- access to highly vulnerable social groups, including people in remote communities or squatter settlements, those with physical or cognitive disabilities, the sick, the elderly, widows and single heads of households, transients and tourists, the undocumented, illiterate persons and those with language barriers, and other socially marginalized groups;
- understanding of user needs and preferences in terms of education and content (what, how, where, when), as well as display and format of information;
- recognition of cultural factors in the access, understanding and reaction to warnings
- social support for public policies and decisions such as mass evacuations;
- enhanced credibility of, and trust in, warning messages; and
- feedback from warning recipients for improvement of early warning systems.

Case: Bangladesh

For the past 30 years, the Bangladesh Red Crescent Society has been working to reduce the effects of cyclones on communities. The Cyclone Preparedness Programme (CPP) disseminates warnings and assists cyclone-affected communities along 710 kilometres of the Bangladesh coastline in the Bay of Bengal.

Over 30,000 village volunteers work for CPP, equipped with hand sirens, megaphones, transistor radios, signal lights, flags, first-aid and rescue kits. They are the communications channel through which the CPP head office in Dhaka relays weather bulletins from the Bangladesh meteorological department to more than 10 million people living in areas of high cyclone risk. Local information on the progress of an approaching cyclone or the resulting effects after it has passed through an area is likewise transmitted back to the central office. The network has also proved to be an important asset for relief operations after a cyclone.

CPP has demonstrated that disaster preparedness programmes can be successful through the use of community-based management methods and basic forms of technology if both are pursued methodically and sustained over a period of time. The CPP volunteer training and public awareness programmes are central to its success.

Public awareness about the risks associated with cyclones is conveyed by the volunteers and demonstrated through drills and demonstrations. Printed materials, the use of films and videos and targeted publicity campaigns together supplement the regular use of the radio and television media to build a common understanding of basic elements of early warning and cyclone protection behaviour.

Box 5.37
Traditional knowledge

Tribal people in Rajasthan, India, rely on nature to provide early warning. They observe the movement of clouds and of animals, the changes in flora and listen to the sound of the river. Examples of reported signals for heavy rain and flooding include: when the patangga (insect) flies in the opposite direction of the river flow; unusual numbers of hende munjh (black ants) moving around with eggs; unseasonal flying of the machharanka (kingfisher); water from thatched roofs are forming bubbles; and profuse flowering of katam and siju (flowers).

Source: Coping strategies and early warning systems of tribal people in India in the face of natural disasters, ILO, 2002.

As pointed out in the study Traditional knowledge of impending hazards: Potential application in coastal Bangladesh, we cannot afford to ignore any potential low-cost strategy which might improve survival and mitigate property losses. We need to explore whether certain combinations of the best indigenous indicators and the best scientific indicators can offer a more appropriate, reliable and comprehensive warning system for vulnerable rural people. The study suggests that incorporating the knowledge of local warning indicators into locally managed warning systems would increase the resilience of poor and vulnerable people.

Box 5.38
Encouraging public participation

Elements that lead to successful public involvement in early warning systems include:

- political commitment and political articulation on early warning;
- early start in the warning design process in order to allow time for building trust;
- definition of how participation will be organized;
- provision of all necessary information to community leaders and civil society representatives;
- advertisement and wide sharing of the warning process through the mass media;
- testing of warning options, monitoring of implementation;
- communication feedback and iteration during the process; and
- institutionalization of feedback procedures and assurance of sustainability and maintenance of the system.

Source: B. Affeltranger, User-based design of socially efficient flood warnings, 2002.

Case: Central America

The RELSAT strengthening of local structures and early warning systems project was implemented in pilot zones in each of the six Central American countries between November 1998 and December 1999. The project was financed by the European Commission Humanitarian Office (ECHO). The project was part of long-term community-based disaster risk reduction cooperation between the Coordinating Centre for the Prevention of Natural Disasters in Central America (CEPREDENAC) and German Technical Cooperation (GTZ).

The purpose of the project was to establish efficient and reliable early warning systems for floods, tailored to the realities and capabilities of the selected pilot zones. However, as the main characteristics of the six zones were comparable, regional action was also possible.

The pilot zones demonstrated the experiences of local communities in applying local disaster risk management techniques, supported by national and regional structures that were competent in the area of disaster reduction. The main activities implemented during this process were:

- analysis of the risk zones;
- training of the local population in flood-fighting measures;
- selecting, training and equipping observers and analysts in the affected watersheds;
- improving communication capacities among the individuals and institutions involved; and
- developing contingency plans and implementing evacuation exercises in the pilot zones.

The project developed early warning systems that work. People living in the upper parts of the river regularly measure rainfall and water level. They transmit this information by radio to a central office in the nearest municipality where data are analysed.

The centre communicates with people in the flood-prone areas. At times of expected danger the centre can alert the population exposed to risks and can prepare for their evacuation, if necessary. In order to be effective, this system requires reliable communication and coordination. Responsibilities must be clearly assigned and commitment must be continuous.

Case: South-East Asia

Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam make up the membership of the Mekong River Commission (MRC). The MRC is designing an early warning system for the Lower Mekong which is prone to flooding. The strategy is technically efficient and relevant to communities.

The ongoing project is guided by research focusing on the complex social process triggered by warnings. This needs to be understood to design both the technical and social aspects of the warning system.

MRC fully endorsed the value of the social ownership of the warning strategy when developing its Flood Mitigation and Management Plan in 2001. Participatory approaches are progressively being introduced by the MRC into the disaster risk management culture of the region.

Box 5.39
Mekong River Commission on the internet

On-line since July 2001, the Mekong River Commission web site provides a flood warning and forecasting facility. It informs in a user-friendly manner about current and forecasted hydrological conditions in the Upper, Central and Lower Mekong areas. The information is updated daily, providing updates on the flood situation and alarm levels in the Mekong basin. New features based on end-user requirements are being added.

<http://www.mrcmekong.org/info_resources/ffw/overview.htm>

Individual countries are developing a similar approach depending on institutional settings and political will. Draft action plans to implement user-based flood warning and disaster mitigation were presented to the MRC secretariat, as well as to representatives of member countries at the MRC Expert Meeting on Flood Forecasting and Early Warning Systems held in Phnom Penh, Cambodia, in early 2002.

The plans emphasized the need to understand vulnerability, risk culture, related trade-offs and the social response to floods necessary to provide useful warnings. National authorities were advised to conduct a proactive, preliminary assessment of the social relevance and expected efficiency of their flood warning strategy in order to improve it further.

A number of activities focused on community-based flood mitigation in the Mekong basin are ongoing or have been completed. New projects will capitalize on these initiatives, thereby strengthening networks, building mutual trust and further developing professional practice and expertise.

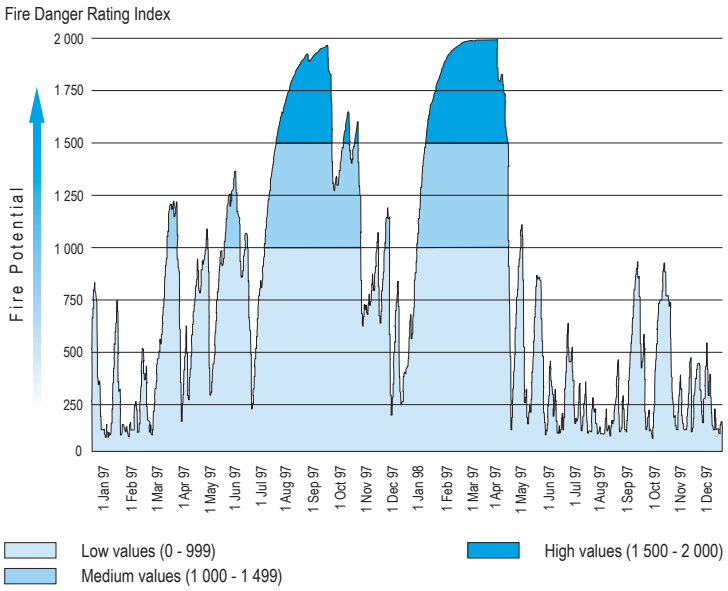
Case: Europe

The European Union *Operational Solutions for the Management of Inundation Risks in the Information Society* project and the Information Society

Box 5.40
Forest fire early warning

The Integrated Forest Fire Management (IFFM) project in Indonesia is a technical cooperation project supported by German Technical Cooperation and the Global Fire Monitoring Centre. The project relies on the involvement of local communities in fire prevention and community-based fire management preparedness. IFFM has been working with a fire danger rating (FDR) system in East Kalimantan since 1995. The FDR is based on the Keetch-Byram Drought Index (KBDI) and is part of a fire information system that manages spatial fire-related data and information in an integrated manner.

Fire Danger Rating Index (FDR),
South Coastal Zone, east Kalimantan, Indonesia, during 1997/1998 El Niño event



The graph of the KBDI readings for the 1997-1998 El Niño years show the development of drought and fire danger in the coastal zone of East Kalimantan. This drought index is easy to handle because it only requires on-site rainfall and temperature measurements. Since fire-weather patterns in the tropical rainforest region vary within short distances, it is advantageous for this system to be used by local entities such as local fire departments, forestry enterprises and communities.

Source: IFFM / GTZ / GFMC, 2001

Technologies Programme assessed the potential added value of new information and communication technologies for flood-related warning and information management. The project also studied conditions necessary for effective operation of such tools, including social ownership factors.

In 2000-2001 the European Centre on Risk Prevention (CEPR) in Niort, France, organized community-based workshops. A two-phased study was carried out to understand differences in risk perception and information demands among stakeholders, and to survey the social relevance and efficiency of existing or planned flood warning systems. UNESCO carried out a study in Hungary on flood-related information management systems and public participation at community-level in flood mitigation and control.

These examples suggest that early warning strategies should not be separated from broader development planning. Practical objectives and incentives are likely to trigger community commitment to user-based processes. Respectful understanding of existing social processes and the ability to capitalize upon them are keys to successful schemes for public participation.

Case: Australia

The fatal 1997 bushfires in the Ferny Creek area of the Dandenong Ranges near Melbourne prompted a small group of residents to express concern that they had inadequate means of knowing when to seek further information regarding fire danger. The residents lobbied all levels of government and the Country Fire Authority for the installation of sirens which could be audible throughout the area.

However residents were told that sirens were used for other purposes. A widely representative working group was set up to examine other options for an early warning system which might address residents' concerns. It also developed and implemented a community education campaign for the Ferny Creek residents on bushfire preparedness and survival. A thorough community consultation process was established, involving a public meeting, individual home visits, and the development of a residential newsletter about the project.

Between January and April 2000, three sirens were installed and tested. During the following fire season, the sirens were sounded on five occasions. Conflicting views about the value of the system seemed to relate to different priorities between community residents and emergency service organizations. The Ferny Creek trial demonstrated that the complex process of engaging the community to reduce risk through information and awareness campaigns requires social trust and commitment to building genuine partnerships.

International and regional support

The third prerequisite for effective early warning systems is the support provided by international and regional institutions. These networks provide incentives and motivation to strengthen early warning capabilities, ensure coordination of activities and promote the development and exchange of knowledge.

International support is needed both for development assistance, particularly capacity building, and for advanced technical information, such as satellite monitoring, El Niño prediction and regional food assessments.

Regional relationships and mechanisms can provide a framework to support and guide action at the national level. Regional institutions can provide motivation and advice to national institutions and can assist in fund-raising. They are key interlocutors for governmental authorities, able to amplify a collection of individual national concerns or distinctive conditions of either need or accomplishment. Regional institutions also help countries engage in international activities, and can assist groups with sometimes limited technical abilities to obtain wider exposure and to build links with collaborators.

International cooperation provides essential support in building national early warning capacities. International networking initiatives facilitate the exchange of information and experience, as well as linkages with international agendas. Specific activities such as the development of uniform standards can only take place internationally with the cooperation of as many countries as possible.

Box 5.41
Principles for early warning systems at international and regional levels

1. Technologically advanced countries can play a major role in reducing adverse effects of disasters by encouraging and supporting improved early warning practices in developing countries, in small island developing states, economies in transition and disaster-prone countries with special circumstances.
2. Disaster affected countries have a primary responsibility to identify their needs for warning and to review and audit the effectiveness of their early warning capabilities. The conduct of assessments of regional and national warning system capabilities after disaster events is particularly important.
3. Specialized regional and global centres involved in the preparation and dissemination of warnings such as the WMO Regional Specialized Meteorological Centres and Drought Monitoring Centers provide important links to national early warning systems. The application of their technical capabilities and the utility of their products should be carefully integrated with the needs of the countries being served, including any necessary clarification of responsibilities between these centres and national agencies in the same region.
4. In the interest of protecting people from the risk of natural hazards, it is essential that the formulation and presentation of warnings be based on the best available technical and scientific knowledge and free of political distortion or manipulation.
5. International bodies and regional organizations must work to maintain the timely exchange and unrestricted access of observational data and other warning information between countries, particularly when hazardous conditions affect neighbouring countries.
6. Early warning systems need to be integrated into the context of commonly accepted international standards, nomenclature, protocols and reporting procedures. Established or internationally agreed means of communication should be employed for the international and regional dissemination of any warning information to specific authorities designated in each country.
7. Collaboration and coordination is essential between scientific institutions, early warning agencies, public authorities, the private sector, the media and local community leaders to ensure that warnings are accurate, timely, meaningful and can result in appropriate action by an informed population.

Recent international poverty reduction initiatives contribute to stronger social support networks and disaster reduction activities, including the establishment and maintenance of early warning systems. Translating early warning principles and strategies into recommendations for action is still a challenge. The World Summit on Sustainable Development reiterated the contribution of early warning systems make to achieving sustainable development.

The Second International Conference on Early Warning (EWC-II) in 2003 was a timely opportunity that generated a renewed commitment and urgency for a bolder and more systematic approach to early warning (see box 5.42). Through enhanced cooperation, partnerships and concrete action effective early warning systems can become a reality.

At the regional level, the growing economic importance of climatic variability has prompted WMO and other technical institutions to expand work beyond scientific research. WMO is using available meteorological information to help establish early warning systems and to strengthen local risk reduction practices.

WMO, USAID, the US National Oceanic and Atmospheric Administration (NOAA), and the International research Institute for Climate Prediction (IRI), have assisted regional and national bodies to organize a series of Regional Climate Outlook Forums (RCOF) over the last decade. These seasonal meetings have brought together meteorologists, climate forecasters, agriculture and water managers, media representatives and disaster managers from neighbouring countries to review the available climate forecasts and to consider the potential implications in their respective countries.

Weather forecast data are discussed with respect to social and economic dimensions of public interest. This is done with a view to integrating meteorological considerations into disaster and risk management, agricultural, public health, energy and commercial interests shared by the participating countries.

An international review of RCOF was undertaken in 2000. Conclusions called for improved links among stakeholders. There is a need to build capacity in key areas including the development of improved forecast products tailored to users' needs.

According to the review, the development and use of seasonal climate forecasts will be enhanced by "more systematic organization of the roles and responsibilities of forum partners including users, researchers, and operational organizations" with partnerships "needed at all levels of the process". Stakeholders are invited to engage in a dialogue for the management of climatic impacts.

Box 5.42
Second International Conference on Early Warning, Bonn, 2003

The Second International Conference on Early Warning, held in Bonn, Germany over 16-18 October, 2003, was a signal event in the international development of early warning. The conference was promoted and developed by a working group on early warning that was set up under the ISDT Inter-Agency Task Force on Disaster Reduction.

The primary aim of the working group was to improve global coordination in early warning activities and its effective use as an instrument in disaster reduction activities. UNEP's Division of Early Warning and Assessment led this working group. Membership included CDERA, FAO, DKKV, and ADRC, GFMC, IGAD, the SADC Drought Monitoring Centres, SOPAC, UN-HABITAT, UNCCD, UNDP, UNESCO, IRI and WMO.

The group built on previous activities undertaken in the field and coordinated with the other ISDR working groups. The group sought to involve as many parties as possible from national, regional and international organizations to ensure its intersectoral and multidisciplinary dimension. Its main activities included the development of an inventory of early warning systems, formulation of criteria for indicating the efficiency of systems and the planning of the early warning conference.

The on-line inventory, which was coordinated by UNEP, the ISDR Secretariat and DKKV provides access to a database of early warning systems around the world. The compilation of the inventory has helped reveal strengths and weaknesses of existing systems. <http://database.unep.dkkv.org>

Over 400 participants convened at the Second International Conference on Early Warning (EWC-II). The conference focused specifically on political commitment and responsibilities, calling upon all national, regional and international authorities to act with resolve to implement the following recommendations which build on the four preparatory regional workshops held in 2003 in Bandung (Indonesia), Antigua (Guatemala), Nairobi (Africa) and Potsdam (Germany).

Participants recognised the progress that had been achieved in understanding the importance of early warning since the first International Conference on Early Warning held in Potsdam in 1998 and the International Decade for Natural Disaster Reduction (IDNDR, 1990-1999). However, it was noted that those guiding principles for early warning identified in 1998 are still not effectively implemented.

The participants, representing political leaders, organizations engaged in disaster risk management and humanitarian aid, the private sector, as well as the scientific community, identified the need to further strengthen capacities for early warning as a crucial element to reduce risk and vulnerability to natural and technological hazards and thus securing sustainable development.

Three main outcomes resulted from EWC-II:

- The conference statement
- A policy brief aimed at policy makers on integrating early warning into public policy
- The delineation of an international early warning programme, with sets of priorities for action.

The Conference identified five main areas of focus aimed at more coherent action at the international, regional, national and local levels:

1. Better integration of early warning into public policies is needed, particularly into development policies and programmes.
2. The improvement of technical aspects such as data collection, forecasting and information exchange.
3. The need for capacity-building and training, especially in developing countries, to strengthen early warning systems.
4. A greater focus on the human aspects of early warning, to build people-centred warning systems that address the needs of those most at risk.
5. Concrete means for sustaining the early warning dialogue, such as through a platform (organizational capacity) to promote international cooperation, to develop information and guidelines, and to promote early warning in international agendas, including the World Conference on Disaster Reduction in January 2005 (Kobe-Hyogo, Japan).

Technical identification and monitoring of hazards

The first part of the early warning process is the forecast of hazards, which relies on scientific knowledge and monitoring capabilities. When combined with vulnerability and risk information, this will allow for the formulation of warning messages.

Typically, most early warning systems have concerned single types of hazards such as storms, or floods, or volcanoes, or have followed individual organizational requirements. In the future, early warning systems are expected to become more comprehensive and to be responsive to environmental and climatic events over a longer period of time.

They will also remain active between hazard episodes, in the calm between periods of imminent threat. There will be a greater demand for uniformity of systems, including nomenclature, procedures, organizational relationships and common approaches to information management. Advances in communication facilities and information technology should make it easier to meet these needs.

As stated in the conclusions of the 1999 IDNDR Programme Forum, there is a crucial need to implement early warning systems that use interdisciplinary knowledge and sociological, political, organizational, economic and scientific information.

There are many organizations and centres throughout the world which provide early warning information and actively promote its use. A few of them are described below.

Hydrometeorological hazards

Almost three-quarters of all natural disasters are related to weather, water or climate. WMO, a specialized technical organization of the of the United Nations, plays an important role in coordinating the development of standards and procedures for the monitoring, analysis, forecasting and reporting of hydro-meteorological hazards. It works through and provides technical support to national meteorological and hydrological services (NHMS) and specialized regional meteorological centres. Without these institutions, early warning capabilities would be almost non-existent.

The following WMO programmes are particularly important in contributing to global detection, forecasting and early warning of hazards, as well as in providing procedures to minimize their adverse consequences through the application of science and technology:

- The World Weather Watch (WWW), supported by NMHS observations, enables the exchange of real-time data, forecasts, warnings and advisories for the public and the international community. This is the bedrock foundation of all weather and climate forecasts.
- The Public Weather Services programme of WWW issues a series of technical documents and guidelines to improve the performance of public services in delivering user-oriented warning products. The Guide on Public Understanding and Response to Warnings was recently issued to assist NMHS efforts in this respect, and is available on the WMO web site.
- The Tropical Cyclone Programme develops professional abilities and promotes national and regional systems to ensure effective preparedness for tropical cyclones and associated phenomena.
- The World Climate Programme's Climate Information and Prediction Services (CLIPS) project helps countries n the early warning and management of climate-related natural disasters.
- The World Weather Research Programme develops and promotes cost-effective and improved techniques for the forecast of high-impact weather such as tropical cyclones, sand and dust storms and heavy rainfall that can provoke severe flooding.
- The Hydrology and Water Resources Programme assists national hydrological services issue forecasts and assess risks of water-related hazards, with a focus on floods and droughts.
- Regional specialized meteorological centres are designated worldwide by WMO to provide weather forecasts and advisories on tropical cyclones or other risks associated with the atmosphere or having global implications. These include volcanic plumes, fire haze, or environmental emergencies.

Box 5.43
WMO technical cooperation

WMO technical cooperation projects contribute to the improvement of early warning systems in many developing countries. One recently completed project supported early warning systems for the national meteorological services of Burkina Faso, Mali and Niger.

Another project is looking into the feasibility of establishing a regional system that would produce and utilize early warning of social and economic consequences based on El Niño forecasts. This will be analysed from technical, economical, social, environmental, legal and institutional perspectives.

The success of the WMO programmes illustrates the economic and social benefits that are derived from an accurate global weather monitoring and forecasting system. Studies show that the benefits of weather forecasting do not stop at the early warning of natural hazards and related risks. However, meteorological services are still undervalued in many countries even though they are a key element in building a national disaster reduction strategy.

Observations of weather phenomena go beyond immediate forecasts determining daily human activity. Long-range studies of the atmosphere and oceans are crucial in understanding El Niño, climate change or the depletion of the ozone layer. WMO scientific analyses and warnings are instrumental in addressing these issues and in supporting multilateral environmental agreements to tackle them. <http://www.wmo.int>

Floods

The Dartmouth Flood Observatory has capacities for detection, mapping, measurement, and analysis of extreme flood events worldwide using satellite remote sensing. Products include yearly catalogues, maps, and images of river floods, from 1985 to the present and current information on flooding updated daily. The observatory provides quick access to a collection of tools and data sets such as the SeaWinds microwave scatterometer data from the NASA Quikscat satellite, which provides a unique and frequent update of surface water conditions worldwide.
<http://www.dartmouth.edu/~floods/>

Box 5.44
Glacial lake outburst floods in Nepal and the Himalayas

UNEP is contributing to the establishment of an early warning system to monitor hazards in the Hindu Kush Himalayan region, including glacial lake outburst floods (GLOF). It is undertaking this initiative through its Environment Assessment Programme for Asia and the Pacific, at the Asian Institute of Technology in Bangkok, Thailand.

Through a project implemented in collaboration with the International Centre for Integrated Mountain Development (ICIMOD), Nepal produced inventories of glaciers and glacial lakes in Bhutan and Nepal, identifying lakes that are potentially at risk of flooding.

The project also recommended establishing a system to monitor lakes at risk using remote sensing, geographic information systems and strengthening national capabilities to implement an early warning system for GLOF hazards. Training for local experts was also provided.

Following panic created by the media earlier in 1997 in the Rolwaling and Tama Koshi valleys, the government of Nepal implemented an early warning system to provide timely warning to the people. An army and two police posts were established at appropriate locations and provided with high frequency radio transceivers, one post having a back-up set. Regular radio contacts were maintained with headquarters in Kathmandu.

In addition, the posts were provided with satellite telephones. The disaster prevention cell at the home ministry received communications twice a day. In the event of a GLOF, Radio Nepal, the national broadcaster, would broadcast a warning. Radio Nepal can be received in most places along the valleys that are at risk.

The GLOF warning system can be essentially divided into two general components: the GLOF sensing system, which detects the occurrence of a GLOF and initiates the warning process, and the downstream warning system, which conveys this warning to communities at risk. These are linked by the signal transmission system. The operation of the warning system has been satisfactory.

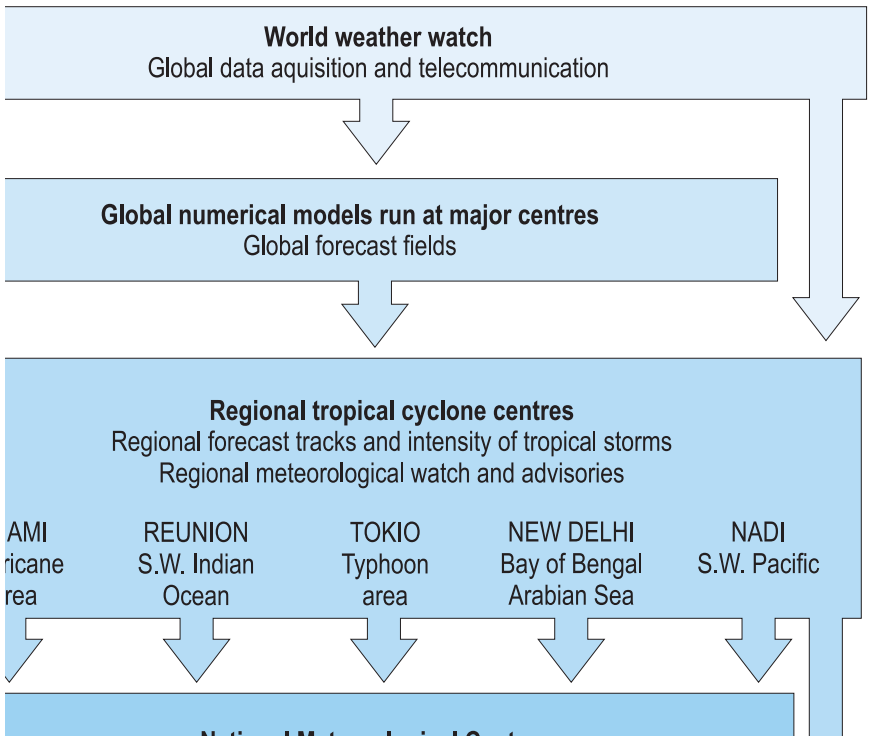
<http://www.rrcap.unep.org/issues/glof/>

(see figure 5.2)

Wildland fires

The Global Fire Monitoring Center (GFMC) in Germany provides real-time early warning information concerning wildland fires. Systems are based on both short-term and long-term

Figure 5.2
Global network of tropical cyclone monitoring, forecasting and warning systems



weather forecasts at different spatial scales with data provided by several different regional organizations. The Experimental Climate Prediction Centre generates information for the whole global.

Regional systems involved include the Association of South-east Asian Nations (ASEAN); Fire Weather Information System of Forestry, Canada; the Eurasian Experimental Fire Weather Information System; and the EU European Natural Hazards Project Forest Fire Risk.

Satellite-based indices and thermal data are also used.

The area, intensity and duration of vegetation stress, fire potential and fire danger can be estimated from maps that are updated regularly. Together with real-time satellite data on active fires the GFMC information system provides a range of information tools for early warning of critical fire situations. <http://www.fire.uni-freiburg.de/>

Box 5.45
Disease early warning in southern Sudan

In 1999, Early Warning and Response Network (EWARN) was launched by WHO in collaboration with several international agencies, NGOs and local communities. The aim was to strengthen disease outbreak detection and response in southern Sudan.

The objectives of EWARN include:

- early detection, alert and prompt investigation of suspected disease outbreaks;
- establishment and strengthening of disease outbreak preparedness and rapid response;
- provision of regular feedback and technical guidance to all involved; and
- building local capacity for early detection, prompt investigation and rapid response.

Currently, EWARN partners handle alerts that would previously have called for mobilization of international teams. EWARN has improved alerting, reporting and response in the event of suspected disease outbreaks and has saved time, money and lives.

Box 5.46
Early warning of El-Niño events

Scientific research produced a breakthrough around 1970 when it was discovered that the El-Niño phenomenon, which affected ocean temperatures, fisheries and rainfall patterns along the western coast of South America, was intimately linked to the Southern Oscillation, which caused drought and changed rainfall patterns thousands of kilometres away across Asia, Australia and the Pacific islands. This understanding of the interaction between the tropical oceans and the global atmosphere quickly led to practical models of the combined phenomenon and useful forecasts of what are now called El-Niño Southern Oscillation (ENSO) events.

Forecasts of ENSO events rely on close observation of the changing temperatures of the Pacific Ocean, and are regularly produced and disseminated by international centres using complex computer models of the oceans and atmosphere. Institutes such as the International Research Institute for Climate Prediction (IRI) not only seek ways to improve the forecasts' quality, but also undertake research on how to make more effective use of forecasts, for example in managing water reservoirs in Brazil and the Philippines, and in choosing drought resistant crops in Tamil Nadu, India.

A UN-supported study of the large 1997-1998 El Niño event, one of the largest events of the century, showed that growing awareness of the El Niño has resulted in more effective responses, but that many lessons remained to be learned in how best to make use of the available forecast information – as indicated by the study's title Once burned, twice shy.

Tsunamis

The Pacific Tsunami Warning System of UNESCO's Intergovernmental Oceanographic Commission (IOC) provides tsunami warnings and information bulletins to Pacific populations. It is operated through the Pacific Tsunami Warning Centre (PTWC) with the support of national and regional tsunami warning centres. The automated tsunami alert system developed by the Pacific Disaster Center in Hawaii and replicated in other tsunami-prone countries automatically delivers official PTWC bulletins. IOC also maintains an International Tsunami Information Centre in Honolulu, which acts as a source of information for national and regional tsunami warning authorities. <http://ioc.unesco.org/itsu/>

El Niño

The International Research Centre for the El Niño Phenomenon (CIIFEN) is based in Guayaquil, Ecuador. It was created under the auspices of ISDR, WMO and the Government of Ecuador. The centre will conduct regional projects on early warning systems. Although it will have global links, the centre will focus on the Eastern Equatorial Pacific and the western countries of South America. Seasonal forecasts and El Niño/La Niña warnings and advisories will be provided and converted into user-oriented information products. These early warnings should benefit many social and economic sectors, including public health, agriculture, fisheries, water management, energy production and use. <http://www.iri.columbia.edu>

Earthquakes

A European warning system coordinated by ECHO has been implemented to respond to earthquakes. The Euro-Mediterranean Seismological Centre in Paris and its 33 networks of seismometers provide information on the location of epicentres, magnitudes and maps of the epicentre locations. <http://www.europarisks.coe.int/csem50.htm>

The UNEP Global Resource Information Database (GRID) early warning portal provides information on existing and emerging environmental problems to reduce societal vulnerability and future risks. Three different temporal and thematic approaches are used to disseminate credible scientific and relevant policy data through strategic alliances and international cooperation:

- Near-term perspectives: Operational warnings normally associated with disasters such as floods, wildfires, volcanic eruptions and earthquakes.
- Longer-term perspectives: Raising awareness about emerging environmental issues such as the impact of climate change, acknowledging that unexpected new issues are inherently unpredictable.
- New ways of looking at contemporary environmental issues: Viewing environmental issues in a more holistic and integrated manner by establishing the connections between land, air, water and biodiversity that amplify environmental problems. <http://www.grid.unep.ch/activities/earlywarning/>

Box 5.47
Early warning of environmental threats

The ingredients of a comprehensive, integrated observation system for the Earth now exists. The Global Climate Observing System (GCOS), the Global Terrestrial Observing System (GTOS) and the Global Ocean Observing System (GOOS) are known collectively as the Three Global Observing Systems (G3OS).

Under G3OS, UN agencies, the International Council of Scientific Unions (ICSU) and satellite agencies work together in providing early warning information needed for long-term global environmental changes. G3OS activities are closely linked to the UNFCCC and harmonized through the Integrated Global Observing Strategy (IGOS). Another contributor to this strategy and useful tool for information and knowledge exchange is the UN Earthwatch. It provides information on environmental concerns that needs to be integrated into the new generation of early warning strategies.

To address the environmental challenges of the 21st century, the existing Earth observation and data management infrastructure needs to be sustained and further evolved. A major international initiative in this regard was the hosting of the Earth Observation Summit by the United States in Washington D.C. in July 2003. The summit focused on the concept of creating an international, comprehensive, integrated, and sustained Earth observation system. <http://www.earthobservationsummit.gov/>

Health

With massive worldwide travel and trade, global surveillance of epidemics is essential to ensure international public health security. International efforts to contain health-related threats are coordinated by WHO.

It has established international networks for specific disease threats and has developed several electronic databases. These include FluNet, a geographical information system to monitor influenza activity, and the Global Public Health Intelligence Network (GPHIN), a web-based system developed in collaboration with Health Canada that scans the internet for outbreak-related information.

Box 5.48
Early warning for agricultural pests

Early warning of agricultural pests and diseases can help reduce catastrophic losses and economic impacts. In 1994, FAO established an Emergency Prevention System (EMPRES) for Transboundary Animal and Plant Pests and Diseases in order to minimize the risks of such emergencies developing. The system's priority is animal pests and desert locusts. The EMPRES web site and its two components on Livestock, and Locust and Other Migratory Pests provide timely early warning messages. They also provide access to training material and software.
<http://www.fao.org/EMPRES/default.htm>

Communications requirements

There are two areas of communication that are integral to the success of early warning systems. The first relates to the maintenance of lifelines, the need to build and strengthen robust hazard-resistant communication systems. The second relates to the maintenance of relationships; the need to establish and maintain effective links and working relationships among the actors involved in the early warning chain.

Early warning systems are more accurate than ever and can deliver information more quickly than ever. However, most of these advanced technologies are not available or affordable throughout the world. Some of the most vulnerable populations are in areas where

Box 5.49

Radio and Internet for the Communication of Hydro-Meteorological and Climate Related Information for Rural Development (RANET)

RANET was designed to make climate and weather related information more accessible to rural populations and communities by combining the resources and knowledge of meteorological services, NGOs and regional and international organization. RANET uses an innovative digital satellite broadcast, provided through the World Space Foundation, to deliver what is in essence a one-way Internet to rural communities, remote NGOs, and national agencies whose main office or field stations cannot access necessary information.

While this new yet inexpensive technology allows RANET to provide a broadcast of information over all of Africa and much of Asia, the strength of the RANET network is its ability to connect the satellite broadcast with locally owned and existing networks of FM radio, community bulletin boards, and even word of mouth. By encouraging local ownership and management of networks, RANET further ensures the sustainability of its efforts by disseminating information over other multipurpose networks, which also carry information on HIV/AIDS, agriculture, education, local information, and even entertainment.

While the networks may only be used 1 per cent of the time for matters related to climate and weather, by addressing broader community information needs, RANET is better able to ensure equipment is maintained and people are able to better address multi-dimensional challenges. In further support of communication capacity-building, RANET provides a series of technical training and content production workshops, as well as a newsletter designed to address issues of communication related to weather and climate services.

RANET relies on a broad network of NGOs, communities, and national meteorological and related agencies. Continuing support is provided through the African Center for Meteorological Applications for Development (ACMAD), the USAID Office of Foreign Disaster Assistance, and the NOAA Office of Global Programs. <http://www.ranetproject.net>

connectivity is poor or simply does not exist. Inadequate connectivity also limits the ability of many national agencies to receive information produced by international and regional organizations, which could be used to improve forecasts and bulletins.

ISDR activities and bilateral and regional technical cooperation programmes offer assistance to developing countries to improve their communications systems, especially those relating to data collection, processing and transmission.

Communications in early warning rely on the following characteristics: timeliness, reliability, backup, accessibility, feedback, effectiveness and authoritative source. Technical requirements involve a subtle balance between traditional and advanced channels, a mixture of mass media and selective formal and informal media. Developments in information technology, especially the variety of new terrestrial and satellite-based wireless technologies, will give added protection to key communication channels in the event of a disaster, ensuring that these remain open.

For the time being, back-up communication systems such as battery-powered radio and telephone links need to be part of effective warning systems. In some countries even if communication structures extend to the local level, they are not always used effectively and communication breakdowns need to be examined. Furthermore the maintenance of dissemination systems needs to be ensured, especially when hazards are sporadic.

Emerging communication technologies, including wireless technologies such as pagers, mobile telephones and personal digital assistants are potentially valuable resources in early warning communications. They are relatively inexpensive, portable and do not rely on traditional power sources that are often damaged in times of disaster. They can be distributed among key community members and used to deliver early warnings in the poorest communities where there are often no fixed landlines in homes.

However, serious limitations remain between these technologies and their more widespread use. In this regard, the applied research initiatives launched by the Simon Fraser University Telematics Research Lab in Vancouver, Canada is relevant as it works in collaboration with Canadian federal, provincial and local government, UN and international, private sector and volunteer organizations. It aims at better understanding of both the potential benefits and resulting

implications of these advanced information networks, to enhance and strengthen emergency management practices.

Unfortunately, improvements in early warning technology do not necessarily equal greater community safety. This is often because of poor communication to and among communities at risk. To be truly effective, human and institutional inadequacies linked to communication requirements need to be addressed. They can be remedied by enhancing the relationships between technical originators, intermediaries, disseminators and the communities at risk.

EMERCOM, the Russian Federation emergency management agency, recognizes the problem between reliability of daily forecasts and actual warnings for their clientele. Thus, they give crucial importance to effective mechanisms to support information flows and interaction between various specialists involved in hazard detection and early warning.

Miscommunication between meteorologists, hydrologists, municipalities, emergency services and the public was one of the reasons put forward by the media for the disastrous impacts of the 2002 summer floods in Germany. Other criticisms included an underestimation of potential effects, which was believed by some to be a conscious effort to avoid unnecessary panic and resulted in no action after the first warning and contradictory warnings that were issued by competing meteorological services.

Communication throughout the early warning chain must be two-way and interactive. Originators, disseminators and end-users must be in continuing contact with one another in order to make the system responsive to people's needs, priorities and decisions. The system has to adjust to users; not the other way around.

The appropriate type, form and timing of meteorological information depends on its intended purpose and users. For example, the climate community recognizes the need for new user products that convey projected seasonal onsets, dry spells, and improved spatial and temporal resolutions. Forecasting capabilities cannot stop when the product is delivered as users also need assistance with climate information analysis. End-to-end coordination of forecasting and monitoring needs to be put in place.

Box 5.50
Example of a public-private partnerships to disseminate warnings

Today, several public-private partnerships are in place in the United States to ensure that the multiple communications of warnings and other vital information get to the public. These include:

- The US National Oceanic and Atmospheric Administration (NOAA) Weather Radio, a sole government radio system for providing direct warnings of natural disasters within listening range of 90 percent of the population.
- The NOAA Weather Wire Service, a satellite-based communications delivery system providing forecasts, warnings, advisories, and other data to users such as emergency managers, public safety officials and the media.
- The Weather Channel, a 24-hour-a-day private cable channel that relays National Weather Service warnings and forecasts and preparedness information including on other natural hazards, together with guidance of possible impacts for different groups.
- The Emergency Broadcast System, to communicate with the public in an event of a national crisis, now also disseminates natural hazard information to the public.
- Plans are now underway to enhance the Weather Radio and the Weather Wire Service with an all-hazards capability, as well as post-event information, such as locations of shelters and other emergency services.
- A programme is underway to place a Weather Radio receiver in every school, hospital, nursing home, and day-care centre through a partnership with state and local governments and the private sector.

The research community, including social science and human behavioural specialists, needs to be in closer contact with the public at risk to understand its requirements and ensure that the subjects and products of research lead to practical applications. The Climate Forecasting Applications in Bangladesh project provides a good example of an effort to create and increase collaboration between international and national partners in flood forecasting. It uses state of the art technology, involves user communities especially to test results of experimental forecasts, and strives to increase dialogue between scientific and user communities.

Strong partnerships are required between different social groups and organizational systems to meet

"Organizing the community to act as one in responding to threat is a live drama that requires effective orchestration, direction and a well-written script that is memorized by all the players. It requires a scenario that needs to be practiced to perfection."

Source: Overview of early warning system for hydrometeorological hazards in selected countries in Southeast Asia, ADPC, July 2002.

We're finding that women farmers prefer seasonal climate forecast information to be made available through the extension officer or school, rather than the radio. In attempting to balance farming, childcare and other domestic responsibilities, they are less able to schedule a fixed time to listen to the radio.

They also prefer information to be provided on-site, in an environment where queries can be handled immediately, and discussion can take place. This confirms a growing sense in the climate impacts and applications community that women are a crucially under-served clientele.

Source: Emma Archer, Contribution to the Online Conference on Gender Equality, Environmental Management and Natural Disaster Management. 2001.

early warning communication requirements. These include the media and public or commercial communication channels. Inter-sectoral and multi-agency communication capabilities also need to be developed outside emergency situations through training and the creation of routine relationships. This will ensure that when a hazard event occurs, the essential parties are already familiar with one another.

Such preliminary arrangements will also contribute to the dissemination of warnings based on the same official information. Established partnerships will be important to explain in a coherent manner why forecasted events sometimes do not occur especially after contingency plans had been implemented. This is crucial for the public's understanding of the inherent limitations of the forecasting exercise. Partnerships also facilitate agreements for special users to obtain advance information about imminent warnings.

Joint training of actors in the early warning chain should take place regularly. It is vital to communicate roles and responsibilities clearly, within the disaster management system. For example, in the Philippines regular training takes place where all actors in a typhoon warning system meet to practice communicating alerts. Information management and communication from the international to the local levels help countries reduce the burden of generating their own scientific and technical data.

Response to warnings

A warning in itself is of little value. The crucial element is how people react to it. This is the ultimate indicator of a warning system's effectiveness. The existence of an early warning system should not lead to a false sense of security. This last link in the early warning chain – the response to warning messages – deserves serious attention in the design and operation of any warning system.

Responsiveness is probably the most complex component of the chain. The appreciation of psychological, community and individual processes in stressful times is more important than technology. Studies on factors that affect response indicate that people have a tendency to underestimate the significance of low-probability, high-impact events (like severe storms or earthquakes). Therefore they may not prepare or respond appropriately.

Critical components that enable communities to act appropriately upon receipt of warning include:

- sufficient lead time and accuracy;
- understanding, believing the warning and the reality of the threat;
- confirmation of the warning from other sources;
- knowing how to react; and
- being prepared.

In addition to the warning itself, vulnerability assessment and resulting maps can play a key role in effective response to warnings.

References to historical events and direct personal experience of hazard events contribute greatly to how people respond to threats and warnings. Warnings must be delivered by multiple credible sources to a receptive audience in a manner that is able to personalize the risk associated with the warning. Familiar, structured, practiced and sustained contingency action plans can then therefore elicit proper responses following clear, consistent and user-friendly messages, especially when speed of response becomes crucial. In this regard regular simulation exercises and public education campaigns develop confidence.

In 1997, after the disastrous Oder River flood in Europe, the need became apparent for emergency exercises and improved coordination between government authorities on both the German and Polish sides of the river. The need for a trans-boundary early warning system became obvious.

Box 5.51
Tropical cyclone bulletins in Hong Kong

Examples of practical precautionary announcements included in tropical cyclone warning bulletins in Hong Kong are as follows:

- Some precautions against damage should be taken now, gutters and drains should be cleared of obstructions. Hinges, bolts, locks and shutters of windows and doors should be checked.
- People living in wooden huts and in low-lying areas should take necessary precautions against strong winds and flooding.
- Listen to radio or watch TV for further weather information.
- Those who have definite duties during a tropical cyclone should now remain on call or contact their control centers from time to time.
- If you are planning to visit Macau, any of the off-shore islands or remote parts of Hong Kong, you are reminded that changes in weather may affect your plans.
- Since sea state is/may be very rough, you are advised to stay away from the shoreline and not to engage in water sports.
- Engineers, architects and contractors should make sure that scaffolding's, hoardings and other temporary structures are secured.
- Owners of small craft should ensure that their moorings are in good conditions and adequate, and take any precautions they consider necessary.
- Owners of shop signs, advertisements and TV aerials which overhang public thoroughfares or which are situated on tops of buildings should make sure that the fastenings and framework of these structures are secured.

Source: WMO, 2002.

In Mauritius, a systematic and annually reviewed process of contingency planning for disaster preparedness and response has been in force since the 1960s. It is derived from the primary forecasting and early warning authority of the national meteorological service and is coordinated across all operational sectors of government under the authority of the Prime Minister's office.

Even though tropical cyclones only directly affect Mauritius every eight to ten years, the programme pays particular attention to maintaining the relevance of operational plans. The public and official acceptance of early warning and disaster preparedness as integral elements of government responsibility, and the resulting informed public behaviour displayed across generations, point to the strategy's success.

In contrast to most other early warning systems, the director of the Mauritius meteorological service is empowered by the political authority to issue warnings himself, without prior approval by any other public authority. In the course of a developing emergency, close communication is maintained with political authorities.

The national meteorological service has been central to the early warning process since its inception. Meteorological services can provide leadership by reaching out to include other partners and professional sectors. The national meteorological service and the country's disaster management unit continue to work closely with other government, commercial and public interests on preparedness and mitigation initiatives to address the possible consequences of climate change.

The interaction between the forecasting and response elements of the warning chain is important. For example, the Russian Federation has institutionalized the interaction of hazard monitoring, forecasting and mitigation in its national safety programme. The framework for interaction extends to all the member countries of the Commonwealth of Independent States through the Inter-State Council on Emergencies. A joint programme develops and adopts systems for forecasting, warning and quick response.

Clear procedures to verify that messages are received, understood and acted upon, are often overlooked. To combat this, in Hong Kong, the typhoon warning system requires that when meteorologists issue a warning message to the police and fire services, recipients must confirm that the warning has been received and they then outline actions they have taken to respond.

In some cases, slow or inadequate response to warning information can be rooted in a lack of trust in the reliability of the system. Sometimes warning messages are not adequately tailored to recipients, and do not take local or cultural beliefs into account. They can be perceived as inadequate

In a village studied in Hawaii, women who manage household budgets and secure food and water resources did not receive any warnings about the upcoming El-Niño conditions. Had they known, they would have saved more household funds and budgeted expenses differently to prepare for the event. One of the problems with male-dominated networks of information is that women cannot minimize risks associated with their regular activities.

Source: Cheryl Anderson, Contribution to the Online Conference on Gender Equality, Environmental Management and Natural Disaster Management. 2001.

Radio and TV are not always found in the homes of some families. In some countries (Bangladesh, among others), women who are confined to the house or family plot have no access through radio, TV or otherwise to warning information. Therefore, not only is there a need to develop gender/culture/economic sensitive warning systems, but also to ensure that the necessary support for women and children to act on the warning is in place.

Source: Fainula Rodriquez, Contribution to the Online Conference on Gender Equality, Environmental Management and Natural Disaster Management. 2001.

if they contradict forecasts based on other traditional warnings or natural signs.

Warnings do not always include advice on viable courses of action to reduce risk. The socio-economic, cultural or political reasons that may impede action once warnings are received need to be overcome. In some cases, the provision of additional resources can reduce losses. In others, deep-rooted barriers to the capacity of people to act on their own behalf must be addressed to advance genuine community resilience. Among these are entrenched poverty and barriers to women's decision-making power.

After the 1991 eruption of Mount Pinatubo, a survey conducted by the Philippines Institute of Volcanology and Seismology indicated some weaknesses in the dissemination process, and the failure of some inhabitants to fully appreciate the risks and take protective actions. The reasons why people did not evacuate as advised included their underestimation of the strength of the eruption, a reluctance to abandon their property, livestock and crops, the unavailability of transport, or an inability to walk long distances. There was also the traditional belief that the volcano was a god who would not harm them.

Box 5.52
Women's role in response to early warning

In the 1991 cyclone in Bangladesh, warning signals did not reach large numbers of women within the home or homestead, and many died as a result. In a highly gender - segregated society, warning information was transmitted between men in public spaces where they congregated, with the assumption that this would be communicated to the rest of the family, which did not always occur.

Many of those who heard the warning ignored it because the cyclones that had occurred after the 1970 disaster had not caused much destruction. In the ensuing procrastination, women who had comparatively less knowledge about cyclones and were dependent on male decision-making perished, many with their children, waiting for their husbands to return home and take them to safety.

Source: Engendering Disaster Preparedness and Management, Jean D'Cunha, 1997.

Box 5.53
Community flood warning systems in Indonesia

The Banorawan Farmers Association (PPB) established a flood early warning system for Indonesian communities during the 2000 floods. The system was based on four units of two-way radio communication equipment with the necessary coverage power. Two of the units came from the communities supporting the association. The warning system was effectively used during the monsoon period since the end of 2001. Upon reports of torrential rains in the upstream area, PPB carries out preparedness activities passing on and disseminating information on water levels, coordinating with government officials at sub-district and village level to evacuate villagers before inundation.

During the dry season, the early warning system is utilized as a coordination mechanism between the chair of PPB and village coordinators or other potential members in the coverage area of PPB. Training on how to use radio communication is carried out. The radio system helps arrange distribution of irrigation water when needed. The radio system contributed to build flood risk management capacity, and address other organizational issues. It was recognized that careful oral dissemination is needed to avoid distortion of information gathered through communities.

PPB is exploring ways to develop the system into a community radio to enhance its effectiveness. The following factors will be taken into account: entertainment function, media for local campaigns, means for community development in line with regional and global issues, enhanced organizational existence and performance, increased coverage and partnerships.

Source: Overview of early warning system for hydrometeorological hazards in selected countries in Southeast Asia, ADPC, July 2002.

Future challenges and priorities

Early warning systems

From the issues discussed in this section, the following areas for action stand out as future priorities:

- communication requirements;
- scope of early warning systems;
- application of scientific forecasts;
- public knowledge and participation; and
- coordination of early warning activities.

Communication requirements

This section has emphasized the need for improved communication channels among stakeholders involved in all stages of early warning. The technology required for early warning exists. However, it has been found that a weak link in the early warning chain is communicating forecasts in a manner that is understandable by intended recipients and therefore elicits an effective response.

This conclusion is not a new one. The IDNDR early warning systems working group found that system difficulties are not technological but rather are related to human and institutionally-based communications and conceptual design.

Institutionalized and regularly tested communication channels that clearly spell out the functions and roles of the actors along the warning chain will contribute to improved understanding. Greater coordination between actors will provide a comprehensive picture of conditions necessary to inform decision-making and response actions.

Specific areas for future action include:

- better linkages among stakeholders at all levels;
- integration of activities, interests and expertise of the various actors in the process;
- exchange of information and technology;
- training users;
- improved design of end-products; and
- strengthening institutional capacities.

Scope of early warning systems

Much of the conceptualization and implementation of early warning systems is still focused on rapid onset disasters or individual sectoral interests. However, disasters must be considered in a comprehensive approach and as multi-factoral events with a potential slow-onset period. This will broaden the prior focus of early warning to incorporate less explored issues linked to longer-term hazards and phenomena, including climate change, El Niño/La Niña phenomena, fire hazards, communicable diseases and social processes.

As a pillar of disaster reduction strategies, early warning systems must be integrated in sustainable development policies. There is also a greater need for institutionalized nomenclature, standards and procedures. The ability of early warning systems to deliver information about vulnerability patterns in addition to hazards forecasting needs to be developed. For example, the conversion of El Niño forecasts into locally usable information is needed to improve the decision-making process.

Perhaps the most important area for future work is the elaboration of criteria to measure the effectiveness of early warning systems. Performance evaluation system should significantly increase warning system credibility and efficiency. Evaluation criteria should consider:

- accuracy of warnings;
- timeliness of warnings;
- coverage and number of recipients;
- economic losses;
- response measures taken;
- users satisfaction rating;
- awareness of the system in place;
- any conflicting, inappropriate or inconsistent information; and
- validation processes.

Application of scientific forecasts

Unrestricted and affordable access to relevant early warning information for all users is necessary but not sufficient. Improvement of the interface between issuers and intermediaries for a better interpretation of scientific predictions and their translation into positive administrative actions is a key factor of the early warning chain. Further scientific research is essential and must address all aspects of the early warning chain - hazards, forecasting, communication and especially social factors and processes.

Advances in forecasting and monitoring must be accompanied by accurate and comprehensive vulnerability and risk information. Major efforts should be undertaken in the coming years to assess vulnerabilities, generate risk scenarios and vulnerability maps, based on standardized methodologies. Then more attention should be devoted to developing user-friendly products for decision makers and communities at risk. This will require a better understanding of user needs and preferences on how information should be presented and how to apply it in the decision-making process. Attention needs to be given to the consequence of uncertainty in forecasts on decision-making.

Public knowledge and participation

User-oriented warning information can only become a reality with the structured and focused involvement of the public. People need to understand the risks they face, be aware of the existence of the warning system, and understand the appropriate early warning reactions.

The performance of early warning systems ultimately depends on the proper consideration of the underpinning psycho-sociological mechanisms and cognitive processes. Issuers of warnings need to understand better those people at risk and what form of information is needed to secure effective responses to the warnings

Public participation is the key to trustworthy and credible early warning systems. This includes the full and equal participation of women. Integrated information systems that ensure community participation in national early warning strategies need to be developed. These systems must take into account traditional and local knowledge and coping strategies. Public participation is also essential for the regular testing of warning systems and in providing feedback for improvement.

Coordination of early warning activities

There is a need to strengthen the international framework for early warning systems drawing on the extensive experience of major early warning organizations such as WMO. Among other things, this will help ensure technology transfer and capacity building for developing countries. The early warning process will benefit from the exchange of resources and information through enhanced contacts with institutions in charge of multilateral environmental agreements, such as UNCCD and UNFCCC. Such contacts will also improve interaction between the early warning process and the international agenda for sustainable development.

The establishment of a global early warning programme and international forum would advance the early warning process. It would improve coordination and cooperation, and enhance exchange of information, experience and technologies among national, regional and international activities.