5.6 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 the people effectively, they need to be integrated instruments designed to link the scientific and technical initiators of warnings and those who identify vulnerabilities, the intermediaries composed of public authorities who issue warnings and emergency instructions, disseminators and processors of sector-specific products, and the ultimate users of the warnings in local communities. Robust, accurate and timely means of reliable and understandable communications are essential. Effective early warning procedures should be part of the national institutional and legislative frameworks for disaster management and have redundancy built into the system. To be fully successful, 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 or avoidable damage.

This section begins with the current status of early warning thinking. An effective early warning system is built on three requisites:

- Political responsibility to promote early warning strategies;
- Participation and knowledge of the public;
- Support at the international and regional levels;

completed by the following three elements:

- Technical identification and monitoring of hazards;
- Multidisciplinary, multi-agency and intersectoral communications;
- Institutional services to react to warnings; and concludes with

Current status of early warning thinking

Early warning has always been considered a cornerstone of disaster reduction. From the outset, IDNDR had set as one of the targets to be attained by all countries by 2000, ready access to global, regional, national and local warning systems and broad dissemination of warnings. During the past decade, significant activities, events/conferences and programmes had promoted the feasibility and added value of early warning, and identified major strengths and weaknesses of early warning capacities around the world. These included the 1994 Yokohama Strategy and Plan of Action for a Safer World, the Declaration of the 1998 Potsdam Early Warning Conference and the Early Warning Programme Action Plan for the Future presented at the IDNDR Programme Forum in 1999. Specific concerns were also addressed related to climatic phenomena such as El Niño (Guayaquil Interna-

Elements of the early warning chain:

- ☑ **Forecast and prediction** of impending extreme events, on the basis of scientific knowledge and monitoring results
- ☑ **Warning processing and dissemination** of information from the first segment together with information on the possible impacts on people and infrastructure (i.e. vulnerability assessment) to the political authorities and to the threatened population. The information includes appropriate response-oriented recommendations
- ☑ **Reaction** to warnings based on a proper understanding of the information by the population at risk and local authorities, and subsequent implementation of protective measures.

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tional Seminar on the 1997-1998 El Niño Event: Evaluation and Projections in 1998), or to specific circumstances such as those of small island developing States (Barbados Global Conference on the Sustainable Development of Small Island Developing States in 1994).

Renewed efforts at all levels to integrate early warning as an essential component in the culture of disaster reduction have always been encouraged by the United Nations General Assembly. Recently, the crucial importance of early warning was again validated by IATF for ISDR which identified early warning as a priority area for its future work and created a specific working group on early warning, described later in this chapter.

Advances in science and technology during the last decade have reinforced the possibilities of

Guiding Principles for Effective Early Warning

THE OBJECTIVE of early warning is to empower individuals and communities, threatened by natural or similar 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 nearby and fragile environments.

RISK ASSESSMENT provides the basis for an effective warning system at any level of responsibility. 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.

Several groups must contribute to this empowerment. Each has a set of essential overlapping functions for which it should be responsible:

Members of vulnerable populations should be aware of the hazards and the related effects to which they are exposed and be able to take specific actions themselves which will minimize their personal threat of loss or damage;

Local communities should have sufficient familiarity with hazards to which they are exposed, and the understanding of advisory information received, to be able to act in a manner 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 should exercise the sovereign responsibility to prepare and issue hazard warnings for their national territory in a timely and effective manner, and to 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 utilize information and to develop operational capabilities is an essential function to translate early warning knowledge into risk reduction practices;

Regional institutions should provide specialized knowledge, advice or benefit of experience in support of national efforts to develop or to sustain operational capabilities related to hazard risks experienced by countries that share a common geographical environment. Regional organizations are crucial to linking macro-scale international capabilities to the particular needs of individual countries and in facilitating effective early warning practices among adjacent countries; and

International bodies should provide means for the shared exchange of data and relevant knowledge among themselves as a basis for the efficient transfer of advisory information and the technical, material and organizational support necessary to ensure the development and operational capabilities of national authorities or agencies officially designated as responsible for early warning practice.

early warning reducing the consequences and especially the human losses from natural disasters. To give but a few examples, forecast time and location of landfall of tropical cyclones is now 48 hours in advance; the warning time of tornadoes has doubled in one decade; and warnings of drought are now issued several months in advance. The development of new information technologies and the very rapid spread of global communications have considerably increased the availability of information and early warnings about natural disasters. These technological advances now enable better monitoring, prediction and forecasting of extreme weather conditions. Significant improvements in global observation systems have also enhanced the early detection of medium-term abnormal climatic conditions such as El Niño events, and will contribute to warnings of long-term hazards associated with environmental change. Sophisticated early warning systems can only become effective with the free and unrestricted exchange of meteorological data throughout and among societies, and with similar attention given to the expression of warnings so that the people for whom they are intended can understand them.

However, the ability to deliver this vital information to the public in the locations where it is most likely to be affected by disasters has not always enjoyed similar success. Local mechanisms for communicating risk, or downscaling the interpretation of alerts to relate to local conditions or experience, remain very weak in many cases. Sophistication has to be weighed against local capacities, needs, resources and traditions. Moreover, information about the adverse impacts of disasters on people and infrastructure (i.e. vulnerability and risk assessments) that is necessary for informed decision-making is often missing. Even where abilities and procedures do exist, communities do not often respond appropriately to them, because there is a lack of planning, resources or viable protective options that they could utilize in a timely manner. Ironically, in many documented cases, the perceived threat of losing their property to looters when unprotected during a time of evacuation, is considered a greater threat by many people than a loss caused by a severe weather disaster.

Elements for effective early warning are well documented. Guiding principles for effective early warning resulted from several years of work undertaken under the aegis of the IDNDR Early Warning Programme, by experts associated with all aspects of warning practices and for various types of hazards. The different sets of these guiding principles are reproduced throughout this chapter as they still provide a clear and comprehensive basis for the early warning process. The challenge to be met in the coming years is to translate these accepted principles into concrete action-oriented modalities.

By way of introduction to the specific issues of concern to improve the effectiveness of early warning, the Mount Pinatubo example illustrates the added value of early warning systems and describes the factors that contribute to the effective warning of populations at risk.

Early warning for the 1991 eruptions of the Pinatubo volcano, the Philippines: a success story

Early warning for the 1991 eruptions of the Pinatubo volcano is a success story in that the number of deaths compared to that of those at risk was small despite the magnitude and violence of the eruption. The success was due to a number of factors that illustrate the important issues in this chapter: timely identification of the hazard and delineation of vulnerable areas, successful application of state-of-the-art monitoring and surveillance techniques, accurate prediction of the destructive phases, timely issuance and dissemination of easily understood warnings, prompt action of key civil defence officials and disaster response workers, and timely evacuation of majority of inhabitants at risk.

The positive aspects of the experience highlighted the value of the following: state-of-the-art monitoring equipment and techniques, 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 science people and civil defence officials, good relationship between scientists and the media adapted from

Punongbayan and Newhall, 1998

Early warning is not a technical and even less a technological issue, but a human and organizational one. Satellite coverage and state-of-the-art surveillance techniques are now sufficient and the most difficult part, which is composed of the following requisites, remains to be tackled.

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Political responsibility to promote integrated early warning strategies

The first requisite for achieving an effective early warning system is recognition of the value of early warning in protecting the interests of societies and communities. Political willingness to use it as a meaningful policy instrument for disaster risk management will derive from this acknowledgement. However, commitment is not enough. Mobilizing the necessary political, human, technical, material and financial resources is needed to underpin better warnings that can avoid, or at least reduce, risks. Governments need to support legislation, administration, contingency planning and operational procedures including inter-ministerial/inter-agency relationships. Well-developed decision-making capacities will avoid disasters that occur because predictions are considered as being too uncertain. Governments need to take the initiative to establish, and thereafter, maintain the necessary collaborative framework needed for the functioning of credible and accountable warning systems. They have the responsibility to promote integrated early warning strategies so as to gain wide support for the implementation of governmental decisions at times of crisis. Political initiatives and support will guarantee the technical and social relevance, usefulness and efficiency of early warning strategies. One element that should increase political commitment towards early warning strategies is the availability of indicators to measure their effectiveness, especially in terms of losses avoided and recipient satisfaction.

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

Mauritius offers an interesting example of institutional arrangements according high priority to early warning of cyclones. The explicit specifications of the principal elements of the cyclone warning dissemination system, including roles and responsibilities (with details of warnings and their dissemination) are set out in the Cyclone and other Natural Disasters Scheme (1995). The Mauritius Meteorological Office is part of the Prime Minister's Office. The Central Cyclone Committee, a well-administered and communication-oriented central body, provides leadership to ensure the effectiveness of the warning system. This endorsement from the political centre of Mauritius is a particularly strong and commendable feature of its disaster planning from which others elsewhere can learn. A high degree of legitimization is accorded by this support. Effective leadership is provided from a central government committee in the area of disaster preparedness (including the warning system), mitigation and recovery (UK Flagship Programme, 1998).

SADC countries have long focused attention on drought and resulting food security issues for which early warning and preparedness mechanisms have been developed over the last twenty years. However, recent extreme weather events have encouraged a wider perspective for early warning and more comprehensive disaster preparedness activities. Such a shift conveys the understanding that potential disasters are rooted in the relations between human actions, environmental conditions, management of natural resources and the climate. Therefore additional warning requirements need to be addressed through policies that can provide an integrated regional early warning and disaster preparedness framework. Necessary steps have been taken through the development of a framework for a multisectoral disaster management strategy supported by UNDP.

Another step forward was made through the process launched by SADC heads of State and Government following the devastating floods in Southern Africa in early 2000. This initiative provides a good example of political willingness to improve early warning and preparedness capacities. A review of the contributions that meteorological and hydrological services provide to early warning and disaster preparedness resulted in recommendations for political decisions to boost regional early warning strategies. Recommendations 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, able to link increased national capacities to improve early warning. It was also recommended that adequate funding be provided to national institutions to equip them with the necessary facilities and tools to maintain their high level of public service in the national interest, and to enable them to

In **Cuba,** a national hurricane preparedness plan is practised every year before the start of the hurricane season, when the early warning system is tested. The system is activated at the first information notice by the military authorities and civil defence, involving the political party authorities and all provincial or municipal government officials, representatives of all administrative and political institutions, companies, co-operatives, etc. 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, Cuba, November 2001 - a success story

Hurricane Michelle formed in the Gulf of Honduras on the 2 November, 2001, landed on Cuba 4-5 November, reaching wind speeds of up to 220 km/h (category 4 Saffir-Simpson-Scale). Michelle has been the strongest hurricane affecting Cuba in the last 50 years.

Upon early notice from the Institute of Meteorology the evacuation plan came into action.
Twelve provincial and 150 municipal headquarters for civil defense involving 87000 people were activated. More than 5000 vehicles were deployed for evacuation, etc.

Over 700,000 persons were evacuated, of which 270,000 for a longer time and provided with temporary accommodation and basic needs. 777,000 animals were also moved to safe areas. Reports indicated only 5 fatalities and 12 people injured.

Nevertheless, a major economic setback was the result of the hurricane. Principal damages were to building infrastructure, agriculture and communications facilities.

contribute more effectively to early warning and disaster preparedness systems on a regional basis. Another recommendation was further development of comprehensive implementation and contingency plans by countries that integrate early warning systems, disaster preparedness and related mitigation activities into overall national disaster management frameworks.

Thanks to UNDP support, the *Viet Nam Disaster Management Unit (DMU)* is benefiting from a nationwide information system that provides a combination of real-time information to the *Central Committee for Flood and Storm Control (CCFSC)*, the primary Government agency for disaster management. The system provides early warning information, updates on developing disaster situations, and related information about damage or needs 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 of Agriculture and Rural Development. Internet provides an expanded opportunity to disseminate timely warnings about floods to the public and to address immediate emergency requirements, or disseminate general information related to disaster management. Since early 2001, the project has benefited from more advanced information technology provided by 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 enable the dissemination of more effective public warnings. Flood maps for all of the central provinces in Viet Nam are being created with the latest GIS technology, accompanied by training that will encourage its effective use by provincial and local authorities. A new flood-hazard alerting system is also being designed for the areas most prone to rapid or flash flooding.

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Public knowledge and participation

The second requisite for an effective early warning system is public participation in the design, implementation and assessment of warning formulation and dissemination. The following principles were developed to provide concrete guidance for the application of early warning at the national and local level. They cover the issues discussed in this subsection.

Early warning messages should reach, be understood, believed and personalized by the public at risk to enable it to take action to reduce its vulnerability to hazards. Therefore community involvement is necessary to design locally efficient and socially relevant early warning systems. Such involvement permits a continuous dialogue between users and authorities to make collective decisions and choices. Investment in modern technology and top-down professional expertise to forecast hazards and issue warnings can only be justified if warnings effectively reach every citizen likely to be affected. In this regard, there is much to be gained and learned from providing support to grass-roots bottom-up approaches. Communities and NGOs that represent their interests are key elements in operating early warning systems, i.e. disseminating messages, operating and maintaining warning equipment, organizing training and regular testing to avoid surprises at times of crisis, raising awareness of the responsibility people have for their own survival, providing motivation and coping strategies, avoiding confusion, contradiction and conflicts.

Principles for the application of early warning at NATIONAL and LOCAL levels

1. Early warning practices need to be a coherent set of linked *operational responsibilities established at national and local levels of public administration and authority.* To be effective, these early warning systems should themselves be components of a broader programme of national hazard mitigation and vulnerability reduction.
2. 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.
3. The *decision 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 previously established disaster management procedures of organizations at national and local level.
4. In the chain of political responsibility, initial hazard information is often technically specialized or specific to a single type of hazard authority. To be applied effectively, *warnings need to be clearly understood and operationally relevant to local agencies* that are more frequently oriented towards non-specific hazard functions.
5. 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. The warning process should *lead to 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.
6. *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.*
7. There is a continuing *need to monitor and forecast changes in vulnerability patterns, particularly at local levels*, such as sudden increases in vulnerability resulting from social developments. These may include conditions of rapid urbanization, abrupt migration, economic changes, nearby civil conflict or similar elements that alter the social, economic or environmental conditions of an area.
8. The *primary responsibilities must rest at local levels of involvement* 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. A high resolution of local knowledge and developed experience of local risks, decision-making procedures, definitive authorities concerned, means of public communication and established coping strategies are essential for functions to be relevant.
9. Groups of people that exhibit different types of vulnerability will have different perceptions of risk and various coping strategies. *Locally appropriate warning systems will provide a range of communication methods and should provoke multiple strategies* for protection and risk reduction.
10. *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 production and verification of information about perceived risks, agreement on the decision-making processes involved, and standard operational protocols. Equally important abilities involve the selection of appropriate communication media and dissemination strategies that can assure an effective level of participation in acting upon receipt of warning information.

The following boxes provide a summary of the benefits of public participation and indicate factors that facilitate this process.

Benefits of public participation include:

- Improved understanding of warnings as a complex social process;
- Identification of warning recipients;
- Identification of resources available at the local level to tailor message contents, dissemination channels and response options (including empirical knowledge of hazards and local coping strategies);
- Access to most vulnerable community groups (an effective early warning system is one that caters adequately and equally to remote and other vulnerable social groups with special needs or limited access to resources, including remote island communities, squatter settlements, disabled and elderly people, tourists and fishermen);
- Better understanding of user needs and preferences in terms of product-type and application, as well as display of information;
- Social support for public policies and decisions, mass evacuations, for example;
- Enhanced credibility of warning messages;
- Easier improvement of early warning systems based on feedback analysis from warning recipients.

How can public participation be facilitated?

1. Political commitment to create the conditions for allowing public involvement.
2. Early start in the warning design process in order to allow time for trust-building.
3. Definition of how participation will be organized.
4. Provision of all necessary information to community leaders and civil society representatives.
5. Advertisement and wide sharing of the process through the mass media, for example.
6. Testing of warning options; monitoring of implementation.
7. Maintenance of communication and iteration (feedback with users) during the process.
8. Institutionalisation of feedback procedures and assurance of sustainability/maintenance of the system.

Adapted from B. Affeltranger, 2002

The following examples show several facets of public involvement, participation and knowledge. They display useful practices such as public involvement in warning dissemination, strengthening of local capacities, the application of local experiences and public participation in the design of early warning systems.

For the past thirty years, the Bangladesh Red Crescent Society's *Cyclone Preparedness Programme (CPP)* has disseminated warnings and assisted cyclone-affected communities along 710 kilometres of the Bangladesh coastline in the Bay of Bengal. Equipped with hand sirens, megaphones, transistor radios, signal lights and flags, first-aid and rescue kits, more than 30,000 volunteers act as the communications channel through which the CPP head office in Dhaka relays weather bulletins from the Bangladesh Meteorological Department to more than ten million people living in areas of high cyclone risk. CPP has demonstrated that disaster preparedness programmes can be successful through the use of community-based management methods and basic forms of technology that can link appropriate and effective warning systems to distant providers of life-saving information. Selected volunteers serve as "information lifelines" for people at times of threatening cyclones.

Through the CPP communications network, high-frequency radio broadcasts are transmitted from the capital city of Dhaka to field stations equipped with additional very high frequency (VHF) radio receivers, where information is then passed on to the volunteer unit teams by way of transistor radios. 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.

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The CPP volunteer training and public awareness programmes are central to its success and well-founded reputation. Public awareness about the risks associated with cyclones is conveyed by the volunteers themselves and demonstrated through drills and demonstrations, dramas and folk songs. Printed materials, the use of films and videos and targeted publicity campaigns 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.

It is the dedication and tireless efforts of these volunteers–and all who support them with their understanding, support and respect–that contributed to the CPP receiving Thailand's "Smith Tunsaroch Award" in 1998 in recognition of the volunteers' efforts to protect the people of Bangladesh.

Informal and social networks have been found to reinforce warning dissemination systems in Mauritius. It appears likely that small, isolated island communities such as Mauritius have particularly strong and effective social networks, which considerably help warning dissemination. Informal personal and community networks can be highly effective in disseminating warnings and deserve the right appreciation from those issuing formal warnings. They usually benefit from an organizational and popular culture in which preparation for cyclone and cyclone warning and response are to some extent embedded.

Source: UK Flagship Programme, 1998

The **RELSAT Project (Strengthening of local structures and early warning systems)** 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 Aid Office (ECHO)* and realized in the context of long-term community-based disaster risk reduction cooperation between CEPREDENAC and the *German Agency for Technical Cooperation (GTZ)*.

The purpose of the project was to establish efficient and reliable early warning systems with regard to 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 possible at a local level. As pilot zones, they served as examples that demonstrated the experiences local communities had had in applying local disaster 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 zones of risk and of the specific demands (risk maps, interviews, participatory planning);
- Training of the local population in flood-fighting measures;
- Selecting, training and equipping observers and analysts in the watershed of the affected river;
- Improving communication capacities among the individuals and institutions involved;
- Developing contingency plans and implementing evacuation exercises in the pilot zones.

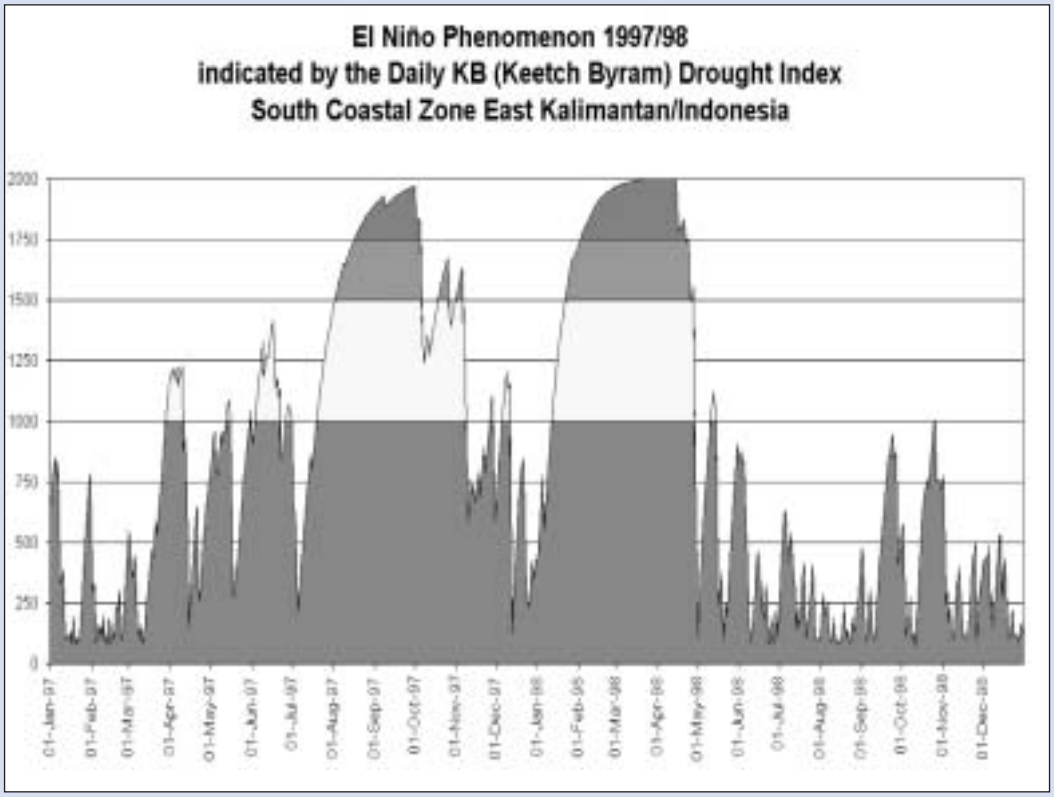
The results of all these efforts in the six pilot zones were early warning systems that work in the following way. Selected people living in the upper parts of the river regularly measure rainfall and water level. They transmit this information by radio to a central office in the closest municipality where the data collected are analysed. The centre itself is in communication with people in the flood-prone areas. At times of expected danger, the centre can thus 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 processes among all actors and the population at risk. Responsibilities have also to be clearly assigned and commitment must be continuous. If these conditions are met, the early warning system helps to reduce substantially the losses and damages caused by floods and to motivate people to take further action aimed at achieving sustainable disaster risk reduction for the region.

The ongoing work to design an early warning system for the Lower Mekong floods undertaken by the *Mekong River Commission (MRC)* and its member countries (Cambodia, the Lao People's Democratic Republic, Thai-

Early warning of forest fire at local level

The Integrated Forest Fire Management (IFFM) project in Indonesia is a technical cooperation project supported by GTZ and the Global Fire Monitoring Centre (GFMC). The project approach relies on the involvement of local communities in fire prevention and preparedness (community-based fire management). 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 (FIS) that manages spatial fire-related data and information in an integrated manner. The graph indicates the KBDI readings for the 1997-1998 El Niño years that 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: GTZ/GFMC, 2001

land and Viet Nam) illustrates efforts to devise a strategy that is both technically efficient, socially useful and relevant to the recipient communities. The ongoing project is guided by research focusing on the complex social process triggered by warnings, which 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. Thanks to the Commission and other parties involved, participatory approaches are progressively being introduced into the disaster management culture of the region. Individual countries should in principle apply a similar approach depending on their institutional settings and political preparedness. Possible 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 on the occasion of the MRC Expert Meeting on Flood Forecasting and Early Warning Systems (Phnom Penh, Cambodia, 26 February-1 March 2002). The plans emphasize the need to understand vulnerability, risk culture and related trade-offs, as well as the social response to floods to provide useful warnings. National authorities were advised to conduct a proactive, preliminary assessment of the social relevance, relative usefulness and expected efficiency of their flood warning strategy in order to further improve it.

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

Similar approaches have been developed elsewhere. The European Union's ***OSIRIS project and Information Society Technologies Programme*** assessed the potential added value of so-called "new information and communication technologies" for flood-related warning and information management. The project also studied conditions for effective operation of such tools, as well as social ownership. In 2000-2001 the *European Centre on Risk Prevention (CEPR)*, Niort, France, organized community-based workshops. A two-phased study was carried out to understand differences in risk perceptions and information demands amongst stakeholders, and to survey the social relevance and efficiency of existing or planned flood warning systems. In Hungary and Mozambique, the *United Nations Educational, Scientific and Cultural Organization (UNESCO)* carried out a study on flood-related information management systems and public participation at community-level in flood mitigation and control.

These examples confirm that early warning strategies should not be separated from broader development planning and poverty reduction goals. Practical and tangible objectives or immediate incentives are likely to trigger communities' commitment to user-based processes. Respectful understanding of existing social processes and capitalizing upon them are keys to successful schemes for public participation.

Support at the international and regional levels

The third requisite for the emergence, maintenance and improvement of effective early warning systems is the support provided by international and regional institutions and networks. The following principles provide a basis to guide the collaboration and coordination efforts required at the international and regional levels.

First of all, international and regional support provides incentives and motivation to strengthen and improve early warning capabilities, while at the same time ensuring coordination of activities and facilitating the exchange of knowledge. There are many benefits to be found in the three-tiered support structure in which international/global efforts are mobilized to strengthen and build capacity at the regional level, which level does the same at the national level.

As seen in the examples given in this chapter, regional processes provide a framework for action at the national level; regional institutions provide advice and motivation to national institutions; these assist in fund-raising and are key interlocutors for governmental authorities thanks to their appreciation of national circumstances; finally, they assist countries to play their part in international activities.

International cooperation provides essential financial and support in kind to build national early warning capacities. Major networking initiatives that facilitate exchange of information and experience and linkage with international agendas are launched through international cooperative arrangements for the benefit of national institutions. Specific activities such as the development of uniform standards and concepts can only take place internationally with the cooperation of as many United Nations Member States as possible.

Recent activities undertaken at the international level include the Expert Meeting on Early Warning and Sustainable Development held in March 2002, under the auspices of the German Committee for Disaster Reduction (DKKV), within the framework of ISDR. The purpose of the meeting was to translate what is needed from the ongoing early warning process into concrete recommendations for action. The rationale of the initiative was to define modalities to implement the action plans and strategies resulting from the work carried out during the past decade and to take the opportunity of the upcoming WSSD to increase the visibility of the early warning process. Outputs of the meeting are intended to serve the WSSD preparatory process and beyond.

The meeting was instrumental in reiterating the contribution of early warning systems to the process of achieving sustainable development. Building on the elements of early warning and disaster reduction negotiated in the

Principles for Early Warning Systems at INTERNATIONAL and REGIONAL levels

1. In the interest of concerted international efforts to reduce the adverse effects of natural and similar disasters, *the technologically advanced countries have an obligation to encourage and support improved early warning practices in developing countries,* small island developing States, economies in transition, and other disaster-prone countries with special circumstances.
2. Primarily affected *countries equally have a primary responsibility to conduct a rigorous audit of the effectiveness, or consequential identification of needs, of their early warning capabilities.* The conduct of post-mortem assessments of regional and national warning system capabilities is particularly relevant following any disaster event.
3. *Specialized regional and global centres involved in the preparation and dissemination of warnings,* such as the WMO Regional Specialized Meteorological Centres (RSMCs) 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 about the warning 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 vital importance of timely exchange and unrestricted access of observational data and other warning information between countries*, particularly when hazardous conditions affect neighbouring countries.
6. *Timely, accurate and reliable warnings should be understood in 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.

WSSD preparatory process, the meeting identified specific needs and suggested a course of action to fulfil those needs. First and foremost need for better interlinkages to ensure dialogue among all stakeholders at all levels was identified, as well as the lack of vulnerability assessments at local and national levels. Capacity-building, technology development, indicators to evaluate the effectiveness of early warning systems as well as a thorough inventory/review of ongoing initiatives/programmes were listed among the specific needs.

The development of a global programme on early warning was suggested to fulfil the needs identified. The purpose of the programme would be to raise political commitment at national, regional and international levels towards the integration of early warning systems in disaster risk management strategies. Recognizing and drawing upon the valuable work already under way, especially by WMO, an important dimension of the programme would be the development of an early warning platform/forum, under the auspices of the United Nations to facilitate dialogue between stakeholders and support exchange of experiences and information on early warning, at the international, regional, national and local levels. Hopefully the global programme on early warning and the international early warning platform/forum would trigger the establishment of national and subregional early warning platforms/forums to strengthen networking and capacities among the actors involved in the early warning chain. Such a programme would also be active in the areas of capacity-building and technical cooperation to reduce the technical/technological and scientific gaps between developed and developing countries.

The above activities would be elaborated within the ISDR framework and relevant strategies and structures through wide consultations, Working Group 2 and the ISDR secretariat being actively associated in this endeavour. Finally, a time frame to implement the above recommendations was developed.

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ISDR Task Force Working Group on Early Warning

The aim of Working Group 2 on early warning created by the ISDR IATF is to better coordinate global practices in early warning and to make sure it is effectively utilized as an instrument in disaster reduction activities. The UNEP Division of Early Warning and Assessment leads this Working Group whose membership includes CDERA, the Food and Agriculture Organization of the United Nations (FAO), the German National Committee for Disaster Reduction, and the ADRC, GFMC, the Intergovernmental Authority on Development (IGAD), the SADC Drought Monitoring Centres, the South Pacific Applied Geoscience Commission (SOPAC), the United Nations Programme for Human Settlements (UN-HABITAT), the United Nations Convention to Combat Desertification (UNCCD), UNDP, UNESCO and WMO. The group builds on previous activities undertaken in the field and coordinates with those of the different IATF working groups in the areas of data and information management, to support assessments of risk and vulnerability to natural hazards and early warning and vice versa. The group seeks to involve as many parties as possible from national, regional and international organizations into its discussions, on an ad hoc basis, to ensure its intersectoral and multidisciplinary dimension.

Key words characterizing the six objectives of the Group are coordination, collaboration, harmonization, dissemination of information and networking to create and share knowledge. The work of the group will focus on inventorying capacities for early warning and vulnerability assessments, as well as related scientific and technical issues, learning lessons and identifying shortcomings, developing effectiveness indicators and communicating early warning information. The group will

At the regional level, the growing economic importance of climatic variability has prompted WMO and other technical institutions to reach beyond scientific research and to extend available information to establish early warning systems and to strengthen local risk reduction practices. An excellent example in this area is the series of Regional Climate Outlook Forums (RCOFs) organized by *USAID*, the *United States National Oceanic and Atmospheric Administration (US/NOAA)* and WMO. These seasonal, multidisciplinary technical meetings have brought together meteorologists, climate forecasters and disaster managers from neighbouring countries to review advance climate forecast indicators jointly and then to consider the potential implications in their respective countries. The weather forecast data are likewise discussed with respect to other social and economic dimensions of governmental interest, in an effort to develop routine opportunities by which climatic and meteorological considerations are integrated into disaster management, agricultural, public health, energy, commercial and similar interests shared by all of the participating countries.

A review to assess the accomplishments and shortcomings of RCOFs and recast their future was carried out in 2000. Conclusions are consistent with the needs identified at the Bonn meeting, i.e. improved interlinkages among all stakeholders involved in the early warning process. As stated in "Coping with the Climate: A Way Forward", there is a need to clarify and reinforce the current three-tiered support structure. There is also a need to focus and build capacity in key areas, including the development of improved, user-tailored forecast products in partnership with appropriate intermediaries, broader outreach through the media, verification of forecast products and evaluation of forecast costs and benefits. Development and use of forecasts will be enhanced by "more systematic organization of the roles and responsibilities of forum partners including users, researchers, and operational organizations" and by the "partnerships … needed at all levels of the process". Governments, policy makers, development experts, scientists and other interested parties are invited to engage in a process of dialogue and programme development needed for the management of climatic impacts.

Technical identification and monitoring of hazards

Scientific knowledge and monitoring capabilities are needed to identify and forecast short to long-term hazards. The first segment of the early warning chain is the forecast and prediction of hazards, which along with vulnerability and risk information, will allow the formulation of warning messages for intermediaries. Until now, early warning has taken place along the lines of singular events and hazards or

organization-specific requirements. However the challenges that humanity will face in the twenty-first century require a systematic and comprehensive approach encompassing both environmental and climatic processes–over a longer period of time as well as during periods of quiescence (e.g. between El Niño episodes, in between fire weather, smoke and haze seasons, during hurricane and typhoon off-seasons, etc.). There is then a much greater need for institutionalized standard nomenclature, procedures, extended organizational relationships and common approaches to information management–which will be eased by advances in omnidirectional communication facilities and information technologies. Recommendations of the Bonn meeting described above and the action programme to be adopted at WSSD implicitly provide a starting point to address these concerns. As stated in the conclusions of the IDNDR Programme Forum in 1999, there is a crucial need to implement an early warning concept of the second generation that must be interdisciplinary and intersectoral comprising sociological, economical, political, organizational and scientific wisdom.

It is difficult to pay tribute to the number and variety of "warning centres", dispersed by type of hazard, location, organization, mandates, etc. Some examples have been selected and are briefly described in this subsection. Other examples are given in chapter 4.1 dealing with information management and communication.

As almost three-quarters of all natural disasters are related to weather, water or climate, WMO plays an important role in structuring the systematic analysis and reporting on hazards. It both works through, and provides, technical support to all National Meteorological and Hydrological Services (NMHSs) and many regional specialized meteorological centres worldwide. Without these institutions, early warning capabilities would almost be non-existent.

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

- **The World Weather Watch (WWW)** programme enables the exchange of real-time data, forecasts, warnings and advisories for the public and the international community;
- **The Tropical Cyclone Programme (TCP)** works to develop professional abilities and promotes nationally and regionally coordinated systems to ensure effective preparedness measures against tropical cyclones and associated phenomena;
- **The World Climate Programme (WCP)** rovides assistance through its Climate Information and Prediction Services to countries for the application of climate information and knowledge in the prediction and early warning of climate-related natural disasters;
- **The World Weather Research Programme (WWRP)** develops and promotes cost-effective and improved techniques for the forecast of high-impact weather like tropical cyclones, sand and dust storms, and heavy rainfall that can provoke severe flooding;
- **The Hydrology and Water Resources Programme** assists national hydrological services in assessing the risks, and issuing forecasts, of water-related hazards, with a focus on major floods and droughts; and
- **Regional Specialized Meteorological Centres (RSMCs)** are designated worldwide by WMO to provide weather forecasts and advisories on tropical cyclones or other specialized risks associated with the atmosphere or having global implications, like volcanic plumes, fire haze, or environmental emergencies including nuclear facility accidents or other local and large-scale pollution emergencies.

WMO technical cooperation projects contribute to the improvement of early warning systems in developing countries. For example, 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, which will produce and utilize early warning of impending danger and related social and economic consequences based on the actual predictions of *El Niño-Southern Oscillation (ENSO)* and thus ameliorate the socio-economic impacts of ENSO by improved early warning mechanisms. Feasibility will be analysed from the technical, economical, social, environmental, legal and institutional points of view.

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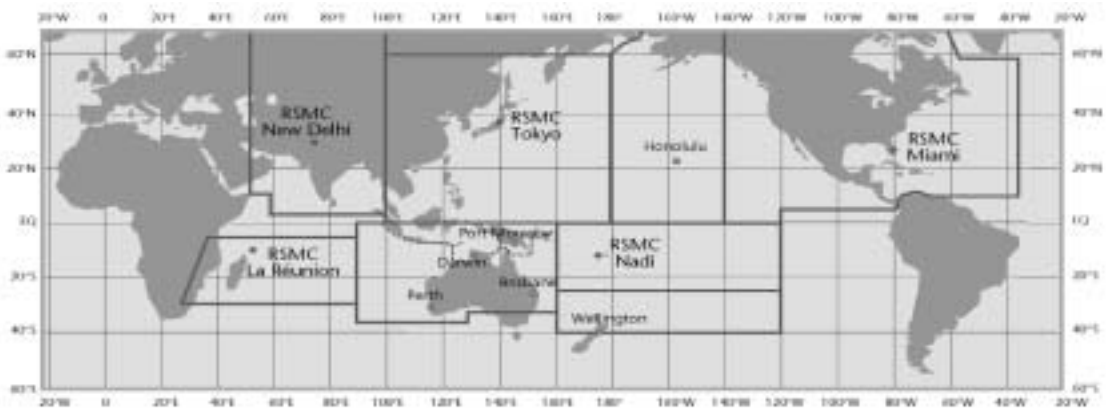
RSMC
New Delhi
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Miami
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La Reunion
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Darwin
Perth
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Wellington


GLOBAL NETWORK OF TROPICAL CYCLONE
MONITORING, FORECASTING AND WARNING SYSTEMS
WORLD WEATHER WATCH
GLOBAL DATA AQUISITION AND TELECOMMUNICATIONS
GLOBAL NUMERICAL MODELS
RUN AT MAJOR CENTRES
• GLOBAL FORECAST FIELDS
REGIONAL TROPICAL CYCLONE CENTRES
• REGIONAL FORECAST TRACKS AND INTENSITY OF TROPICAL STORMS
• REGIONAL METEOROLOGICAL WATCH AND ADVISORIES
MIAMI
HURRICANE
AREA
REUNION
S.W. INDIAN
OCEAN
TOKYO
TYPHOON
AREA
NEW DELHI
BAY OF BENGAL
ARABIAN SEA
NADI
S.W. PACIFIC
NATIONAL METEOROLOGICAL CENTRES
• LOCAL METEOROLOGICAL WATCH
• SPECIFIC FORECASTS
• ADVISORIES
• WARNINGS
GENERAL
PUBLIC
LOCAL
GOVERNMENT
CIVIL DEFENCE
AGENCIES
LOCAL
MEDIA
INTERNATIONAL
MEDIA
signal
system
recorded
announcement
radio broadcasts
TV news
WARNING
BROADCASTING

The success of the WMO programmes illustrates the economic and social benefits that are derived from an accurate global weather forecasting system. Studies show that the benefits of weather forecasting do not stop at early warning of natural disasters. However, meteorological and hydrological services are still undervalued in most countries even though they constitute a building element of any national disaster reduction strategy given their importance in early warning systems. Moreover, observations of weather phenomena go beyond the immediate and seasonal forecasts determining daily human activity. Long-range studies of the stratosphere are crucial in understanding the phenomenon of global change, including El Niño, climate change or the depletion of the ozone layer. WMO scientific analyses and warnings are instrumental in addressing these issues and supporting multilateral environmental agreements.

An *International Research Centre for the El Niño Phenomenon (IRCEN, CIIFEN in Spanish)* is being established in Guayaquil, Ecuador, under the auspices of the Government of Ecuador, ISDR and WMO. The Centre will be a means to conduct a regional project that will address, inter alia, early warning systems for disaster loss reduction. It is conceived as a centre with global connections to other centres, but with a special focus on the Eastern Equatorial Pacific and the western countries of South America. Socio-economic benefits will be derived from seasonal forecasts and El Niño/La Niña warnings and advisories, which will be converted into information products designed for disaster loss reduction purposes and key socio-economic sectors, public health, agriculture, fisheries, water management, energy production and use. The centre should be starting its operations in September 2002.

Glacial Lake Outburst Flood (GLOF)

UNEP through its *Environment Assessment Programme for Asia and the Pacific (EAPAP)*, at the Asian Institute of Technology, Bangkok, is contributing to the establishment of an operational early warning system to monitor hazards in the Hindu Kush Himalayan region. Through a project implemented in collaboration with the *International Centre for Integrated Mountain Development (ICIMOD)*, Nepal recently produced inventories of glaciers and glacial lakes in Bhutan and Nepal, specifying the potential risk lakes. Outputs of the project also included recommendations for the establishment of a system for monitoring potential risk lakes using remote sensing, GIS and strengthening of national capabilities to implement an early warning system for GLOF hazards. Training of local experts was also provided.

Implementation of an early warning system in Nepal

Following panic created by the media in the summer of 1997 in the Rolwaling and Tama Koshi Valleys, His Majesty's Government of Nepal implemented an early warning system at the end of June 1997 to provide timely warning to the people. An army and two police posts were established at appropriate locations and provided with high frequency (HF) 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 was informed 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 early warning system

The first flood warning system in Nepal was installed in May 1998 to warn the people living downstream from Tsho Rolpa Glacial Lake, in the potential GLOF affected areas along the Rolwaling and Tama Kosi Valleys as well as at the Khimti Hydroelectric Project. The Department of Hydrology and Meteorology implemented the project financed by the World Bank. The operation of the warning system has been satisfactory. 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

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GFMC provides a web portal with the global, regional and national systems that are available for real-time or nearly real-time early warning of wildland fire. Most systems are based on weather forecasts at short to extended time ranges and global to regional space scales. The global system is generated by the *Experimental Climate Prediction Centre (ECPC)*. Regional systems are provided by the Association of South-East Asian Nations (ASEAN) *Fire Weather Information System* (generated by Forestry Canada), the *Eurasian Experimental Fire Weather Information System* (Forestry Canada and GFMC) and the *European Natural Hazards Project Forest Fire Risk* (European Union). Other systems are satellite-based indices, e.g. the Normalized Difference Vegetation Index (NDVI) and thermal data from the NOAA Advanced Very High Resolution Radiometer (AVHRR) sensors. Area, intensity and duration of vegetation stress, fire potential and 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.

The *Pacific Tsunami Warning System (PTWS)* of the *International Oceanographic Commission (IOC)* of UNESCO provides timely and effective tsunami warning, watch and information bulletins to the populations of the Pacific. It is operated through the *Pacific Tsunami Warning Centre (PTWC)* with the support of national and regional tsunami warning centres. IOC also maintains an *International Tsunami Information Centre (ITIC)*, which acts as a source of information for national and regional tsunami warning authorities.

Alongside these programmes, the *Three Global Observing Systems (G3OS)*, namely the *Global Climate Observing System (GCOS)*, the *Global Terrestrial Observing System (GTOS)* and the *Global Ocean Observing System (GOOS)*, in which United Nations agencies, the *International Council of Scientific Unions (ICSU)* and satellite agencies work together, make important contributions to the warning process. G3OS activities are harmonized through the *Integrated Global Observing Strategy (IGOS)*, to which the United Nations system-wide Earthwatch is also providing support especially as far as environmental observation and assessment are concerned. Environmental data need to be integrated into early warning strategies and Earthwatch provides a useful platform for information and knowledge exchange.

With continuing globalization in travel and trade, global epidemic surveillance is essential to ensure international public health security. International efforts to contain health-related threats are coordinated by WHO. WHO has established a number of international networks for specific disease threats and has developed several electronic databases including: 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 which scans the web for outbreak-related information. The early warning and response network of Southern Sudan (see box) also

Early Warning and Response Network (EWARN), Southern Sudan

EWARN was launched in 1999 by WHO in collaboration with several international agencies, NGOs and local communities to strengthen outbreak detection and response.

Objectives of EWARN:

- Early detection, alert and prompt investigation of suspected outbreaks;
- Establishment and strengthening of outbreak preparedness and rapid response;
- Provision of regular feedback and technical guidance to all involved;
- 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.
In 2000 a relapsing fever outbreak was contained within two weeks of reported onset, with 154 cases and eight deaths. Partnership has improved alerting, reporting and response in the event of suspected outbreaks and saved time, money and lives. The development of an early warning and response network in Southern Sudan which has built on the experiences and resources of existing NGOs, has provided a model of success in using scarce resources to build capacity and make a difference within a multidisease or integrated disease surveillance and response framework.

Drought early warning systems

Possible achievements through concerted and systematic approaches undertaken internationally, regionally and nationally are evidenced by the accomplishments in drought early warning systems established in the wake of the world food crisis in the early 1970s.

The FAO Global Information and Early Warning System on Food and Agriculture (GIEWS) provides a framework for institutional links and information-sharing agreements among United Nations organizations, governments, NGOs and trade, research and media organizations, while supporting national and regional initiatives. It monitors food supply and demand conditions for all countries in the world on a continued basis and provides timely warnings of any imminent food shortages, droughts and hunger at individual country or sub-regional level.

The USAID Famine Early Warning System (FEWS) Net provides a full range of products and services strengthening the abilities of African countries and regional organizations to manage threats of food security through the provision of timely and analytical early warning and vulnerability information.

Article 10 of UNCCD encourages parties to "enhance national climatological, meteorological and hydrological capabilities and the means to provide for drought early warning". UNCCD encourages parties to ensure that the collection, analysis and exchange of data and information on drought and land degradation addresses the needs of local communities and that these are involved in these activities (article 16). Parties to UNCCD have recognized the importance of building on existing operational early warning systems within the framework of national action programmes. The UNCCD Committee on Science and Technology established two ad hoc panels of experts to examine the issue of early warning systems in the light of the approach adopted by ISDR. The panels concluded that early warning for drought prediction and assessment, and monitoring and assessment for desertification are fundamentally interrelated, yet operationally different activities. The panels recommended that operational drought warning systems should incorporate desertification monitoring into their activities and integrate systems to address both drought and desertification, rather than establishing separate systems. Traditional knowledge should also be integrated into monitoring and assessment activities.

The IGAD policy on food security and environment addresses requirements of early warning systems such as remote sensing services. *Drought Monitoring Centres for Eastern and Southern Africa* primarily focusing on drought have extended their products and services to cover weather and climatic patterns, as well as impact assessments.

The new SADC Food Security Programme has widened its scope to encompass economic development, trade, investment and poverty (see also chapter 3.2). A regional coordination and cooperation programme supports cooperation on all food security, agricultural and natural resources development issues. A regional information system for food security supports the generation and exchange of information relating to all aspects of food security, ranging from information about policies through socio-economic data of economies to data concerning the nutrition of households for decision-making purposes across all the facets of the food, agriculture and natural resources sector. Components of the system include: the *Regional Early Warning System for Food Security (REWS)*; the *Regional Remote Sensing Unit (RRSU)*; and the *Regional Environmental Information System (REIS)*.

The Sahelian *Regional Training Centre for Agrometeorology and Operational Hydrology and their Applications (AGRHYMET)* of the *Permanent Inter-State Committee for Drought Control in the Sahel (CILSS)* is now also dealing with natural resources management and the impacts of climate change.

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Early warning of volcanic eruptions in Japan

The *Japanese Coordination Committee for the Prediction of Volcanic Eruptions* dedicates its efforts to the mitigation of damages from volcanoes. In this regard, early warning of eruptions is essential. Therefore, the *Japan Meteorological Agency (JMA)*, universities and other research institutes are constantly monitoring and conducting research on volcanoes using up-to-date technologies. JMA and university institutions regularly observe the most active volcanoes on a real-time basis by using seismographs and cameras. Usu is one of the intensively observed volcanoes. In March 2000, the Committee reported the possibility of an eruption. In response, the relevant administrative organizations such as the National Land Agency, JMA, the Ministries of Construction, Home Affairs and Transport, and the national police dispatched officials to the site and organized a local liaison meeting, followed by the setting up of a local headquarters for major disaster countermeasures to share information and decide on appropriate action. Local government officials, public corporations/companies and relief services were dispatched on site. Thus a response system both at the national and local levels was in place before the eruption. Advisory evacuation bulletins were issued to local residents using local community networks and mass media. The agencies and ministries concerned arranged shelter, transportation and security. Evacuation orders then followed, whereby 10,000 people were evacuated; no death or injury was reported. The absence of human casualties can be attributed to the coordinated efforts of the organizations involved in disaster management. In this regard, accurate prediction of the eruption through constant observation with the latest technologies was a key factor, allowing quick governmental response. Strong collaboration between each ministry and organization allowed quick evacuation and provision of shelters. Moreover, partnerships with other organizations such as the media secured efficient dissemination of warnings and evacuation orders.

Source: ADRC, 2001

provides a concrete example of health-related early detection, alert and investigation of disease utbreaks.

At the national level, the Nicaraguan Government has given natural hazard prevention an important role in its politics. Scientific investigations, mapping activities and the establishment of early warning systems are carried out by INETER. These efforts and cooperation with the Civil Defence of Nicaragua and other institutions should lead to successful early warnings.

Multidisciplinary, intersectoral and multi-agency communications requirements

Communication-related issues in the context of early warning systems have two aspects; the hardware aspect relates to the maintenance of lifelines, i.e. the necessity to build or strengthen robust hazard-resistant communication systems; the software aspect relates to the maintenance of relationships, i.e. the need to establish and maintain effective links and working relationships among the actors involved in the early warning chain.

As stated earlier, considerable scientific, technical, communication and managerial efforts have been achieved to improve early warning systems for a range of natural hazards. Systems are more accurate than ever and can deliver information more quickly than ever. However, most advanced technologies for observation, analysis and transmission are not equally available and affordable throughout the world. Present and anticipated activities within the ISDR framework and bilateral/regional technical cooperation programmes offer concrete vehicles to assist developing countries in improving their forecast, prediction and communication systems. Moreover, it is recognized that occurrence of a hazard and ensuing relief aid, usually target the more "technical in nature" needs, such as hazard-resistant forms of communication or sophisticated means of data collection and processing, to mention but two.

The necessity to build or strengthen key lifeline resources, such as electrical supply or telephone networks, to robust hazard-resistant standards is well documented and obvious. Solutions exist and are well

Experience shows that one of the most effective measures for reducing damage and consequences of natural disasters is a well-functioning coordination of actions among a number of governmental institutions involved in this activity. In the framework of the State Emergency Commission of **Ukraine**, special procedures for natural disaster preparedness and mitigation have been established by the Government for national agencies. These specify basic principles and directives, define roles and responsibilities of different departments and institutions for action at the national, subregional and local levels.

The role of the mass media in early warning systems

An effective early warning system is one that reaches people using means with which they are conversant. Mass media can serve to warn the public effectively, especially about slow-onset hazards. Television and radio have potentially important roles in making and disseminating public information and educational programmes that can help improve the population's knowledge and behaviour in the face of hazards and risks. However low capacity to make their own programmes reduces the extent to which national media and broadcast services can fulfil a more important role in hazard education and warning. An additional shortcoming is the lack of interaction between professional originators of warnings and professional media presenters and programmers. If both sides work together, the impact of broadcasts on warning response is significantly enhanced. In **Mauritius**, a low-cost media weather presentation system allows weather professionals to prepare, construct and record their own weather presentations on video for broadcast. Selected weather professionals are trained in presentation and video recording, as their authority is higher than professional presenters with some meteorological training.

Source: UK Flagship Programme , 1998.

known; recent developments in information technology will go a step further in protecting key resources from damages caused by disasters. Back-up communication systems such as battery-powered radio and telephone links need to be part of effective warning systems. In **Mauritius**, the back-up system would still operate even if a cyclone were to destroy or interrupt the power supply system.

At the intersection of technology and communication issues, capitalizing on the extensive penetration of mobile phones even among the poorest of the poor and into village life, street vendors and coastal fishermen, constitutes a potentially valuable means for "leapfrog technology" to be used in delivering warnings. It will require a consistent process, based on collaboration between public services, communications technology and a highly competitive commercial field, to work out uniform standards, inter alia.

Improvements in the hardware side of early warning have unfortunately not meant that communities have been made safe from disasters. This will be achieved by devoting more attention to the software side of early warning, i.e. developing improved or alternative methods of communication to address the inappropriate linkages between technical originators, intermediaries, disseminators and the receivers of warnings. To be truly effective, human and institutional inadequacies of communication links need to be addressed. Communication throughout the early warning chain must be an integrated multiple-way process, through which originators, intermediaries, disseminators and users are in constant touch with one another in order to make the system responsive to people's needs, priorities and decisions or in other words, translate predictions into response actions. This implies recognizing early warning as a socio-organizational process and finding suitable means of communication to establish strong partnerships between different social groups and organizational systems, including the media and private/commercial communications channels. Institutionalized intersectoral, multi-agency communication capabilities need to be developed outside emergency situations so as to be able to function and generate timely response when disasters strike. Such efforts should start with an assessment of the existing information systems and organizations in place, as well as of their communication channels. Mutual trust and respect has to grow from friendship and regular joint working between actors in a warning system. It is also vital to define roles and responsibilities clearly, preferably by law within an effective operational system of disaster management. In the **Philippines**, regular training takes place where the different actors in a typhoon warning system meet to practise management of the warning–from origination to protective action on the ground.

Proper information and data management and transfer from the international to the local level will also help countries reduce the resource burden generated by scientific, technological and technical sophistication.

The basic aim of the recommendations from the Bonn meeting described above, was to create linkages to ensure dialogue among all stakeholders involved in early warning through early warning platforms. They also addressed most of the concerns described in this subsection.

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Institutional services that can react to warnings

Warning in itself has no value, what is fundamental is how people react to it. The ultimate indicator of a warning system's effectiveness is the warning recipient's response to the warning. The mere existence of an efficient early warning system should not lead to a false sense of security.

In **Kenya**, the *Early Warning System (EWS)* model pioneered by the *Turkana Drought Contingency Planning Unit (TDCPU)*, which has now been scaled up to cover 10 districts in the north of the country, provides an interesting example of how early warning data can be translated and communicated clearly to decision makers. Although monitoring at least 18 indicators, covering environment, the rural economy and human welfare, EWS delivers a simple message to decision makers. By using a predefined sequence of warning stages, from "normal" to "alert" to "alarm" to "emergency", it presents an easily understood summary analysis, directly linked to response interventions.

Early warning is widely acknowledged as being much more than a technological issue related to hazard monitoring, forecasting and telecommunications and a scientific issue related to climatology, volcanology and seismology. It is expected to provide clear, consistent, critical and user-friendly information to emergency management officials and the public in due time to ensure that appropriate action can be taken to minimize loss of life and property. Therefore, the last segment of the early warning chain, namely the reaction to warning messages, deserves more attention in the design and operation of early warning systems. Known, structured, practised and sustained contingency action plans are required to elicit proper response after clear and consistent messages are issued, especially when the time to act becomes shorter. In this regard the importance of regular simulation exercises is critical to improve both the efficiency of the response actions and receive the necessary feedback to adjust the overall design of the early warning system. After the disastrous Oder flood event in 1997 it was recognized that there was a necessity for combined exercises for emergency situations and improved coordination of countermeasures between respective government authorities on the German and Polish sides of the river. It also pointed to the need for some early warning systems to be transboundary in nature.

There is one example of disaster management contingency planning based upon a well-understood early warning system and accomplished measures of disaster preparedness that could provide wider beneficial experience. A systematic and annually reviewed process of contingency planning for disaster preparedness and response has been in force in **Mauritius** 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 overall authority of the Prime Minister's Office. This programme has given particular attention to maintaining the relevance of its operational plans throughout changing conditions of growth and development in the country, even though tropical cyclones directly impact the society only every eight to ten years. 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 must both be considered as factors of the strategy's success. The National Meteorological Service has been central to the early warning process and has been a motivation for the preparedness strategy since its inception. It has further demonstrated the leadership that mete-

Warrick et al. (1981) cited the case of the ash fall warning that was issued by the Washington State Department of Emergency Services in advance of the eruption of Mount St. Helens. Although issued by an authoritative source, this message was not passed on to the community at risk by intermediate agents because it lacked a sense of urgency, was not specific about the areas likely to be affected by ash fall and contained no guidance about precautionary actions which people were expected to take. It is now believed that effective warning messages should contain a moderate sense of urgency, estimate the time before impact and the scale of the event and provide specific instructions for action, including the need to stay clear of the hazard zone

Source: Gruntfest 1987

orological services can provide by reaching out to include other partners and professional sectors through disaster preparedness initiatives. By appreciating the threat of future potential natural disasters, the National Meteorological Service and the 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 on all the social and economic aspects of the country.

Unusual for early warning systems, the Director of the Mauritius Meteorological Service is empowered by the political authority to issue necessary warnings himself, without prior or additional recourse or approval by any other public authority. In the course of a developing emergency, close communication is manifestly maintained with the political authorities. This is, however, a clever contingency if communication is impossible; it also clearly situates the responsibility on the professional shoulders of the Meteorological Service.

The interaction between the prediction and response elements of the warning chain is important. For example, the **Russian Federation** has institutionalized interaction between disaster prediction and mitigation in its national "Safety" programme, responsible for risk response activities in emergency situations. 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, inter alia, systems and technical means for prediction, warning and quick response measures.

However, clear procedures for verification that messages are not only received and understood, but also acted upon, are often overlooked. In **Hong Kong**, for example, the typhoon warning system requires that when meteorologists issue a warning message to the police and fire services, recipients should confirm that the warning has been received and will be acted upon.

In some cases, slow or no response to timely early warning information received can be rooted to a lack of trust in the reliability of the system; to contradictory information or to the fact that messages are not tailored to potential beneficiaries or do not include advice on viable courses of action to reduce risk. The socio-economic, cultural, or else political reasons not to act once warnings are received, need to be overcome by making provisions for follow-up response capacities.

This is illustrated by the comparative study conducted by the *Philippine Institute of Volcanology and Seismology (PHIVOLCS)* of the Mayon volcano and Taal Volcano Island in the Philippines. The study showed that on Mayon volcano, inhabitants at risk complied with evacuation orders received through the radio only after having sought confirmation from the barangay (village) or municipal leader. In comparison, on Taal Volcano Island, most of the inhabitants were responsive to evacuation orders received from community leaders and by broadcasts. The difference in attitude was explained by reporting habits/styles of popular local radio announcers and consistency of the radio announcers' warning with folk-observed precursors to eruptions (Jean C. Tayag, 1998).

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Future challenges and priorities

What should the early warning process accomplish in the coming years? From the issues discussed in this chapter, the following areas for action stand out:

- Human-based and communication requirements;
- Conceptualization of early warning;
- Interpretation of scientific predictions based on vulnerability and risk assessments and their translation into effective actions;
- Public participation;
- Coordination of national, regional and international early warning activities.

The establishment of a global early warning programme and the development of an international early warning platform/forum, as suggested at the Bonn meeting on early warning and sustainable development (March 2002), should provide a useful framework to respond to these challenges. If as envisaged the global programme on early warning and the international early warning platform/forum trigger the establishment of national and subregional early warning platforms/forums to strengthen networking and capacities among the actors involved in the early warning chain, many of the above needs could be solved.

Human-based and communication requirements

This chapter made clear that more than a process of technological paraphernalia, the early warning process should become a clever communication system. The most pressing need is to address the human-based and communication systems-related weaknesses. This conclusion is not a new one; a major output from the IDNDR early warning systems Working Group was that the difficulties are decidedly NOT technological ones, but rather conceptual, systemic, and human or institutionally-based communication ones. The same fact is reflected in the recommendations of the Bonn meeting, which calls for better interlinkages to ensure dialogue among all stakeholders at the international, regional, national and local levels, to, among other things, integrate activities, interests and expertise of the various groups involved in the early warning process, organize information and technology exchange, train users to find and utilize appropriate early warning products, strengthen institutions at all levels and build capacities. Institutionalized and regularly tested communication channels clearly spelling out the functions and roles of the various actors along the warning chain will avoid contradictions and duplication and ensure the ultimate success of getting the warning message down to populations at risk wherever they live. Greater coordination between services involved in the provision of data and information will provide a comprehensive picture of conditions and outlooks necessary to inform decision-making and response actions.

Conceptualization of early warning

The initiative to hold a meeting on early warning and sustainable development was timely in addressing one other challenge, which relates to the fact that conceptualization and implementation of early warning still take place along the "old rapid onset hazard/event or organizational specific" lines. This is counterproductive to an overall, and more systematic, comprehensive approach to the global needs of the twenty-first century. Early warning being a pillar of disaster reduction strategies has to find its way in sustainable development policies. This means that early warning must now necessarily encompass both environmental and climatic processes–over a longer period of time as well as during periods of quiescence (e.g. between El Niño episodes, in between fire weather, smoke and haze seasons, during hurricane and typhoon off-seasons, etc.) rather than being singular event-based concepts or scenarios. There is then a much greater need for institutionalized standard nomenclature, procedures and extended organizational relationships, which should benefit from advances in communications facilities and information technologies. Convergence and coherence in early warning activities in the context of sustainable development should be promoted. This will involve the ability of early warning systems to deliver information about vulnerability patterns in addition to hazards forecasting. Systems such as GIEWS and FEWS that provide vulnerability information related to food security are needed in the areas described in chapter 2.

Criteria to measure the effectiveness of early warning systems need to be elaborated to increase their credibility and improve their efficiency. In this regard, special attention should be given to the accuracy, timeliness and coverage of warnings, including number of recipients and validation process, calculation of avoided deaths and economic losses, failure to identify risk and take response measures, rating of recipients' satisfaction, including awareness of the system in place, warning time, conflicting information and inappropriateness or inconsistency of it.

- **Interpretation of scientific predictions based on vulnerability and risk assessments and their translation into effective actions**

Unrestricted and affordable access to all relevant information on early warning 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. This issue involves several facets. First of all, if as noted, advances in forecasting and monitoring are remarkable, the accompanying vulnerability and risk information is often missing. 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 the information should be presented and how to apply it in the decision-making process. This last point will need treatment of the uncertainty factor in predictions and its consequence for decision-making processes.

- **Public participation**

The user-oriented requirements spelled out above will be met through structured and focused participation of the public in the design and dissemination of warning messages. People need to know the types of risks they are facing, then be aware of the alert systems in place in case the risk becomes a reality, then to understand the warning messages they will receive in case of crisis and finally the reaction expected from them. Public participation is the key to trustworthy and credible early warning systems. Therefore integrated information systems ensuring community participation in national early warning strategies need to be developed. These systems will have built-in capacities to record, test and incorporate traditional and local knowledge and coping strategies in early warning systems, including from one generation to the other. This feature is important for infrequent events. Public participation is also essential to regularly test systems in place and carry out after-event feedback analysis to improve them.

- **Coordination of national, regional and international early warning activities**

The need to strengthen the international framework for improving early warning systems through an effective international mechanism, including for the transfer of technology to developing countries is not a new one either. The recommendation from the Bonn meeting to establish a global early warning programme and develop an international early warning platform/forum responds to this need. Coordination and cooperation, exchange of information, experience and technologies, interface between national, regional and international activities are necessary driving elements to avoid duplication and move the early warning process forward. The early warning process will benefit from resources and information/knowledge exchange through enhanced contacts with institutions in charge of multilateral environmental agreements, especially UNCCD and the United Nations Framework Convention on Climate Change (UNFCCC). Such contacts will also improve interaction between the early warning process and the international agenda for sustainable development.

back

Main challenges for drought early warning systems illustrating the range of issues faced in the early warning process

- Data sharing: Meteorological and hydrological data are often not widely shared between government agencies. This restricts early assessment of drought and other climate conditions and retards its use in drought preparedness, mitigation and response. In some countries, the high cost of data acquisition from meteorological services restricts the flow of information for timely assessments and for use in research. Memorandums of Understanding (MOUs) between government agencies would facilitate data sharing and use and could bring tremendous societal benefits;

- Early warning systems products: Data and information products produced by early warning systems are not often user-friendly. Products are often too complicated and do not provide the type of information needed by users for making decisions. Users are seldom trained on how to apply this information in the decision-making process or consulted prior to product development. Products are often not evaluated for their utility in decision-making. User needs should be assessed and products evaluated through permanent feedback mechanisms;

- Monitoring tools: In the case of droughts, triggers for specific mitigation and response actions are often unreliable because of inadequacy of detection tools and inadequate linkages between indices and impacts. Integrated assessment products are preferred but few attempts have been made to integrate meteorological and hydrological information into a single product for purposes of detecting and tracking drought conditions and development. It is critical that an integrated approach to climate monitoring be employed to obtain a comprehensive assessment of the status of climate and water supply;

- Impact assessment methodology: One of the missing links in early warning systems is the connection between climate/drought indices and impacts. The lack of effective impact and reliable assessment methodologies has hindered the activation of mitigation and response programmes and reliable assessments of drought-related impacts;

- Delivery systems: Data and information on emerging drought conditions, seasonal forecasts and other products are not often delivered to users in a timely manner. This characteristic significantly limits the usefulness of these products for most users. It is critical that delivery systems be improved and be location appropriate. For example, the Internet provides the most cost-effective information delivery in many settings but is inappropriate in most developing countries. Electronic and print media, as well as local extension networks, need to be used more fully as part of a comprehensive delivery system to diverse user groups.

Source: WMO, Early Warning Systems for Drought Preparedness and Drought Management.