SYNTHESIS OF THE FINDINGS OF THE EARLY WARNING REGIONAL CONSULTATIONS IN AFRICA, ASIA, THE AMERICAN HEMISPHERE AND EUROPE

REPORT FOR THE

SECOND INTERNATIONAL EARLY WARNING CONFERENCE
(EWC II)

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Acronyms

AHPS	Advanced Hydrological Prediction Service
CLIFF	Cluster Initiative for Flood & Fire Emergencies
DKKV	German Committee for Disaster Reduction
ECCAS	Economic Committee of Central African States
ECMWE	European Center for Medium Range Weather Forecasting
EFFIS	European Forest Fire Information System
EWS	European Early Warning System
FAO	Food and Agriculture Organization of the United Nations
GFMC	Global Fire Monitoring Center
IDNDR	International Decade for Natural Disaster Reduction
MDGs	Millennium Development Goals
MEDNET	Mediterranean Network
NCEP	National Centers for Early Warning Prediction
NEPAD	New Partnership for African Development
NOAA	National Oceanic and Atmospheric Administration
NSTC	National Science and Technology Council
NWS	National Weather Service
SARCOF	Southern African Regional Climate Outlook Forum
UMA	Maghreb Arab Union
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Childrens Education Fund
UN/ISDR	United Nations International Strategy for Disaster Reduction
WFP	World Food Programme
WMO	World Meteorological Organization

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EXECUTIVE SUMMARY

A number of international events, including the International Decade for Natural Disaster Reduction, Agenda 21 and the World Summit on Sustainable Development, have marked and signify growing concern with early warning for disaster reduction. The Second International Conference on Early Warning, and its preparatory consultations, are part of processes based on the First International Conference on Early Warning in Potsdam in 1998, the end of International Decade for Natural Disaster Reduction (IDNDR 1990-1999) Geneva Programme Forum in 1999, and the 2002 World Summit on Sustainable Development, aimed at supporting the development of early warning at the international level. They are also part of the ongoing review process of the 1994 Yokohama Strategy for a Safer World. The Bonn Conference will examine issues relating to the integration of early warning into public policy to help enhance the practice of early warning worldwide and improve its effectiveness in disaster risk reduction. This report presents trends in advances, constraints and lessons learned based on a synthesis of the findings of the regional consultations.

The achievement of the Millennium Development Goals is in jeopardy if recent trends in natural disaster occurrences and effects continue unabated. The frequency and effects of natural disasters have increased, although fatalities are declining. The negative impacts of disasters are more onerous for developing countries, particularly Asia, the most disaster-afflicted region in the world, Africa where natural disasters exacerbate an already weak development situation, and small island states, the very existence of some of which are threatened by natural hazards.

Ominously, disaster outcomes are expected to worsen as the vulnerability of developing countries to natural disaster is increasing due to factors, including poverty, worsening environmental soundness, population growth, urban growth, conflicts, weak governance and institutional factors, and climate change and variability. In developed countries, vulnerability factors include emerging climate issues and those relating to addressing residual risk. Early warning, by protecting and enhancing livelihoods, and other mitigation interventions are cost effective ways of disaster risk reduction: a $1 expenditure on mitigation saves about $4-10 in recovery costs.

Most progress in Africa was in development of regional systems for food security and climate early warning coupled with advances in establishment of the institutional framework for early warning system development through creation of disaster management platforms in several countries and improvement in communication of warning messages, mainly through the sub-regional climate outlook forums. In Asia, overall, there has been progress in improving forecasting and access to warning information. Several Asian countries are developing more comprehensive and user-friendly new generation flood early warning systems. In Central America and the Caribbean, the trend towards development of early warning systems for agrometeorological hazards, particularly for windstorms and flood, gained momentum in the aftermath of hurricane Mitch and are based on varied methodologies and configurations of actors, stakeholders and participants.
In developed countries, there has been general progress in identifying, monitoring, modelling and predicting hazards, particularly in flood prediction. In Europe a major improvement in flood warning occurred, including through improvements in

institutional mechanisms, refocusing on the needs of end users in warning systems and greater cross-boundary cooperation.

The fastest (earthquake) and slowest (drought) onset hazards are the most difficult to predict and pose the greatest challenges to the development of early warning systems worldwide. Earthquake and volcano forecasting have not yet been achieved worldwide, as countries are shifting to the approach of emphasizing mitigation. Similarly, no fully operational drought and desertification early warning systems exist in the world.

Worldwide, flood forecasts and predictions are based on forecasted rainfall and run-off models and are in general not yet good enough for warning purposes but efforts continue to improve predictability of forecasts, particularly in developed countries. Regarding climate factors, there has been increasing and sustained worldwide efforts to better understand and predict climate change and variability causes and expand the use of climate outlook forums. However, recognizing that climate change is uncertain and procedures are presently generally unavailable to accurately predict these uncertain hazards, developing countries, particularly Caribbean, Latin American and Pacific countries, are developing early warning systems as part of integrated adaptation strategies.

The basic trend regarding development of early warning systems observed in Potsdam persists: much progress has been made in boosting the scientific basis and technological aspects of warning systems but progress has been slower in integrating forecasting in effective risk management, even in developed countries. However, due to widespread understanding and recognition that early warning is but an aspect of disaster management and sustainable development, there is a growing movement from focussing on hazards to emphasizing vulnerability and socio-economic factors, as early warning has become a window for introducing and expanding the practice of disaster risk management.

In terms of warning systems output, technology is changing the definition and measurement of real time for various hazards, but the development of better short time forecasts and warnings still presents very difficult obstacles, particularly for some quick-onset climatic and geological hazards, such as flash flood and earthquakes. Meanwhile, progress in seasonal and long term seasonal forecasting of weather and climate factors is helping increase preparedness against natural hazards. Overall, prospects are good for further application of seasonal forecasting of climate-related hazards in arid and semi-arid regions of the world, and even in Europe.

There has been considerable progress in developing the prediction and warning generation component of early warning, through application of modern information and communication technologies, but equally considerable weaknesses remain in making warning messages effective in enabling people and institutions to take protective action to reduce the impact of disasters. Thus, communication from forecast agencies to warning organizations to vulnerable communities represents the weakest link in warning systems. The use of the new information and communication technologies, particularly the internet, in the dissemination of warning messages is creating problems of untargeted messages inducing wrong responses.

The following obstacles are common to early warning systems worldwide: (a) declining resources for system development and maintenance, especially at local level, (b) weak national focus on warning, partly due to persistence of disaster response outlook among the disaster management community, (c) lack of clear definitions of concepts, terms and procedures for presenting risk and warning information and responsibilities in warning systems, (d) inadequate user orientation of early warning systems, (e) inadequate decentralization of early warning practice, (f) inadequate land use planning as risks are not always considered above other criteria, and, (g) weak trans-boundary and international cooperation.

In addition, the major obstacles in developing countries are weak governance and institutional factors, including insufficient political commitment, and inadequate external support. The main problems and gaps with early warning systems in developed countries include inadequate identification and attention to residual risk, the weak legal foundation for early warning in common law countries in contrast to civil code countries, and inadequate monitoring and measurement of success. In developed countries, technological and engineering and organizational aspects of early warning systems are fairly advanced; the remaining tasks in early warning system development in industrial countries are mainly issues of institutions and people interface. In contrast, in most developing countries, particularly in Africa, even the basic issues of developing national and regional early warning infrastructures still need to be addressed.

Critical needs common to development of early warning globally are: increasing financial support, clearly identifying functions and responsibilities, strengthening the participatory, user-oriented and decentralized approach, expanding data and information sharing between different levels, creating public awareness on early warning, and, improving monitoring of early warning systems. Additionally, developing countries need to strengthen the institutional base of early warning while developed countries need to maintain community awareness and response, and, address emerging and long-term issues, such as people migration and effects of climate change and variability.

Priority recommendations are to (a) support integration of disaster risk management, including early warning, into development processes and policies, (b) improve data collection and availability, (c) support capacity development, particularly in developing countries, (d) develop people-centered warning systems, (e) create a process and mechanism, to be coordinated by the Secretariat of the UNISDR, to facilitate implementation of key recommendations of the Conference.

Additional recommendations for developing countries are to: develop warning systems for additional hazards, maintain and strengthen collaboration with international partners, and develop regional disaster reduction institutions, particularly a regional disaster reduction and information center in Africa. For developed countries, peculiar recommendations are to: de-emphasise reliance on regulatory approaches and enforcement, develop standards for warning dissemination using the new technologies and pay greater attention to implications of privatization for early warning.

1. Background and Context

1.1 From Potsdam to Bonn…and beyond

Mankind's impulse and attempts to read the elements and natural phenomena, through risk assessment, for information on the risk of disasters, to help ensure safe living is as old as the awareness of the consciousness of being alive. The International Decade for Natural Disaster Reduction (IDNDR 1990-1999) has highlighted disaster risk reduction as key to the achievement of sustainable development and called for actions to address the problem of the negative developmental impacts of disasters and to ensure that development interventions do not exacerbate vulnerability to natural hazards and human actions. It also raised the profile of early warning. The enunciation of the principle of the Yokohama Strategy for a Safer World at the 1994 Yokohama World Conference on Natural Disaster Reduction that established guidelines and targets for countries to reduce their vulnerability to disasters and make progress towards reducing disaster risks re-affirmed the crucial role of early warning in engendering effective disaster reduction and prevention.

In addition, other development frameworks, including Agenda 21, the multilateral environmental agreements, particularly the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD), the 1994 Barbados Plan of Action for Small Island Developing States (SIDS) and the 2002 World Summit on Sustainable Development (WSSD) called for action in several areas to expand, deepen and strengthen local, national and international initiatives to develop early warning in particular, and disaster management in general, as critical tools for promoting sustainable development and poverty reduction.

The Potsdam Conference on Early Warning Systems for the Reduction of Natural Disasters was held in 1998 (EWC '98) as part of the process of promoting, and reviewing progress on, natural disaster reduction since 1994. The Secretariat of the UNISDR is continuing the programme of international consultations on early warning through the Second International Early Warning Conference (EWC II). EWC II is part of processes based on EWC '98, the end of International Decade for Natural Disaster Reduction (IDNDR 1990-1999) Geneva Programme Forum in 1999, and the WSSD, aimed at supporting the international development of early warning.

EWC II will build on the outcomes of EWC'98 by focusing on strategic issues and institutional requirements. The objectives of EWC II are to: assess the effectiveness of early warning, identify successful early warning practices, and, develop recommendations for replicating best practices in early warning. To achieve these objectives, EWC II will emphasize three themes: emerging issues in early warning, application of early warning mechanisms in the context of sustainable development, and, issues in sustaining the early warning dialogue among stakeholders.

The process of preparations for EWC II have involved a series of stakeholder consultations in Asia region (Bandung, Indonesia, 26-28 May 2003), American Hemisphere (Antigua, Guatemala, 3-5 June 2003), Africa region (Nairobi, Kenya, 23-24 June 2003), and Europe region (Potsdam, Germany, 28-29 July 2003) and

preparation of a number of discussion papers (Villagran et al. 2003, Vordzorgbe 2003, Platte 2003 and Omachi et al. 2003).

The regional consultations offered opportunities, for the first time in some regions, for early warning practitioners and some key stakeholders, including political authorities, regional and sub-regional organizations, United Nations agencies, bilateral donor partners, academics and civil society organizations to interact and network on developing the science and art of early warning. The meetings were not political meetings of official representatives of countries but were technical meetings to identify, discuss and propose ways of addressing key issues pertinent to improving early warning through its incorporation in public policy.

This report synthesizes the findings of the regional consultations and applies them in identifying key global advances and trends, difficulties, lessons learned and needs in integrating early warning systems in public policy as part of the process of supporting strengthening of early warning in disaster reduction.

1.2 The task at hand….

Achieving the Millennium Development Goals and building a safer world in the 21st century is only possible when the world more effectively reduces damage from disasters triggered by natural events. This is no easy task: while the number of deaths from disasters is declining, its frequency (number of occurrences) and effects (economic losses and number people affected) are worsening, mainly due to increasing frequency and severity of many hydrometeorological disasters, partly as a result of global climate change. Globally, natural disasters affected an average of 200 million people, and claimed 62,000 lives, annually between 1992 and 2001. The economic cost of natural disasters rose 14 fold since the 1950s, reaching $1 trillion in the last 15 years with such losses doubling every 10 years (United Nations 2002). It is estimated that the impact of natural disasters on the 25 most vulnerable countries in the world has caused losses and damage of between 28% and 1,200% of their annual GDP (Commonwealth Secretariat and World Bank 2000).

The Asia-Pacific region is the most afflicted region in the world, particularly by flood-related disasters that caused estimated $110 billion damages over the last decade. Most of the disasters that occurred and the highest percentage of totally affected people in the world in 2002 took place in Asia. Other major hazards in Asia include cyclones and tornado, earthquake and drought. But perhaps the situation is graver in Africa: it is the only continent whose share of reported disasters in the world increased over the last decade, as an already low level of development progress is further hampered by major natural disasters of epidemic, flood and drought. In small island states, natural disasters, especially from hydrometeorological sources, threaten the very existence of several nations. Flood, windstorms and earthquake dominate in Europe while the major natural disasters in the America region are flood, windstorm, wildfire, earthquake and volcano.

Global trends indicate that the exposure of people to disaster risks is increasing due to the growing importance of vulnerability factors. In developing countries, the major causes of increased vulnerabilities to natural disasters are: poverty, worsening environmental soundness of the natural resource base, population growth and displacement, urban growth, conflicts, weak institutional capacities, and climate

variability and change. In developed countries, vulnerability factors relate to emerging climate variability and change, space weather issues, and those of addressing residual risk. The latter include the vulnerable location of many key urban areas, particularly lifelines and infrastructure, and freedom of movement of people that is manifest in several vulnerability patterns such as movement into disaster prone areas.

These emerging trends require that development practice is re-oriented towards focussing on the vulnerability of a society to natural disaster rather than on its total wealth. This new focus explicitly recognizes the links between early warning, disaster risk reduction and sustainable development.

1.3 Early warning, disaster risk reduction and sustainable development

Early warning has the potential to contribute significantly to reducing current and future disaster losses as an important non-structural component of risk reduction. It is a proactive political process in which networks of various institutions undertake systematic information collection and analysis together in a collective effort to generate information to help prevent likely disaster events from occurring or to reduce their outcomes. Risk assessment is the starting point and context for identifying risks by determining situations in which conditions for a particular type of disaster exist while early warnings are the interpretations and projections that the outbreak of disaster in a high-risk situation is likely and imminent (Ampleford and Troy 2000). Warning helps provide the knowledge to identify impending risks, determine their levels and potential impacts, both in terms of people and locations, and guide actions to avoid, reduce or mitigate the effects of those risks when they occur.

Early warning plays such a strong role in improving human security because it is one of the most effective measures for reducing negative impacts of threats and risks triggered by natural disastrous events. Early warning and other mitigation interventions are a cost effective way of disaster risk reduction: studies have shown that a $1 expenditure on mitigation saves about $4-10 in recovery costs (Benfield Creig Hazard Research Centre et al. 2002).

Early warning, as a branch of risk information, serves several purposes and provides many developmental benefits, including the following:

- it is a disaster protection mechanism;
- it introduces and supports services at the local level that directly enhance development;
- it promotes increased development and application of scientific knowledge, including improved science and technology information dissemination. For example, early warning research currently provides the context for technological advances in such areas as supercomputing and computer modelling, remote sensing, visualization and decision support systems that contribute to the quest for higher levels of human security;
- it advances consensual development, including community participation for its own sake;
- it promotes public-private partnerships;
- it creates the potential for increased utilization of indigenous knowledge and values;

- effective early warning promotes improved environmental management and sustainable livelihoods that are harmonious with the environment through helping increase the security of vulnerable populations and endangered environments.

2. Progress in early warning – advances and trends

For exposition purposes and to take a comprehensive and multi-dimensional view of early warning development, advances and trends in early warning are discussed from geographical, hazard-specific and thematic perspectives.

2.1 Regional advances and trends

2.1.1 Africa region

Warning systems for food security are the most developed and widespread in Africa. Each of the major sub-regional groupings in Africa, apart from UMA and ECCAS, have developed food security and climate early warning systems common to each sub-region. Vulnerability assessments are underway in some countries as part of food security early warning systems development. A sub-regional flood warning system exists in southern Africa and is being developed in the Horn but national warning systems are not yet developed. Regional drought warning systems and desertification monitoring initiatives are being actively developed in west and southern Africa but there has been less progress in other sub-regions and at national levels. Early warning systems for other major threats, including epidemics, are undeveloped (Vordzorgbe 2003).

The following key issues represent emerging trends in the development of early warning systems in Africa:

- a slow but gradual movement from a reactive to a proactive stance in responding to threats;
- progress in establishment of the institutional framework for early system development through creation of disaster management platforms in several countries;
- initiatives to integrate warning and response through development of comprehensive disaster reduction strategies; NEPAD will develop such a continent-wide strategy this year;
- efforts to focus warning on providing practical advice for risk reduction, partly through improvement in communication of warning messages, mainly through the sub-regional climate outlook forums;
- gradual recognition of the need to integrate traditional systems with modern practices of early warning system development;
- development of specific early warning systems targeted at particular end-users, such as agriculture and power generation users in southern Africa;
- dwindling resources for early warning and the increasing need to demonstrate the economic benefits of early warning to generate increased financing from governments and development partners.

2.1.2 Asia region

In Asia, overall, there has been progress in improving the capacity and capability to forecast events, access to warning information through expanding communication systems, ability and willingness to disseminate climate forecasts, and, the use of hazard mapping in risk assessment.

Reflecting their transition status, several Asian countries are revising their hydrometeorological warning systems. New generation flood early warning systems that are general, comprehensive and user-friendly, are being developed in parts of Asia such as China and India. These systems combine rainfall prediction and flood forecast, erosion prediction and tidal surge forecasting in coastal areas. Perhaps the best example is in Japan, where flood forecasting and warning systems established three decades ago are in transition, in terms of need and content, to accommodate the changing the nature of flood, developments in the technology for flood detection and prediction, and, effects of human factors (Omachi et al. 2003). This evolution of flood warning development illustrates the fact that hazard and vulnerability threats change and the design and implementation of warning systems need to be flexible and be based on continuous learning.

2.1.3 American Hemisphere

The trend towards development of early warning systems for agrometeorological hazards, particularly for windstorms and flood, gained momentum in Central America and the Caribbean in the aftermath of hurricane Mitch. These systems are based on varied methodologies and configurations of actors, stakeholders and participants including centralized telemetric systems, utilizing sophisticated instrumentation, covering large river basins and employing national civil defence institutions for response activities together with decentralized community-based systems utilizing volunteers for providing warnings in several rural areas. This example shows that a variety of early warning systems covering a particular natural hazard, such as flood or windstorms, which are tailored to specific circumstances can co-exist (Villagran et al. 2003).

Systems for early warning of floods and various windstorms are the most advanced of all warning systems throughout the American Hemisphere. Systems also exist for tsunamis and forest fires and some volcano-related hazards (eruptions and lahars) but those for landslide, earthquakes, climate change and El Nino are least developed due to several factors including inadequate knowledge of the risk characteristics of the natural hazard phenomena. Satellite-based systems have been extended from the traditional use in hurricane warning systems to forest fire systems in several countries, including USA, Canada, Brazil, Mexico, and are being developed in others such as Nicaragua.

2.1.4 Europe region

In general, there has been progress in the identification, monitoring, modelling and prediction phase of early warning systems, involving expanded hazard monitoring instrumentation cover, better understanding of physical causes of disasters and improved modelling. Consequently, provision and accuracy of warnings have increased leading to improved prediction of disasters in the Europe region, and other developed countries. Improvement in flood prediction has been mainly in hazard forecasting, in areas such as network establishment, increasing accuracy of modelling and forecasts, scientific advance in research, including radar for hydrology, and data sharing and improved trans-boundary coordination within river basin systems context.

Other general advances in early warning in Europe include the availability of medium term forecasts and development of an ensemble of techniques of meteorological parameters as a research instrument to extend lead time of warnings and to assess uncertainty in flood warning, widespread use of the internet for warning information and communication, efforts in space weather research, use of GSM technology for communication and data transfer, and, improved tele-transmission of data.

Perhaps the most significant development in early warning in Europe during the last decade has been in relation to flood. The culture, attitude and practice of flood early warning in Europe has undergone a sea change after the great floods of the 1990s that engendered significant changes in the modus operandi of flood early warning based on lessons learned. This is perhaps the most important learning effect from natural disasters in early warning system design and operation in recent years. These improvements include changes in forecasting methodologies, institutional mechanisms, refocusing on the needs of end users in warning systems and greater cross-boundary cooperation, as exemplified by the recent situation in the United Kingdom (see Box 1).

BOX 1. *Learning lessons from disasters to improve early warning – the case of flood warning in the UK.*

After the Easter flood of 1998, the UK Environment Agency developed an action plan to address the lessons learned from the flood to improve the flood safety of England and Wales by:

- enhancing radar detection and display systems, quantitative precipitation forecasts and flood detection systems
- establishing a network of Flood Warning Centres at regional, area and national levels to develop flood forecasting and warning systems
- implementing a new four-stage flood warning and dissemination and communication programme
- starting programmes to significantly increase warning dissemination coverage through new technologies, such as automated voice messaging and the internet
- designing appropriate warning advice for the public
- launching high profile public awareness campaigns
- reviewing warning dissemination and interpretation for the media, authorities and some end users.

The newly installed forecast and warning systems, set up in cooperation with the Meteorological Office under a National Weather Services Agreement, worked well during the flood of Autumn 2000. (Sources: Environmental Agency, 2001; EMA 2002).

A noteworthy development in Europe is the proliferation of research activities geared towards improving the scientific hazard monitoring and modelling phase of early warning as part of regional initiatives in early warning development, implementation and promotion in Europe. For example, large international efforts in climate change research, such as those by the Danish Meteorological Institute and the Max Plank Institute for Meteorology, are contributing to the improvement of early warning.

Efforts aimed at developing a cheap and efficient system of satellite communication for natural hazards in Europe, based on advanced ICT, such as seismic monitoring systems for improved real time prediction and decision-support for risk assessment and management in active volcanic areas of the European region, include the e-Ruption programme of the European Union and the Satellite Network for Natural Risks (SANARIS) project.

2.2 Hazard-specific advances and trends

2.2.1 Food security

Early warning systems for food security in many developing countries are based on or utilize directly the major international systems. The Global Information and Early Warning System on Food and Agriculture (GIEWS) is the most widespread, the role of Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS) and the Vulnerability Analysis and Mapping (VAM) systems in early warning for disaster risk is increasing while Famine Early Warning Systems Network (FEWS NET) is limited to Africa. As at the beginning of 2000, Africa accounted for 68% of the operational coverage of these systems globally, followed by Asia (26%) and central/south America (6%) (Italian Cooperation 1999).

2.2.2 Flood

Most flood forecasting is still based on traditional methods and indicative variables: worldwide, flood forecasts and predictions based on forecasted rainfall and run-off models are in general not yet good enough for warning purposes. The major trend is towards improvement of predictability of forecasts through research and development of new hazard modelling, and, of effectiveness of warnings, particularly in developed countries. A number of approaches are being adopted, including worldwide efforts to operationalize combined models through coupling of meteorological with hydrological models, but developed countries (and others such as China) are making better progress in combining rainfall forecast with numerical run-off models to generate operational and effective flood warming. For example, there are initiatives to expand operational flood forecasts to more than three days in Europe under the aegis of the European Centre for Medium Range Weather Forecasting.

An ongoing trend that is gathering momentum and is expected to make significant improvement in flood forecasting, particularly in developed and other countries, such as North America, Europe and China, is the movement towards incorporation of satellite rainfall estimates and the use of infrared and radar information in combination with existing systems to improve rainfall prediction. Radar alternatives are also being assessed in the USA for use in deriving real-time non-contact measurements of changing river profiles, such as river depth, velocity and discharge to improve flood forecasting. The technological foundation for developing new generation flood early warning systems include: rainfall radar, stable and low-cost observation systems for rainfall and other climate variables, satellite communication, mobile telephony, broadband and other communication systems, broadcasting and information dissemination systems (e.g. satellite and internet broadcasting), and computers and software that allow use of geographical information systems (GIS) and other emerging applications (Omachi and Le-Huu 2003).

Regarding effectiveness of warnings, an approach that is likely to become a future trend in enhancing the utility of flood warnings is that adopted by the UK National Flood Warning Centre in reawakening public awareness and preparedness for flood, including early warning, through strategies based on the social marketing approach. However, in several developing countries, particularly in Africa, the concern is more fundamental: how to develop the basic infrastructure for flood forecasting.

2.2.3 Drought

Early warning systems for drought and desertification are more complex than those of other hydro-meteorological hazards and are, consequently, relatively less developed globally. No fully operational drought early warning systems exist in the world. Even in the developed countries, progress in developing drought monitoring capabilities as part of comprehensive drought mitigation programmes has been slow. For example, in the USA, Congress passed the National Drought Policy Act in 1998 (United States Department of Agriculture 2000) while 35 states (about 70%), as of April 2003, had drought plans in the USA (NDMC 2003). The Australia National Drought Policy was only formulated in 1992 while China established its first integrated operational drought monitoring and climate prediction system during 1996-2000 (Li 2001). As of June 2002, a total of 57 affected countries worldwide had drawn up National Action Programmes (NAPs) under the UNCCD (United Nations 2002).

2.2.4 Geological hazards

There has been progress in developing probabilistic and time dependent seismic hazard assessment for most of the active regions of the world but detailed hazard maps and warning systems do not exist for many regions. Globally, there exists no reliable system for forecasting earthquakes for period longer than a few seconds (the longest being 60 seconds for Mexico city) as real time prediction of the location, magnitude and time of occurrence of earthquakes has yet to be attained. Similarly, progress has been extensive in monitoring changes in seismic activity but the exact onset of a dangerous volcano eruption cannot be accurately predicted. Some prototype earthquake and volcano warning systems have been installed for a few locations but earthquake and volcano forecasting has not yet been achieved worldwide.

To overcome the problem, basic research on earthquakes has received increased attention, particularly in developed countries. In Europe, a high priority has been the continuation of the promising approach of integrating GPS and radar use in seismological monitoring to improve deterministic earthquake prediction in addition to efforts to predict technical, social, economic and ecological vulnerability to seismic events. But it is not expected that even space technology could help in improving earthquake prediction any time soon.

Consequently, countries are shifting to the approach of emphasizing mitigation. Due to the little success in predicting the place, time and size of specific earthquakes worldwide, the approach to earthquake hazard warning has shifted to determining seismic risk. For example, the USA has adopted this stance while Japan just this year has also switched from emphasising pursuit of real time earthquake prediction to focus on other mitigation and preparedness measures (Omachi and Le-Huu 2003).

Nonetheless, fundamental research in earthquakes and mitigating interventions, including developing adequate preparedness to respond effectively to warnings in earthquake prone areas, must continue to be a key part of future research agenda on mitigating earthquake risks. In particular, substantial efforts need to be devoted to undertaking microzoning for major urban areas in earthquake prone regions.

2.2.5 Climate

A significant trend has been increasing and sustained worldwide efforts to better understand and predict climate change and variability causes, including sea surface temperature anomalies such as El Nino–Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO). Efforts have centered on modelling climate processes, detecting climate change, monitoring climatic variability, developing climate applications and services, and, assessing effects of climate. Countries are developing early warning systems as part of integrated adaptation strategies based on the recognition that climate change is uncertain and procedures are presently generally unavailable to accurately predict these uncertain hazards. Caribbean, Latin American and Pacific countries have progressed along this track further than Africa and Asian countries.

2.2.6 Tsunami

As a result of improvements in predicting capability, tsunamis can now be detected at least 60 minutes before they strike, regional and national warning systems have been established in several prone countries in the Pacific area for local level warnings to complement those from the International Tsunami Information Centre, and, preparation of tsunami maps for prone locations is progressing. Most tsunami warning systems still lack accuracy but efforts are underway to reduce false alarms.

2.2.7 Fire

Most industrial countries have in place systems to address all aspects of fire early warning, including prediction of fire risk, danger and spread, and, smoke pollution assessment. These warning capabilities are generally absent in the majority of developing countries and countries in transition. Overall, fire monitoring has improved significantly through activities of the National Atmospheric Release Advisory Capability of the USA that can detect substance release into the atmosphere worldwide in tens of minutes. In general, however, the early warning component in fire research and development has received less attention than fire monitoring. Consequently, global and regional collaborative efforts are underway, such as under the World Weather Research Programme (WWRP) and by the Global Fire Monitoring Center, to develop, adapt and apply fire early warning systems. The method of dynamic fire risk mapping being adopted in the early warning system being developed for East Kalimantan could become a cheap and valuable system for developing countries (GFMC 2003).

2.2.8 Space weather

Interest in the role of space in early warning continues to expand due to the increase in its support for observation facilities, including satellites, to the emerging issues of space weather and its effect on ground-based technological systems. Earth observation has become a major tool for environmental early warning at global, regional and national levels and will continue in importance for warning of various disasters. The issue of space weather is gaining importance in risk management and human security because of its influence on the performance of space-borne and ground-based technological systems, including monitoring systems for disaster mitigation, ground weather, and human life or health. The European Space Agency (ESA) and the EU are supporting efforts in Europe to investigate issues such as the effect of space weather on the atmosphere and terrestrial weather and climate, including the relationship between the North Atlantic Oscillation and solar activity.

Understanding space weather relationships with our weather and climate will be a major area of research in the coming years.

In summary, the fastest (earthquake) and slowest (drought) onset hazards are the most difficult to predict and pose the greatest challenges to the development of early warning systems worldwide.

2.3 Thematic advances and trends

The general observation from the regional consultations was that that much progress has been made in boosting the scientific basis and technological aspects of warning systems, particularly in the area of application of the information and communication technologies, but progress has been slower in integrating forecasting in effective risk management, even in developed countries. Thus, the basic trend regarding development of early warning systems observed at the First International Early Warning Conference in Potsdam persists.

2.3.1 Vulnerability to disasters is increasing

Disaster losses, unmitigated, will continue to rise due to increasing vulnerability arising from population growth, urbanization, poverty and inequality, environmental degradation, climate change and variability, lack of mitigation and institutional weaknesses. Hence, perhaps the most basic trend in risk management and early warning is the move from a focus on hazards to emphasis on vulnerability and socio-economic factors. This is part of the gradual but discernible movement towards expanding the scope of formal early warning systems in relation to broader issues of risk assessment and management. This emerging pattern is most advanced for the seemingly intractable problems of earthquake and drought prediction and forecasting.

2.3.2 Lead times are increasing

In terms of warning systems output, a major trend is that technology is changing the definition and measurement of real time for various hazards. The timescale in which the onset of hazard events can be predicted to allow response to the event ranges from several months for climatic variations such as El Nino, days for hurricanes, days to hours for volcanoes, hours to twenty minutes for tsunamis and seconds to about one minute in the case of Mexico city for earthquakes (American Geological Institute et al. 1998, Wenzel et al. 2001). For example, in the USA, the lead time for flood warnings has been extended through the combination of meteorologic, hydrologic and climatologic analysis: the Advanced Hydrologic Prediction Service (AHPS) of the National Weather Service (NWS) can predict river levels and inundation areas due to flood weeks and months in advance.

2.3.3 Use of seasonal forecasting is expanding

The development of better short time forecasts and warnings presents very difficult obstacles, particularly for some quick-onset climatic and geological hazards, such as flash flood and earthquakes. But, while pursuing that objective, it is also important to develop medium term seasonal forecasts as they help increase preparedness against natural hazards. Since the majority of natural disasters are due to weather and climate factors, developments in the methodology, approach and process of seasonal and long-term predicting and forecasting of these hazards are substantial pointers to the overall direction of natural disaster forecasting and warning.

Overall, prospects are good for further application of seasonal forecasting of climate-related hazards in arid and semi-arid regions of the world, and even in Europe: the application of climate change models for seasonal forecasting is progressing with most of the advance expected from direct applications of numerical models. Presently, accurate weather predictions are difficult after 6 days and nearly impossible after 10-14 days (Murphy et al. 2001). However, recent developments provide the evidence and expectation that the lead time for seasonal forecasts of climatic hazards can be successfully extended to up to several months. Both indirect and direct approaches to seasonal forecasting are making some impact. The practice of applying temperature and precipitation predictions to indirectly forecast the impacts of climate on flood, drought and related hazards, has culminated in the world-wide adoption of the seasonal climate outlook forums scheme as a useful model for seasonal forecasting (see Box 2). In addition, direct forecasting of climatic impacts based on the large-scale modes of oceanic variability, such as ENSO on crop yield and hydrological risk, is also progressing (Murphy et al. 2001).

BOX 2. *Climate outlook forums as model for seasonal climate forecasting*.
The practice of participatory development of consensus seasonal climate forecasts for regions of the world started with the Southern African Regional Climate Outlook Forum (SARCOF) during the 1997/98 season. It is now widely used in many parts of the developing world, including West Africa, South and Central America and South-east Asia. The Forum provides a platform of pre-, mid, and post-season meetings for interaction between national and international forecasting community, warning agencies and user groups. Seasonal forecasts, particularly involving dynamic modelling, have also been developed or operationalized elsewhere, such as in Australia (pasture growth conditions), the USA (seasonal hurricane) and Canada (climate) and shown to have potential applications in Europe. Source: Murphy et al. (2001).

2.3.4 Application of information communication technologies is expanding…

The past decade has witnessed an explosion in the types, extent and depth of application of communication and information technologies to early warning, albeit mainly directed at improving the technical identification, monitoring, modelling and forecasting of threats. Advances in the application of modern information and communication technologies in warning dissemination continue unabated, particularly in developed countries. For example, operators are testing new methods of warning transmission including short message text on mobile phones in Europe and pagers and satellite radio systems in the USA. Future warning systems will be more active, allow people to see the hazard themselves through technologies such as the new mobile phones with cameras that send pictures by e-mail, and aim at warning only those at risk through the use of central technologies such as remote sensing, geographic localization, GIS and pervasive computing and communications.

Progress in enhancing warning and response through application of technology has, in contrast, been relatively slow, particularly at the local level in developed countries and at the national and community levels in developing countries. However, the Hong Kong Observatory is testing approaches based on personal computer-internet

combinations that allow cheap, fast and targeted meteorological forecasts for promotion in developing countries (Lam 2003).

2.3.5 …but is creating some communication and response problems

A general observation at the pre-EWC II consultations was that the use of the new information and communication technologies, particularly the internet, in the dissemination of warning messages, while useful in expanding the coverage and reducing time lags in warning dissemination, is creating problems of untargeted messages inducing wrong responses due to misinterpertation.

This problem is also related to the type of hazard under consideration. For example, while the internet has been a useful communication tool for hurricane warning dissemination in Latin America, the Caribbean and North America, its use in disseminating warnings on El Nino has been fraught with problems of engendering wrong responses that have causes unnecessary losses (Villagran et al. 2003). The internet should complement and augment traditional mechanisms for disseminating predictions by functioning as a clearinghouse of information exchange, repository of information, and a medium for self expression and community communication.

2.3.6 Focus on institutionalizing early warning is growing

Partly to address these concerns, there is growing focus on institutional development activities under the major international drought and food security warning systems such as FEWSNET. Also, countries are making efforts to develop the institutional environment of early warning, as part of designing legal and administrative frameworks for emergency management. This is key to ensuring that warnings are authoritative and trusted and accepted by stakeholders. The focus on issues of institutionalization in developing warning systems is important because it is how people respond to warning that determines its effectiveness. The process of interfacing technology systems and people is probably the weakest link in the early warning chain. For example, during the flood on the Elbe river in August 2002, different forecasts and warnings were given by different sources while local administrators failed to inform downstream neighbours of impending floods (Morgenschweiss et al., 1998).

2.3.7 The need to balance enforcement of regulations with the approach of self consent is growing

The devolution of the organization of early warning to lower administrative levels continues to gather the greatest momentum in developed countries and in community approaches in developing countries. However, in developed countries, an emerging issue relates to effectively inducing voluntary compliance with warning advice in the face of individual liberties and freedoms and in the absence of laws that compel people to comply with official warning advisories. In dealing with issues of engendering effective public response to warnings and compliance with planned response measures, especially for addressing residual risk in these countries, there is growing recognition of the important of striking an appropriate balance between enforcing compliance with regulations and adopting participation-oriented cooperation approaches (Handmer 2002). As openness and democratic governance expand, the desire of people to determine for themselves what measures they take to mitigate their risks can help make early warning effective when system implementers adopt the approach of self consent.

2.3.8 Emphasis is shifting from focus on details of warning messages

A noticeable trend was that most of the discussion on improving disaster early warning has focussed on micro-issues, such as improving the effectiveness of warning messages, due to the concentration on engineering aspects of early warning (Handmer 2001). However, efforts have began to rectify the situation of excessive focus on the details of warning message design, dissemination and response, without adequate attention to necessary processes for achieving the multi-organizational change, cooperation and multi-stakeholder interaction needed to engender total warning and to make warning messages more effective.

2.3.9 Public expectations regarding warning services are rising

The concern with the performance of early warning is derived from rising expectations of people regarding public safety and security during disasters. Contributory factors to this trend fo rising expectations include: increased exposure to disaster threats, conception of warnings as a human security and development right, expanded stakeholder involvement, reduced public tolerance for errors, climate change, and rising demands from insurers.

2.3.10 Regionalism is promoting integration of early warning in sustainable development

Early warning has become a window for introducing and expanding the practice of disaster risk management, writ large, and for promoting regional cooperation. A common and significant recurring theme in contemporary discussion of early warning in all regions is the widespread understanding and recognition that early warning is but an aspect of disaster management and cannot be treated in isolation from the other components of disaster risk reduction. Consequently, early warning is gradually being integrated into the development process through various efforts to mainstream disaster risk reduction in sustainable development, most of which have occurred within the context of regional cooperation (see Box 3).

BOX 3. *Integrating early warning and disaster reduction within the framework of regionalization – examples*:
(i) the Basic Plan of the Coordinating Center for the Prevention of Natural Disasters in Central America (CEPREDENAC); (ii) Comprehensive Hazard and Risk Management (CHARM) initiative in the South Pacific; (iii) famine and climate early warning systems under the Southern Africa Development Community (SADC) Comprehensive Disaster Management Strategy; (iv) pilot project on flood forecasting and early warning in the humid tropics of Asia covering countries such as Malaysia, Indonesia, Thailand, Vietnam and the Philippines; (v) multinational river system flood warning systems in Europe through international commissions for the safety of the Rhine, Danube, Elbe and Mosel rivers.

3. Early warning development and integration in sustainable development: obstacles

There has been considerable progress in developing the prediction and warning generation component of early warning, but equally considerable weaknesses remain in making those warning messages effective in enabling people and institutions to take protective action to reduce the impact of disasters. Thus, the single most important weakness of existing early warning systems is the growing improvements in the technical identification, detection and modelling of hazard threats built upon relatively unchanging capability and procedures for warning and response management: a case of modern forecasting using unchanged warning procedures and systems. Consequently, the communication from forecast agencies to warning organizations to vulnerable communities represents the weakest links in warning systems. In particular, few systems incorporate feedback loops for end-users to assess the effectiveness of forecasts and warnings.

3.1 Common constraints

The following obstacles are common to early warning systems worldwide, but are more critical in hampering the development and effectiveness of early warning systems in developing countries, particularly Africa:

1) weak national focus on warning, often due to inadequate national commitment to continuously supporting the development and maintenance of early warning systems
2) persistence of disaster response outlook among the disaster management community
3) inadequate user orientation of early warning systems partly due to dominance of scientific, technological and engineering perspectives in early warning and the weak role of social, political, economic and cultural considerations
4) lack of clear definitions and harmonization of risk concepts, and terms and procedures for presenting risk and warning information
5) the institutionalization of early warning systems is hampered by the lack of clarity of responsibilities in the warning systems, including determining a clear chain of command for early warning functions, particularly that of issuing warnings. Often, information and messages come from various sources, thereby creating confusion as to the authenticity, effectiveness and trustworthiness of each message as well as the proper response. Unclear administrative responsibilities also result in inadequate integration and coordination of different early warning systems for the same hazard and of key institutions and actors involved in early warning and disaster prevention and mitigation. This has delayed effective response and weakened the impacts of early warning and other risk management activities
6) inadequate decentralization of early warning practice; most warning systems are agency-centred and top-down and lack adequate partnerships with community involvement
7) inadequate land use planning as risks are not always considered above other criteria; non-compliance with appropriate land use controls and standards undermine the effectiveness of warning advice and response plans
8) weak trans-boundary and international cooperation constraints the development of effective warning systems for several trans-boundary hazards.

3.2 Developing countries

In developing countries, the major obstacles to development of early warning and risk management capabilities are lack of financial resources and technical expertise, weak governance and institutional factors, including insufficient political commitment, over ambitious targets and inadequate external support. Regarding Africa, key constraints to integrating early warning into public policy include:

1) weak advocacy for general awareness, political responsibilities and public participation regarding disaster risk management
2) deteriorating state of monitoring stations for hazard monitoring and forecasting, especially hydrometeorological networks
3) weak communication sub-systems that limit the ability of early warning systems to effectively influence effective disaster risk prevention and reduction
4) inadequate translation of early warning into response planning and activities
5) inadequate warning coverage of disease epidemics, conflict, small and localized hazards, and other serious threats to livelihoods.

3.3 Developed countries

The problem of resource inadequacies, including declining resources for system development and maintenance, especially at local level, is a common world-wide constraint, as it is of concern to developed countries as well. Beyond this, the main problems and gaps with early warning systems in developed countries relate to the following:

1) institutional and human failures of inadequate identification and attention to residual risk, including inadequate attention to micro issues of design of messages, factors affecting response, advice on appropriate response and ensuring high risk groups access to warning, and, key macro factors such as policy concerns, issues of designing warning systems and sharing knowledge (Handmer 2002)
2) determination of acceptable public risk and improving outcomes of warning services
3) the weak legal foundation for early warning in common law countries, such as the UK, USA and Australia, in contrast to civil code countries, such as France
4) insufficient reliability of longer term flood forecasting
5) low engagement with communities, particularly inadequate strategies to encourage greater community ownership of warning systems, including how to get messages across to communities and to sustain their interest
6) inadequate monitoring and measurement of success, including effectiveness of the warning services and community benefit assessment
7) insufficient national approach and commitment, particularly for addressing issues of legal liability.

4. Integrating early warning into public policy: lessons and pointers

4.1 Common global lessons

4.1.1 Warning is a component of risk management

To be effective, it is important to recognize that early warning and early warning systems must be part of comprehensive disaster risk reduction and management systems that ensure consistent and national or region-wide development of all components of risk management. However, this recognition implies that it is equally essential to consider that even the perfect early warning can only achieve so much: other safety and risk management interventions are needed to ensure effective risk mitigation. This is because the success of early warning is determined largely by the extent to which other components, such as compliance with land use planning standards, building codes and regulations, are effective in developing effective disaster risk response capabilities.

4.1.2 Effective early warning systems depends on some essential elements

The review of lessons from experience in early warning systems in general shows the following essential elements in developing a successful system:

(a) adequate institutional capacity, including financial and human resource endowment, to provide effective warning services
(b) accuracy of forecasts, based on adequate hazard and risk assessment
(c) effective communication of warnings to at risk individuals, groups, businesses and locations
(d) good planning for implementation of the system, including preparedness planning
(e) effective participation, coordination and partnerships across sectors, locations, disciplines, institutions and boundaries, stressing local networks, capabilities and consensus
(f) high level of awareness of risks and warning advice, including through public education and training
(g) effective data, information, knowledge, skills and experience exchange
(h) mechanisms for review of outcomes and outputs, including sustainability, of the system
(i) strong and long-term political commitment to continuos development of warning services, using integrated and consistent government policies and programmes.

Some of these factors, and others, are elaborated below.

4.1.3 Effective warning requires sound basic infrastructure…

Development of effective early warning systems requires the establishment of the requisite infrastructure and capabilities for detecting, modelling and predicting natural hazards. These must be based on the principle of optimizing benefits of the new technologies while utilizing the appropriate mix of technologies within a framework informed by traditional systems of hazard warning.

4.1.4 …but not necessarily a lot of money or technology

A common conclusion from the regional and hemispheric consultations was that the availability of financial resources for sustained support for early warning work, particularly maintaining and strengthening observation and monitoring networks for hydrometeorological hazards, is reducing globally. Addressing this requires innovative financing mechanisms but, although early warning systems involve physical and electronic facilities, they do not necessarily require a lot of money or technology, as exemplified by the experience of decentralized low-tech warning systems in Central America, Cuba and Bangladesh. The basic ingredients are organization and information backed by political commitment (Association of Caribbean States 2003). Deficiencies in these retard progress in early warning development and become obstacles in integrating early warning in sustainable development.

4.1.5 Early warning systems need to be well managed

For effectiveness, early warning systems need a clear chain of command that assures that only one official warning is given to each affected community and that stakeholders know the official source of the warning to avoid confusion and panic. Early warning systems, like other management systems, require sustained management input to endure. In the absence of strong professional management, early warning systems lose their capability to provide useful warning information for disaster reduction.

4.1.6 The coverage of warnings must be broad

Warnings are most effective when targeted at only the people at risk, however, warnings must be issued to all at-risk groups or locations within the target area. Early warning activities must equally cover all parts of a national jurisdiction or targeted areas and not favour or be under-represented in some parts of a country. The warning message must be the same for all in target areas, but the medium of transmission must be targeted at specific groups. However, messages must be passed through as wide a variety of warning devices as possible to reach all in the target group. Also, warning messages must be crafted in such a way as to be understood by all concerned.

4.1.7 Good preparedness is essential for effective warning

It is not sufficient to ensure that appropriate and timely warning reaches target groups; it is also essential that the local population knows how to react and what to do in emergencies. This depends on the extent to which warning services are decentralized and participatory. Realigning warning systems to addressing community needs implies that warning authorities have to engage communities to know those needs, recognize people's personal contacts, assess risks and manage public expectations of the warning system (Handmer 2002).

4.1.8 Participation, partnerships and community involvement are crucial

Early warning decision making is an integrative process that requires interaction between information sources, safe actions and choices, and, societal impact. Extreme events are inherently contextual and relational, hence the importance of placing the needs and circumstances of at risk populations at the centre of warning system objective, design and implementation. This involves engaging the target groups and communities in warning development so as to institutionalize emergency

response structures at the community level. Active participation of vulnerable communities, full co-operation of civil society, partnerships among various interest groups, including the informal and private sectors, and education and training at all levels are necessary for the effectiveness, good governance and sustainability of early warning systems.

4.1.9 Warnings must be integrated in user decision making

The effectiveness of predictions and warning of complex and extreme events, such as natural disasters, are enhanced if they are part of the decision making process of intended target groups and other stakeholder interests (see Box 4). This is facilitated by: (a) generating predictions with the needs of the end user in mind at all stages of the process, (b) all stakeholders understanding clearly articulated uncertainties associated with predictions, and (c) system implementers recognizing that predictions and prior experience shape response and subsequent behaviour of individuals and institutions to risk warnings.

BOX 4. *Good science should aim at good decisions rather than good forecasts.*
In northeast Brazil where droughts are common, lack of the technology and techniques required to benefit from seasonal climate predictions and the poor match between the timing, uncertainty and utility of the forecasts and the circumstances of local farmers have made them lose confidence in official sources of seasonal warnings and the warning themselves. Source: Sarewitz and Pielke (2000).

4.1.10 Effective warning communication is a critical condition for effective warning

Most warning systems fail at the interface between early warning and other risk management activities, particularly those that involve local decision making and management. Apart from the internet, there are very few examples of successful application of modern technologies in local warning and response on a large scale, particularly for flood warning, even in developed countries (Handmer 2002). Excessive emphasis on technology in early warning at the expense of attention to the human interface in the system negates efforts aimed at ensuring cost and outcome effective warning systems.

For early warning to empower communities threatened by impending disasters, it must be provided in good time, be precise and prompt and should convey reliable and actionable information. Early warning communication is more than simply the dissemination of facts: effective early warning requires that the target population not only receives advance warning of hazards and vulnerability changes but also that they understand the content of the message, accept it, believe it and know how to use to guide their response actions. The latter is catalyzed by on-going public education and awareness-strengthening processes on potential risks and the role of early warning advice in disaster risk reduction.

For effectiveness, the warning message and dissemination processes should show the attributes presented in Box 5.

BOX 5. *Features of effective disaster warning messages.*
The message process should: (a) make the information understandable, (b) keep the information consistent; (c) package the information for the media. In addition, the message for the public should describe and explain potential losses, discuss the chances that the losses will happen in a given timescale, specify those who are at risk, suggest how to reduce losses and indicate uncertainties regarding the incidence and effects of the hazard. Regarding the dissemination process, it should: (a) use multiple credible information resources, (b) tailor information to the needs of each group, (c) use multiple media and the type appropriate to the target audience, (d) make access to information easy, (e) use incremental, interactive and experiential approaches, (f) use hazards as learning opportunities, (g) have a long-term focus (Source: Nathe et al. 1999).

The contexting of warning information from regional and global sources, including the internet, within national and local circumstances ensures that the responses generated are effective through minimization of misinterpretation of that information. Warning information from international and regional systems need to be interpreted within local contexts and utilized in conjunction with national level information to be effective and to prevent misinterpretation, misuse and negative impacts. With the proliferation of information systems on the internet, the transmission of false or misunderstood information to the public domain occurs; it is easy to make forecasts but difficult to retract or modify false ones. Hence, there is the need for skills to adapt global or regional information to local circumstances.

4.1.11 Pre-event education makes warning response effective

The preparedness component of the early warning of impending disaster needs to be clear, ready and known to end-users. Public knowledge of early warning systems, including response mechanisms, through information, education and communication initiatives enhances the success of warning messages. Responses to warnings are most appropriate and effective when the public has received prior education and sensitization about the hazard and people have worked out a response plan in advance of the warning. To facilitate this, the probabilistic nature of warning messages have to be made clear and target populations have to be educated on how to interpret probabilistic warnings (National Science and Technology Council 2000). The object is to minimize wrong warnings and to reduce the uncertainty in decision-making.

4.1.12 Warning systems must be based on continuous learning

Successful early warning involves continuous learning. The practice, accuracy and effectiveness of warning as a risk reduction tool would be greatly enhanced by documenting, analyzing and creating a knowledge base that compiles experiences on warning during past disasters, and, through effective networking by connecting people to ideas and linking people to people to access development information.

The importance of this lesson was brought home forcefully during the central Europe floods of 2002 (see Box 6).

BOX 6. *Effective early warning depends on learning from previous experiences.*
The large flood of August 2002 on Elbe and Danube caused one of the largest disasters that ever hit Germany and Czech Republic, with economic losses of more than US $13 billion. The flood provided some insight into what could be done better. The warning system left much to be desired: the rainfall field was too local to be accurately forecasted by the German Weather Service, the warning did not reach people early enough, and much confusion was caused by not having a clear chain of command for the actions that needed to be taken. In the Czech Republic and Bavaria, the authorities had learned from 1997 and later disasters but in the Elbe basin in Germany, the authorities were not prepared for such a disaster. By learning from the experience, preparedness will be improved in the future. (Source: Plate 2003)

4.1.13 Regionalism is essential for developing warning systems

Regionalism is crucial for the development and sustainability of early warning systems for a number of reasons. First, the development of integrated early warning systems for structural vulnerabilities and livelihood risks depends on coordination at the international level. Second, assessing hydrometeorological hazards is best done over large geographic areas. Third, the approach has proved effective in promoting the development of early warning systems in several parts of the world.

4.2 Lessons peculiar to developing countries

4.2.1 Multi-purpose monitoring is required for vulnerability warning

Broadening the traditional scope of early warning to not only save lives but also improve livelihoods, requires multi-purpose monitoring which can be used both to warn of crises and as an annual planning tool: data and information from the system can be used in 'normal' periods for development work and also 'expanded' when disaster crises occur. This is a key to integrating early warning in sustainable development.

4.2.2 The scope of warning systems need to cover other hazards

The contribution of early warning systems, as a class of preparedness measures, to disaster risk reduction and prevention in developing countries will be enhanced if they possess the capacity to respond to emerging hazards. Hence, it is essential to develop early warning systems for other dominant hazards in developing regions, in addition to those for food security and hydrometeorological that currently dominate the early warning landscape in those countries.

4.2.3 Drought and desertification monitoring is a long-term process

The evolution of a solid and effective capacity for the development of early warning systems in drought and desertification monitoring is a long-term affair. For example, in the case of AGRHYMET in West Africa, it has taken three decades for the programme to mature enough to begin to develop early warning systems for these hazards.

4.2.4 Traditional indictors must be integrated in formal warning systems

Traditional indicators and languages play a key role in indigenous and local early warning systems and coping strategies and need to be understood by formal early warning practitioners. Knowledge systems of traditional early warning systems need to be studied and preserved to avoid erosion of that knowledge base because they have evolved over long periods and traditional indicators can often be corroborated scientifically. Consequently, technical identification, monitoring and forecasting of hazards need to incorporate information on traditional indicators.

4.2.5 Early warning of conflicts are often pointers to natural disasters

Conflicts exacerbate the effects of natural hazards while the type, onset and intensity of conflicts are also influenced by environmental factors and circumstances. This relationship of mutual determination underscores the need to integrate both issues in the development of comprehensive early warning systems and disaster reduction platforms in developing countries, particularly in Africa.

4.2.6 Assured funding is crucial for development and sustainability of early warning systems

The sustainability of early warning systems depends on assured funding from national sources and is undermined by the dependence on donor funding. Given the financial resource costs of monitoring hazards, early warning systems need to adopt a multiplicity of approaches to overcome resource constraints, including emphasizing the use of local resources, stakeholder participation, cost recovery of selected localized early warning services utilized by private interests, and cooperation with foreign institutions engaged in collecting long-term data on environmental and human factors.

4.2.7 New approaches to capacity development are needed

Effective early warning development requires a re-orientation towards networking, technical partnering, joint assessments, international cooperation, decentralization of early warning activities, advocacy activities, and similar approaches. Early warning capacity development efforts in developing countries in the past were mainly based on the transfer of knowledge approach and were less than successful in institutionalizing early warning systems in several areas.

4.3 Conceptual framework for effective early warning systems for sustainable development

Conceptually, the development of early warning should follow a framework that not only ensures development of the warning services per se, albeit as part of broader disaster risk management platforms, but also promotes their overall effect on sustainable development.

Such a framework is proposed in Box 7.

BOX 7. Comprehensive framework for early warning development. Achieving disaster risk reduction depends critically on effective public policy and strong public commitment based on supportive local, national and international institutional frameworks and community actions. Such a policy framework for early warning development would promote the following:

- investment in data, information, communication and management infrastructure and systems
- integrated development
- professional management of warning systems
- strengthening of community action for disaster risk reduction, including early warning
- macroeconomic policy environment that allows the allocation of requisite resources and the provision of adequate incentives for mitigating and adapting to disaster risks.
- social policies that harness and strengthen the social capital of vulnerable individuals, groups and communities, thus enhancing the success of response to warning advice
- environmental policy and management that is integrated into national development interventions, improves natural capital base, promotes increased awareness of environmental issues, and improves monitoring and assessment of disaster-environment linkages
- application of science and technology to all phases of the early warning cycle and to enhance the resilience of the natural capital base
- good governance of warning systems that is participatory and transparent, tolerates and accepts diverse perspectives, operates by rule of law to enforce regulatory stipulations, is efficient and effective in the use of resources, and, is accountable
- local resource utilization and resource leveraging
- mainstreaming traditional knowledge
- international institutional frameworks and commitments that enhance the roles of international bodies, promote resilience to disaster risks, reform and increase development assistance, promote the integration of disaster risk reduction in the development policy of countries, support regional cooperation and seek coordination and synergies between relevant agreements
- building understanding through knowledge development and information sharing.

5. Integrating early warning into public policy: major needs and priority recommendations

5.1 Major needs

5.1.1 Context for determining needs

Key challenges for early warning system development are: (a) strengthening disaster prevention and preparedness capacities of developing countries and addressing residual risk in developed countries, (b) developing early warning for integrated risk management and vulnerability reduction, by addressing localized disasters, undercovered hazards and implications of key emerging threats and drivers of increasingly complex disasters, such as population concentrations and urban hazards, environmental and natural resource vulnerability, and climate change and variability, (c) ensuring co-ordination, co-operation and implementation of early warning interventions at all levels, including engaging with those at risk and sharing experiences and knowledge among the various agencies and jurisdictions involved in early warning. Achieving the goals of the Yokohama strategy and the Potsdam declaration to contribute to the Millennium Development Goals (MDGs), depends on intensifying cooperation at all levels to generate the political, institutional and financial resources required for disaster warning as part of risk reduction, which has become a global and common good.

Three basic issues are relevant for conceptualizing needs in relation to integrating early warning systems in public policy: first, developing or strengthening early warning; second, improving the utility of early warning in reducing disaster risks; third, expanding the developmental impacts and linkages of early warning. Achieving the first requires attention to a mix of macro and micro issues, such as increasing resource investment in developing the technological, human resource and institutional aspects of early warning, knowledge exchanges and international cooperation. Progress in the second is linked to that in the first but the relevant change factors here are mainly micro issues, such as increasing the predictability of forecasts, improving warning dissemination (particularly the content and context, scope, resolution, accuracy, timeliness, and frequency of warning information), targeting warning information based on end-user characteristics, and enhancing user involvement. Expanding the development effects of early warning depends mostly on macro issues, such as putting in place the policy, legal and regulatory framework necessary to enhance the links of early warning to everyday development planning.

Weaknesses in the organization and implementation of early warning systems should be viewed as challenges and opportunities. To an extent, some early warning systems are pushing the envelope regarding how far they can go in helping reduce disaster risks from most of the major hazards in developed countries. This is partly because technological and engineering and organizational aspects of early warning systems are fairly advanced; the remaining tasks in early warning system development in industrial countries are mainly issues of institutions and people interface. These are best addressed in tandem with other issues in developing integrated risk reduction capabilities, such as enforcement of the rule of law for regulations and standards. In contrast, in most developing countries, particularly in Africa, even the basic issues of developing national and regional early warning infrastructures still need to be addressed.

5.1.2 Needs in integrating early warning into sustainable development

Despite advances in some areas, overall progress in fulfilling the recommendations from Potsdam has been tardy in terms of realising the potential for early warning to empower people to make timely and safe decisions during disasters. It emerged from the regional consultations that meeting the following needs will go a long way towards ensuring integration of warning into development programming:

1) integrating early warning into relevant sectoral development agendas of sustainable development, including through designing and implementing comprehensive and integrated development plans that incorporate disaster risk reduction. In addition, there is the need to implement proactive and comprehensive risk and vulnerability information systems that can be used for normal development planning and for disaster early warning during times of crises. This calls for development of national, regional and global risk information systems, including risk mapping, hazard notification and early warning
2) ensuring multi-sector, multidisciplinary, inter-modal (formal-informal) and inter-institutional collaboration and coordination in developing early warning systems
3) strengthening awareness on vulnerability and early warning issues. Regarding the public, the key to changing public awareness of disaster risks into action is for system implementers to adopt the informed consent approach and help people convince themselves that they may be at risk and need to take protective actions (Cook 2002).
4) meeting local community and national needs while strengthening regional and global efforts in early warning through: (a) accelerating and deepening the adoption of bottom-up approaches to disaster risk reduction, (b) directing resources to the local level to induce greater willingness of communities to participate in disaster risk reduction activities, and, (c) demonstrating the economic gains from early warning to partners in warning development, including authorities and local communities, (d) coordinating national plans with regional and global initiatives
5) making early warning people centered, not technology oriented
6) considering the early warning systems being developed under international frameworks and commitments, such as the UNCCD and the UNFCCC, in integrating early warning systems into sustainable development
7) transforming post-disaster relief assistance into a disaster risk reduction mechanism by ensuring that post-disaster rehabilitation and reconstruction assistance includes explicit risk reduction interventions and by governments maintaining their own priorities
8) adopting a long-term perspective and vision in developing and implementing early warning systems.

5.1.3 Identified needs by level of development

A. Developing countries

1) establishing and enforcing national guidelines and standard operating procedures for early warning
2) developing institutional capacity of early warning bodies, especially by: (a) strengthening monitoring instrumentation, (b) developing risk maps and other risk assessment tools as part of enlarging the data and information base of early

warning, (c) improving communication equipment, methodologies, systems, and practice, (d) transferring and adapting warning technology, including forecast models, and, (e) maintaining permanent staff of early warning services to ensure continuity in the event of change of national political administrations
3) streamlining mandates of various institutions engaged in the warning system, including establishing a single voice for early warning and information on crisis management in coordinating warning issuance
4) shifting the early warning planning paradigm to adopting the participatory and decentralized approach, including involving communities in warning so as to develop task-focused systems through community engagement.
5) expanding data and information sharing between different levels
6) creating public awareness on early warning, including emphasising early warning instruction in education system and advocacy programmes targeted at decision-makers
7) improving monitoring of early warning systems, including development of national monitoring indicators
8) increasing budgetary support for early warning development

B. Developed countries

1) improving early warning databases, including ground and space based technologies
2) targeting warnings at specific at-risk groups
3) strengthening information exchanges among various bodies engaged in early warning research and other activities
4) clearly identifying functions and responsibilities, including accountabilities and reporting requirements and feedback mechanisms of all parties in the warning chain, including setting of performance targets
5) developing risk assessment and management skills of people and institutions in the warning chain
6) maintaining community awareness and response
7) addressing emerging issues such as people migration and resource privatization, and long-term issues, such as expected changes in frequency and magnitude of natural hazards due to effects climate change and variability

5.2 Priority recommendations

5.2.1 Common recommendations

1. **Support integration of disaster risk management, including early warning, into development processes and policies**. This includes support for actions to:
   (a) strengthen regional and national development frameworks and coordinating mechanisms and increase their use as the conduits for introducing or strengthening early warning systems
   (b) expand harmonization and standardization of early warning concepts, terminologies and data both within countries and across borders
   (c) ensure effectiveness of complementary non-structural and structural measures of disaster risk reduction. For example, physical planning should consider hazard exposure as a priority to enhance the success of early warning through improving peoples' response to warning advice

(d) support development of public/private partnerships to leverage government and private sector needs, capabilities and resources in developing effective early warning systems, particularly warning communication
(e) motivate strong long-term political commitment
(f) demonstrate the cost-benefit and show positive results of early warning worldwide at all levels to elicit the required support from authorities in terms of investment and design of a conducive environment for early warning. These should include projects to measure the success of early warning systems through assessment of outcomes (in terms of lives saved, property and natural resource loss avoided and satisfaction with warning by those at risk), outputs (such as timing and accuracy of predictions, and, other systemic performance targets), and, inputs (such as system infrastructure and resources and design quality) (Handmer 2002 B).

2. **Support capacity development** to strengthen early warning systems, particularly in developing countries, including through programmes to:
(a) train people involved in early warning and risk management, including on participatory methods and future techniques for early warning
(b) provide equipment needs
(c) strengthen approaches, techniques and systems for early warning data and information collection, analysis and management as well as for vulnerability and risk assessment.

3. **Develop people-centered warning systems**, including through actions to:
(a) develop community-based early warning and disaster risk reduction programmes based on participatory approaches
(b) make the needs of those at risk the focus of warning service delivery for successful warning
(c) improve public awareness through promotion of awareness and education on fundamental risks in developing countries and remaining risks in developed countries, including education on the probabilistic nature of risks, hazard forecasts and warning messages.

4. **Improve data collection and availability to improve short and medium range forecasting and to investigate long-term perspectives.** This involves actions to:
(a) strengthen the scientific/technical base for early warning systems, including rehabilitating, modernizing and expanding basic hazard monitoring and data infrastructure, particularly maintaining and enhancing hydrometeorological networks and facilities, and scientific institutions
(b) establish and develop operational processes for sharing and exchanging scientific, technical and social data, information and experience, and technology application, and for enhancing interactions among stakeholders involved in the design and operation of early warning systems, including through initiatives to:
    (i) compile inventories of existing and planned early warning system activities, including scientific research and institutional interventions
    (ii) specify clear definitions of responsibilities, including among different warning systems, levels of government, regional and national coordinating frameworks and other partnerships

(iii) promote the definition of terminology, common acceptance, and usage of terms, including standardizing technical specifications of warnings disseminated through new media
(iv) promote the adoption of common methods to assess danger levels for weather triggered risks by all countries in any region to avoid different and sometimes conflicting information to citizens of different countries on cross-country or regional disasters
(v) improve and increase the resolution of information on warning and adaptation of knowledge and information on warning from developed countries and international bodies to situations of developing countries, and from national to local levels within countries.

5. **Create a process and mechanism,** to be coordinated by the Secretariat of the UNISDR, **to facilitate implementation of key recommendations** of the Conference through the medium of an international early warning platform or programme.

5.2.2 Recommendations for developing countries

1. **Develop warning systems for additional or emerging hazards** - While emphasising issues of integrating early warning into public policy, the need to urgently address the task of developing, implementing and effectively managing early warning systems for several disaster threats facing developing countries remains large. Hence, it is crucial to expand the scope of warning services in disaster reduction by developing and implementing early warning systems for undercovered risks, such as localized hazards and region-specific gaps, including flash floods, landslides and forest fires for Asia and epidemics, flood, desertification and conflicts for Africa.

2. **Maintain and strengthen collaboration with international partners**, including mechanisms for enhancing financial assistance, knowledge exchanges and other capacity development resources. However, it is also essential to promote local (at regional, national or community level) ownership and anchor for early warning systems development and support initiatives, particularly those driven by external partner inputs. This calls for increased budgetary support from national governments based on demonstration of the net benefits from early warning to national authorities and donor partners by practitioners.

3. **Develop regional disaster reduction institutions** -The development of the institutional base for early warning is of paramount importance in developing countries. Support should be maintained and enhanced for developing and strengthening regional disaster reduction and information centers. In the case of Africa, such a centre should be developed as a facilitating node for promoting early warning development.

5.2.3 Recommendations for developed countries

1. **De-emphasise reliance on regulatory approaches and enforcement** in risk management to focus more on cooperation with at-risk groups to increase community engagement and compliance

2. **Develop standards for warning dissemination using the new technologies**, such as the internet and mobile telephony. The internet has become a powerful and pervasive tool for predicting the occurrence of disaster threats. It is therefore essential to improve its use in designing and effectively delivering effective early warning messages,

3. **Pay greater attention to implications of privatization for early warning** – Given the trend of privatizing hydrologic-based services such as water, power and transport, it is essential to consider its implication for early warning, including cooperation with the reinsurance industry in the use of common risk assessment processes and information.

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