

Early Warning Systems
in the Indian Ocean and Southeast Asia
2011 Report on Regional Unmet Needs

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ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness



United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)

About this report

This report has been developed at the request of the Advisory Council of the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness and will act as a guide for future funding.

This report updates the 2009 ESCAP Report on Regional Unmet Needs in Tsunami Early Warning Systems. In line with the Fund's Strategic Plan, this update also includes information on early warning of other coastal hazards in the region.

This report continues to be closely guided by the key elements for Early Warning Systems (EWS) found in the "Checklist" developed as a product of the Third International Conference on Early Warning held in 2006.¹



Figure 1: The Five Elements of Effective Early Warning Systems²

The Checklist also covers cross cutting issues such as a multi-hazard approach, involvement of local communities and consideration of gender perspectives and cultural diversity.

This report is a broad, regional overview and analysis of unmet needs in regional early warning systems of tsunami and coastal hazards, based on desk research and consultation with key ESCAP partners. A list of documents consulted for this Study is included in Annex A of this Report. The draft of this report was prepared by Justin Shone, Consultant.

ESCAP would like to thank the Governments of Thailand, Sweden, Turkey, Bangladesh and Nepal, which have made financial contributions to the Fund, and the many other countries and partners that have made important contributions of their time and expertise.

¹ ISDR (2006) Third International Conference on Early Warning, Developing Early Warning Systems: A Checklist.

² ISDR Platform for the Promotion of Early Warning Systems

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Acronyms and Abbreviations

AADMER	ASEAN Agreement on Disaster Management and Emergency Response
ABU	Asia-Pacific Broadcasting Union
ADB	Asian Development Bank
ACDM	ASEAN Committee on Disaster Management
ADPC	Asian Disaster Preparedness Center
ADRC	Asian Disaster Reduction Center
ADRRN	Asian Disaster Response and Recovery Network
AIT	Asian Institute of Technology
ASEAN	Association of Southeast Asian Nations
ATWS	Australian Tsunami Warning System
BAP	Bali Action Plan
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
CBDRM	Community-based Disaster Risk Management
CCA	Climate Change Adaptation
CCR	Coastal Community Resilience
COP	Conference of the Parties
CRED	Centre for Research on Epidemiology of Disasters
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
DART	Deep-ocean Assessment and Reporting of Tsunamis
DRR	Disaster Risk Reduction
EOC	Emergency Operations Centre
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
EWS	Early Warning System
GDPFS	Global Data Processing and Forecasting System
GLOSS	Global Sea Level Observing System
GOS	Global Observing System
GOOS	Global Ocean Observing System
GSN	Global Seismographic Network
GTS	Global Telecommunications System
HFA	Hyogo Framework for Action
ICAM	Integrated Coastal Area Management
ICG	Intergovernmental Coordination Group
ICT	information and communication technology
IFRC	International Federation of Red Cross and Red Crescent Societies
IO	Indian Ocean
IOC UNESCO	Intergovernmental Oceanographic Commission of UNESCO
IOTWS	Indian Ocean Tsunami Warning and Mitigation System
IOWave	Indian Ocean Wave
IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy for Disaster Reduction
ITIC	International Tsunami Information Centre
JMA	Japan Meteorological Agency
JTIC	Jakarta Tsunami Information Centre
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
LoA	Letter of Agreement
MDGs	Millennium Development Goals
MoU	Memorandum of Understanding
NDWC	National Disaster Warning Centre
NEIC	National Earthquake Information Center
NGI	Norwegian Geotechnical Institute
NGOs	non-governmental organizations

NOAA	National Oceanic and Atmospheric Administration (United States)
NMHS	National Meteorological and Hydrological Services
NTWC	National Tsunami Watch Centre
OCHA	Office for the Coordination of Humanitarian Affairs
PAGER	Prompt Assessment of Global Earthquakes
PPEW	Platform for Promotion of Early Warning
PTWC	Pacific Tsunami Warning Center
PTWS	Pacific Tsunami Warning and Mitigation System
RISTEK	Indonesian State Ministry of Research and Technology
RTWP	Regional Tsunami Watch Provider
SAARC	South Asian Association for Regional Cooperation
SCMG	Sub-Committee on Meteorology and Geo-physics
SDMC	SAARC Disaster Management Centre
SEI	Stockholm Environment Institute
SEisComp	Seismological Communication Processor
SMS	Short Message Service
SOPs	Standard Operating Procedures
TEWS	Tsunami Early Warning System
TWFP	Tsunami Warning Focal Point
UNDP	United Nations Development Programme
UNDP-RCB	UNDP Regional Centre in Bangkok
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
USGS	US Geological Survey
WG	Working Group
WMO	World Meteorological Organization

Executive Summary

Since the Indian Ocean tsunami of 2004, intensive work has been carried out by a range of stakeholders to support the development of all elements of an early warning system in the Indian Ocean and Southeast Asia. This included adoption of disaster management legislation in a number of countries, development of technical monitoring and warning services, and community-based initiatives by a wide variety of actors.

In some countries, these initiatives have established the foundation for effective action the next time an ocean-wide tsunami or other coastal hazards occurs. To some extent, the initiatives remain fragmented, and there are also concerns about long-term sustainability. In almost all countries, a significant overarching need is to strengthen partnerships between these initiatives and incorporate them into an overall Government framework with funding from Government budgets and regular testing.

Climate change is predicted to increase the frequency, severity and impact of disasters in Asia. In fact, the Intergovernmental Panel on Climate Change lists Asian and African megadeltas as one of the four areas of the world most vulnerable to the effects of climate change, due to large populations and high exposure to sea level rise, storm surges and river flooding.³ There is already evidence that climate change is altering weather patterns. This makes it increasingly likely that areas will be exposed to disasters they are not used to, and are poorly prepared for.

The ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness was established in 2005, originally to support tsunami early warning through a multi-hazard approach. In 2010 the key donors of the Fund approved the broadening of the scope of the Fund to include overall disaster and climate preparedness within its core areas of support. As the only United Nations Asia-Pacific fund in this area of work, and to avoid spreading resources too thinly, the Fund gives priority to strategic initiatives at the regional level, including regional resource sharing arrangements, South-South cooperation approaches, and initiatives that can have value region-wide (e.g., model or pilot approaches).

There are a large number of unmet needs with regard to early warning of coastal hazards in the Indian Ocean and Southeast Asia. This report identified the following as the most important priorities in strengthening early warning in the region:

Risk knowledge is an area of work that needs to be given greater attention. Even at the broadest scale, the levels of risk from mega-disasters like tsunamis in different parts of the region are poorly understood. Partly as a result, most of the resources for disaster risk reduction and early warning are provided in the months following a major disaster, and are often tied to the affected area and/or the particular type of disaster that has just occurred.

Communication and dissemination of warnings, and response capacity – particularly at the “last mile” – is a particular challenge in Asia because of its huge population, strong disparities in wealth, culture and living conditions, and the remoteness of many communities. There are a number of aspects that need ongoing strategic support, e.g., development of end-to-end Standard Operating Procedures from the Government to the community levels, strengthening of partnerships (e.g., between Government, non-governmental organizations and the media) and dissemination of good practices (e.g., for education and awareness programmes).

³ IPCC, *Fourth Assessment Report: Climate Change*, 2007.

Priorities:

- Support increased coverage and use of risk and vulnerability assessments, in particular at the local level, building on initiatives like ICG/IOTWS⁴ tsunami risk assessment guidelines. Long-term assessments need to factor in the expected impacts of climate change.
- Strengthen end-to-end dissemination and response to warnings through the development of Standard Operating Procedures (SOPs) that cover a range of hazards and link the regional, national, provincial and community levels.
- Support strategic regional initiatives to raise public awareness of disaster risks and how to prepare for and respond to them.
- Promote development of regulations that stipulate frequency for drills, standards for evaluation, and procedures covering different areas and hazards.
- Strengthen access to critical information, e.g., through regional arrangements for standardized information storage, compatibility of technical systems, access to critical data (e.g., bathymetry) and their use for disaster risk reduction, and support capacity building in these areas of work.
- Build institutional capacities contributing to the sustainability and maintenance of instrumentation networks that are required for disaster and climate change monitoring, through a multi-hazard approach, and in particular from a planning and policy perspective (including network-wide effectiveness reviews).
- Cost-benefit analysis of early warning, disaster risk reduction and climate change interventions at different levels.

⁴ Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System, coordinated by IOC UNESCO.

CHAPTER 1

Introduction

Natural hazards, such as storms, floods, tsunamis, or earthquakes, create disasters when a community or population is exposed to these hazards and cannot cope with its effects. The effects of natural hazards can and have been reduced when people receive an alert of what is likely to happen soon, and are aware of the appropriate actions to take to get out of harms way. A warning prompts people to take immediate action. The goal of a warning is to prevent hazards from becoming disasters.

An early warning system is defined by the United Nations International Strategy for Disaster Reduction (UNISDR) as:

The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.⁵

1.2 ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness

The ESCAP Tsunami Regional Trust Fund was established in 2005, originally to support tsunami early warning through a multi-hazard approach. The Fund has received contributions from the Governments of Thailand (US\$ 10 million), Sweden (US\$ 2.6 million), Turkey, Bangladesh and Nepal.

In 2010 the key donors of the Fund approved the broadening of the scope of the Fund to include overall disaster and climate preparedness within its core areas of support. Accordingly, the Fund changed its name to the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness.

End-to-end early warning, defined broadly, will be the overall framework for the Fund. In line with the Fund's objectives and geographic scope, the Fund will primarily focus on early warning of coastal hazards such as tsunamis, coastal zone flooding, storm surges and cyclones, while continuing to adopt a multi-hazard approach.⁶ The Fund provides grants to Governments, intergovernmental and non-government organizations, which submit applications through various rounds of funding. As the only United Nations Asia-Pacific fund in this area of work, and to avoid spreading resources too thinly, the Fund gives priority to strategic initiatives at the regional level, including regional resource sharing arrangements, South-South cooperation approaches, and initiatives that can have value region-wide (e.g., model or pilot approaches).

The Fund works closely with United Nations partners such as the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC UNESCO), the secretariat of the International Strategy for Disaster Reduction (ISDR), the Office for the Coordination of Humanitarian Affairs (OCHA), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Meteorological Organization (WMO).

Some of the Fund's efforts in addressing gaps and unmet needs in early warning include supporting:

⁵ UNISDR (2009) Terminology on Disaster Risk Reduction.

⁶ ESCAP (2009) Strategic Plan of ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness.

- work on risk knowledge led by the Asian Disaster Reduction Center on community-based hazard map development, which aims to use scientifically developed hazard maps in community preparedness activities. This is viewed as a potential bridge between active ongoing work by the scientific community on the one hand, and on the other hand ongoing work by Governments and development agencies that are working at the community level.
- training of selected governments in the Coastal Community Resilience methodology, which is a tool for assessing the disaster vulnerability of a coastal community and targeting issues on which further work is needed.
- work led by IOC UNESCO to raise awareness of tsunami hazard from the Makran fault using paleotsunami studies.
- work to promote application of the ICG/IOTWS risk assessment guidelines into standard operating procedures – this work focuses on Indonesia and Sri Lanka.
- elements of Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), which would be one of the Regional Tsunami Watch Providers, and will also provide early warning of various climate hazards. As part of this centre, the Fund has also supported work to strengthen the regional network of seismic and sea level stations through installation of new stations in Myanmar, Philippines and Viet Nam.
- work of IOC UNESCO on Standard Operating Procedures for tsunami warning and emergency response focusing on four countries – Myanmar, Pakistan, Philippines and Vietnam.
- work by the Asia-Pacific Broadcasting Union (ABU) to further involve the media in disaster risk reduction and the early warning chain.
- an initiative by UNESCO's Jakarta Tsunami Information Centre to compile a depository of some of the education, awareness and information tools. The project will also test their use in regular education and disaster awareness programmes carried out by the Government and other organizations in Indonesia, Philippines, Thailand and Timor-Leste.

1.2 Assessing Regional Unmet Needs in Early Warning of Coastal and Climate Hazards

Climate change is altering the face of disaster risk through increased weather-related risks and sea-level rise. Climate change is expected to increase the severity and frequency of weather-related natural hazards such as storms, high rainfall and floods.⁷ The Global Assessment Report⁸ has emphasized that a surface temperature increase of 2°C above pre-industrial levels makes possible unforeseen, non-linear impacts on poverty and disaster risk.

The predicted effects of climate change coupled with the Asia-Pacific region already being the most disaster prone region in the world most seriously affected by many types of natural disasters, including fires, floods, droughts and severe hydro-meteorological events, seismic, geological, maritime and ecological disasters, presents enormous challenges.

⁷ Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report: Climate Change 2007.

⁸ United Nations, 2009 Global Assessment Report on Disaster Risk Reduction: Risk and poverty in a changing climate. Invest today for a safer tomorrow.

An end-to-end disaster early warning system (EWS) should be a fundamental component of all nations' disaster risk reduction (DRR) strategies, enabling governments from the national to the local levels, as well as communities themselves, to take appropriate actions to mitigate and reduce both the loss of lives and livelihoods in anticipation of a disaster.

It is important to emphasize that the likelihood of the loss of lives and livelihood from a natural disaster (the "risk") depends not only on the hazard itself, but also on a number of other vital factors including the density of population and infrastructure, ecosystems, as well as the vulnerability of the communities (and their livelihoods) and the potential of those communities to respond to the disaster and or a disaster warning.

As such there is a fundamental need for effective and efficient disaster preparedness and more particularly now that there is an international acceptance of the need to take into account the anticipated severe impacts of climate change.



CHAPTER 2:

Climate change adaptation and disaster risk reduction

2.1 Climate change negotiations

The Bali Action Plan (BAP) was agreed by the United Nations Framework Convention on Climate Change (UNFCCC) 13th Session of the Conference of the Parties (COP 13), Bali in December 2007 and provided a guide to the negotiations in Copenhagen in December 2009. The Bali Action Plan recognized the importance of risk reduction for adaptation and called for risk management and risk reduction strategies, including risk sharing and transfer mechanisms such as insurance, disaster reduction strategies and means to address loss and damage.

The Copenhagen Conference of the Parties to the UNFCCC ended on 18 December 2009. The Copenhagen Accord itself however does not make any reference to disaster risk reduction, only to adaptation in a more general sense. On the other hand, the negotiating texts that will be the basis for further work during 2010 do still contain strong references to disaster risk reduction.

The Accord calls for increased funding, capacity and technology transfer, although the specific financing arrangements were one of the main stumbling blocks in the negotiations. In any case, a number of existing financing mechanisms (including Funds, multilateral financial institutions and bilateral development agencies) are helping to foster synergy and integration of climate change adaptation (CCA) and disaster risk reduction (DRR), including funding areas such as:

- Increased capacity for weather and climate modeling and monitoring;
- Strengthening of disaster risk management agencies and systems at local, national and regional levels;
- Strengthening of EWS (including end-to-end EWS);
- Risk assessments;
- Incorporation of development, poverty reduction and environmental sustainability initiatives into DRR strategies.

2.2 Linking climate change adaptation (CCA) and disaster risk reduction (DRR)

Both climate change adaptation, which focuses on climate-related hazards, and disaster risk reduction, which focuses on all disasters (climate- and non-climate-related), need to have a clear focus on reducing people's vulnerability to hazards they face by improving methods to anticipate, resist, cope with and recover from the impact of the hazard.

Climate change adaptation (CCA) and disaster risk reduction (DRR) have similar aims and mutual benefits. However, to date the policy and institutional frameworks for climate change adaptation are only weakly connected to those for disaster risk reduction, at national, regional and international levels.⁹ Closer collaboration between the two communities is likely to result in the following benefits:

- Reduction of climate-related losses through more widespread implementation of DRR measures linked with adaptation.

⁹ ISDR (2009), Global Assessment Report on Disaster Risk Reduction

- More efficient use of financial, human and natural resources.
- Increased effectiveness and sustainability of both adaptation and DRR approaches.
- Access to new partnerships and funding sources.
- Increased chances to integrate DRR into development, including an ability to influence sectors such as livelihoods, health, and the environment.

A number of entry points exist to link climate change adaptation and disaster risk reduction initiatives. Some of these include:

- Joint programming and activities (at regional and country levels), including joint capacity building programs;
- Enhancing and building on existing legal and institutional structures in countries (and avoidance of creating new structures);
- Focusing on the shared goal of CCA and DRR in saving livelihoods, as well as saving lives, and including enhanced engagement with vulnerable communities.

2.3 Asia – Pacific context

As a result of climate change an increase in the magnitude and frequency of weather-related disasters, both globally and in particular in the Asia-Pacific region is expected to occur.

In a region where 75 per cent of the world's major natural catastrophes between 1970 and 1997 occurred (mostly in developing countries),¹⁰ there has also been a general upward trend in the number and severity of natural disasters due to severe hydro-meteorological events (such as cyclones and flooding).

2009 Typhoon Ketsana (South East Asia Region)

Typhoon Ketsana struck the Philippines on September 26th 2009 bringing winds of up to 100 km/hr and dumping copious amounts of rain to areas in and around the capital city of Manila. Approximately 80 percent of Manila was submerged as it experienced its worst flooding in 40 years.

In the Philippines almost four million people were affected by Typhoon Ketsana and 375,000 were forced to flee their homes. At least 295 fatalities due to flash flooding were reported. Damage to crops and infrastructure was estimated to be over U.S. 100 million dollars.

The storm moved over the Philippines and regained strength as it headed across the South China Sea, it then struck central Viet Nam on September 29th as a Category 2 typhoon with winds of 105 mph (169 km/hr). Towns and villages in central Viet Nam were flooded and 162 people were reported killed. An estimated 170,000 people were evacuated from their homes. Damage was initially estimated at U.S. 168 million dollars in Viet Nam.

From Vietnam Ketsana moved inland and over to the Lao PDR and Cambodia, in the Lao PDR it caused 24 fatalities and 17 in Cambodia. In the Lao PDR the typhoon resulted in flash flooding in the upland mountain areas and severe river overflow onto land surrounding the Mekong River. The total damages to housing, agriculture and transport is estimated at US 58 million dollars.¹¹

¹⁰ UNESCAP and ADB 2000

¹¹ Government of the Lao PDR Report: Ketsana typhoon in the Lao PDR: Damage, Loss and Needs Assessment



Figure 2: Tracking of Typhoon Ketsana¹²

2008 Cyclone Nargis (Myanmar)

Cyclone Nargis was a strong tropical cyclone that caused the worst natural disaster in the recorded history of Myanmar. The cyclone made landfall in the country on 2 May 2008, causing catastrophic destruction and at least 138,000 fatalities. There were around 55,000 people missing. Damage has been estimated at over US 10 billion dollars, which makes it the most damaging cyclone ever recorded in this area.¹³



Figure 3: Tracking Cyclone Nargis¹⁴

¹² Source: Reliefweb

¹³ Sources: AFP, Reuters, United Nations Office for the Coordination of Humanitarian Affairs (OCHA)

¹⁴ The background image is from NASA. Tracking data from the National Hurricane Center or the Joint Typhoon Warning Center

CHAPTER 3

Governance and Institutional Arrangements

Well developed governance and institutional arrangements, internationally, regionally, and nationally, form the foundations for successful development and sustainability of sound early warning systems. Clear indicators of political commitment are the level of resources allocated and the efficiency of their use by stakeholders. Decentralization of authority, as well as building capacity and devoting resources at provincial and local levels are means to foster participation. Ultimately, the early warning system functions as part of the overall disaster risk reduction system.

3.1 Coordination and Cooperation Mechanisms

Intergovernmental Coordination Group (ICG/IOTWS)

The Intergovernmental Oceanographic Commission (IOC) Twenty-third Assembly (21-30 June 2005) decided, by resolution XXIII-12, to create the Indian Ocean Tsunami Warning and Mitigation System (IOTWS) and to establish an Intergovernmental Coordination Group (ICG/IOTWS). It is IOC UNESCO's mandate to coordinate all activities, groups and NGOs and UN agencies involved in the ICG/IOTWS.

The Seventh Session of the ICG/IOTWS, held in Banda Aceh, Indonesia (14- 16 April 2010), reviewed progress against the commitments of the Sixth session and recognised the progress towards establishing national tsunami warning centres in all countries around the Indian Ocean.

The Seventh session reaffirmed that:

- 1) The IOTWS will be a coordination network of national systems and capacities, and will be part of a global network of early warning systems.
- 2) That member states have the responsibility to issue warning within their respective territories.

The ICG/IOTWS recently underwent restructuring and now includes three Working Groups (WG1: Tsunami Risk Assessment and Reduction, WG2: Tsunami Detection, Warning and Dissemination, WG3: Tsunami Awareness and Response).

Regional, Integrated, Multi-Hazard Early Warning System for Africa and Asia (RIMES)

The Regional, Integrated, Multi-Hazard Early Warning System for Africa and Asia (RIMES) is an international and intergovernmental institution, owned and managed by its Member States, for the generation and application of early warning information. RIMES evolved from the efforts of 26 countries in Africa and Asia, in the aftermath of the 2004 Indian Ocean tsunami, to establish a regional early warning system, within a multi-hazard framework, which generates and communicates early warning information, and builds capacity to prepare for and respond to trans-boundary hazards. RIMES is an integral part of the IOTWS and works alongside the national and regional watch providers.

By signing the RIMES Cooperation Agreement a country commits to collectively own, manage, maintain, and fund the RIMES regional early warning centre and to exchange observation and monitoring data.

The objectives of RIMES are to:

- Facilitate establishment and maintenance of core regional observation and monitoring networks, and to ensure data availability for early warning purposes;
- Provide regional tsunami watches within the framework of the United Nations Educational, Scientific, and Cultural Organization's Intergovernmental Oceanographic Commission (IOC UNESCO);
- Provide research and development support to National Hydrological and Meteorological Services (NHMS) for providing localised hydro-meteorological risk information within the framework of the World Meteorological Organization (WMO);
- Enhance capacities of national systems to respond to early warning information of various lead times at national, sub-national, local, and at-risk community levels within each national early warning framework.

The regional early warning centre itself is located at the Asian Institute of Technology (AIT) campus near Bangkok, Thailand. The Asian Disaster Preparedness Center (ADPC) facilitated the establishment and advocacy of RIMES with US\$ 4.5 million in funding support from the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness.

ESCAP/WMO Typhoon Committee¹⁵ and WMO/ESCAP Panel on Tropical Cyclones¹⁶

The Typhoon Committee was established to promote and coordinate the planning and implementation of measures required for minimizing the loss of life and material damage caused by typhoons in East and Southeast Asia. The Panel on Tropical Cyclones is the equivalent organization to the Typhoon Committee serving the Indian Ocean.

Economic and Social Commission for Asia and the Pacific (ESCAP)

ESCAP has been actively involved with disaster management, preparedness and risk reduction for more than five decades focusing on the development of regional cooperation mechanisms. ESCAP, at its 64th Session in April 2008, established a new intergovernmental Committee on Disaster Risk Reduction and programme of work on disaster risk reduction, and mandated ESCAP to further strengthen its capacity in this area. The main objectives of this programme are to:

- Identify and advocate policy options and strategies on multi-hazard disaster risk reduction and mitigation;
- Strengthen regional cooperation mechanisms for disaster risk management, including space and other technical support systems;
- Promote multi-hazard assessment, preparedness, early warning and response to disaster risk.

The programme of work is guided by the Hyogo Declaration and the Hyogo Framework for Action 2005-2015 with the objectives of building the resilience of nations and communities to disasters.

¹⁵ The Typhoon Committee is currently composed of 14 Members: Cambodia; China; Democratic People's Republic of Korea; Hong Kong, China; Japan; Lao People's Democratic Republic; Macao, China; Malaysia; the Philippines; Republic of Korea.

¹⁶ The Panel on Tropical Cyclones is currently composed of 8 Members: Bangladesh; India; Maldives; Myanmar; Oman; Pakistan; Sri Lanka; and Thailand.

Regional Climate Change Adaptation Knowledge Platform for Asia and Asia Pacific Adaptation Network

The Regional Climate Change Adaptation Knowledge Platform for Asia focuses on sharing information on climate change adaptation and developing adaptive capacities in Asian countries. Early warning and climate risk information is one of the areas covered. The Platform has been jointly established by the Stockholm Environment Institute (SEI), the Swedish Environmental Secretariat for Asia (SENSA), the United Nations Environment Programme (UNEP) and the Asian Institute of Technology (AIT)/UNEP Regional Resource Centre for Asia and the Pacific (AIT/UNEP RRC.AP), with funding support from the Swedish International Development Cooperation Agency (SIDA).

The Asia Pacific Adaptation Network aims to build climate resilience of vulnerable human systems, ecosystems and economies through the mobilization of knowledge and technologies to support adaptation capacity building, policy setting, planning and practices. The Asia Pacific Adaptation Network is facilitated by UNEP, Institute for Global Environment Strategies (IGES), AIT/UNEP RRC.AP, and the Asian Development Bank (ADB) in partnership with other key actors in the region.

Regional Thematic Working Group on Environment and Disaster Risk Management (TWGEDRM)

The Working Group is a mechanism under the United Nations Asia-Pacific Regional Coordination Mechanism (RCM)¹⁷, which objectives and functions in regard to Hyogo Framework for Action (HFA) include: promoting coordinated and joint action; supporting the preparation, implementation and follow-up of the international and regional agreements on environment and disaster risk management in the region; advocating for effective mainstreaming of environment and disaster management in the UN system and for regional coherence. ESCAP is co-chairing this Working Group with UNEP and the United Nations Office for the Coordination of Humanitarian Affairs (OCHA).

ASEAN¹⁸/AADMER

The ASEAN Agreement on Disaster Management and Emergency Response (AADMER) is a regional legally-binding agreement that binds ASEAN Member States together to promote regional cooperation and collaboration in reducing disaster losses and intensifying joint emergency response to disasters in the ASEAN region. AADMER is also ASEAN's affirmation of its commitment to the Hyogo Framework for Action (HFA) and sub-regional coherence in its implementation.

AADMER contains provisions on disaster risk identification, monitoring and early warning, prevention and mitigation, preparedness and response, rehabilitation, technical cooperation and research, mechanisms for coordination, and simplified customs and immigration procedures.

In support of this Agreement, the ASEAN Committee on Disaster Management launched a regional Work Programme covering the period of 2010-2015. In the first phase of the Work Programme, a regional risk assessment will be conducted, and with it, the setting up of a regional system for early warning and monitoring. Regional

¹⁷ The RCM, chaired by the Executive Secretary of ESCAP, has 35 members, of which 27 have Bangkok-based regional offices. The RCM was established to improve coordination and cooperation at the regional level among the work programmes of the organizations in the United Nations system and to move towards regional-level system-wide coherence and delivering as one.

¹⁸ ASEAN Member States are: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam.

mechanisms will be further enhanced for a more effective disaster preparedness and well-targeted and timely emergency response. The Work Programme also seeks to develop a regional strategy for integrating disaster risk reduction into national development plans as well as urban and community action plans, and to develop a tool kit for effective disaster recovery planning for ASEAN Member States.

Asian Ministerial Conferences on Disaster Risk Reduction (AMCDRR)

The Asian ministerial conferences on disaster risk reduction (AMCDRR) represent a high-level forum for Governments to reaffirm their commitment to the Hyogo Framework for Action and exchange practical ways to implement effective disaster risk reduction at the national and local levels and move towards sustainable development. The outcome document of the fourth session held 26-28 October 2010, the Incheon Declaration, calls on countries to promote sharing of early warning information and systems through strengthening existing systems.

3.2 Legal and Policy Frameworks

Countries that develop policy legislative and institutional frameworks for disaster risk reduction and that are able to develop and track progress through specific and measurable indicators have greater capacity to manage risks and to achieve widespread consensus for engagement in, and compliance with disaster risk reduction measures across all sectors of society.¹⁹

National progress reports on the implementation of the Hyogo Framework for Action (2007-2009)²⁰ indicate that countries in the Indian Ocean and Southeast Asian region are making substantial progress in strengthening their legal and policy frameworks for disaster risk reduction. Although good progress is made in enhancing the institutional mechanisms necessary for early warning for all major hazards a strong need remains to integrate early warning into broader disaster risk reduction and development policies.

Major governance issues include whether management of the disaster risk reduction system is decentralized, how well it is resourced, and how well it is linked to the community level. The link between provincial, national and regional levels of early warning systems continues to require further development.

A project currently being implemented by the Raks Thai Foundation in India, Indonesia, Maldives, Sri Lanka and Thailand plans to address some of these issues by strengthening institutional linkages and roll out good practices in multi-hazard community-based disaster risk management (CBDRM) in close partnership with local and national government, and in line with national and decentralized capacity and strategies.

As climate change is increasing the risk from weather-related hazards adaptation could and should reinforce disaster risk reduction efforts. Adaptation policies and institutional frameworks should be connected to those created to reduce disaster risk, at both the national and international levels.

3.3 Financial Resources

A major indicator for sustainability of early warning systems is the level of ongoing financial support from national government budgets essential for its long-term effectiveness. Early warning systems is an area where more spending by

¹⁹ Hyogo Framework for Action 2005-2015. Building the Resilience of Nations and Communities to Disasters.

²⁰ <http://www.preventionweb.net/english/hyogo/progress/priority1/?pid:222>

governments is required, especially weather forecasting. Spending on improving weather forecasting and sharing data could have high returns.²¹

Funds are continuously needed to support capacity development, participation in meetings, maintenance of hardware and software and databases, dissemination of information to the public and ongoing educational, media and disaster risk reduction programmes covering various hazards including tsunamis. Most major donors are tending to phase out funding for early warning systems, especially for tsunamis, after years of intensive effort; political will to protect the region needs to be maintained.

The Copenhagen Accord calls for increased funding, capacity and technology transfer, although the specific financing arrangements were one of the stumbling blocks in the negotiations.

3.4 Priorities and recommendations

1. Provide support at the national level to integrate early warning into broader disaster risk reduction and development policies.
2. Support links between institutional arrangement at different levels of government, from the regional to the national, provincial and community levels, including end-to-end Standard Operating Procedures.
3. Promote efficiency through regional resource sharing arrangements and a multi-hazard approach.

²¹ The World Bank and the United Nations (2010): Natural Hazards, UnNatural Disasters. The Economics of Effective Prevention.

CHAPTER 4

Risk Knowledge

4.1 Introduction

Risk can be defined as a measure of expected losses (deaths, injuries, property, economic activity etc) due to a hazard of particular magnitude occurring in a given area over a specific time period. Risk identification and hazard maps help to motivate people and to prioritize early warning system needs by illustrating the likely severity of the disasters at a particular location. Assessments of risk require systematic collection and analysis of information and should consider the dynamic nature of hazards and vulnerabilities that arise from processes such as urbanization, rural land-use change, environmental degradation and climate change.²² With a clear understanding of local, national and regional risks faced it is possible to better plan for and mitigate future risks and disaster. As such disaster risk knowledge is a key component of all early warning systems.

4.2. Organizational Arrangements

National progress reports on the implementation of the Hyogo Framework for Action (2007-2009)²³ indicate that although institutional commitment for identification, assessment and monitoring disaster risks has been secured in most reporting countries in the Indian Ocean and Southeast Asian region, roles and responsibilities of key national government agencies need to be clarified.

Several countries indicate a need for clear mandates and standards for collection, analysis and dissemination of data. In Indonesia efforts are underway by the government to standardize disaster risk mapping. In the Philippines government agencies are working out a system to disseminate the collected data to communities and other stakeholders.

Other existing challenges are strengthening capacities of government agencies, academic and research organizations to conduct risk and vulnerability assessment of key sectors, improving the understanding of the interdependencies across sectors, and assessing socio economic loss. Little progress is reported in mainstreaming vulnerability and risk assessment into social, economic, urban, environmental and infrastructural planning. Governance arrangements are needed to facilitate integration of risk considerations into development.

4.3 Coastal hazards in the Indian Ocean and Southeast Asia

4.3.1 Tsunami

The 2009 Geoscience Australia assessment “A Probabilistic Tsunami Hazard Assessment of the Indian Ocean Nations – 2009” resulted in two maps - a “high hazard” and a “low hazard” map. The development of two maps reflects the uncertainty about the capacity of certain fault zones to generate a major tsunami, in particular fault zones with theoretical potential to generate tsunamis, but for which no historical data exists. It was felt that a single map could mislead decision makers about the uncertainties involved in developing a tsunami risk map for the region.

²² ISDR (2006) Third International Conference on Early Warning, Developing Early Warning Systems: A Checklist.

²³ <http://www.preventionweb.net/english/hyogo/progress/priority2/?pid:224&pil:1>

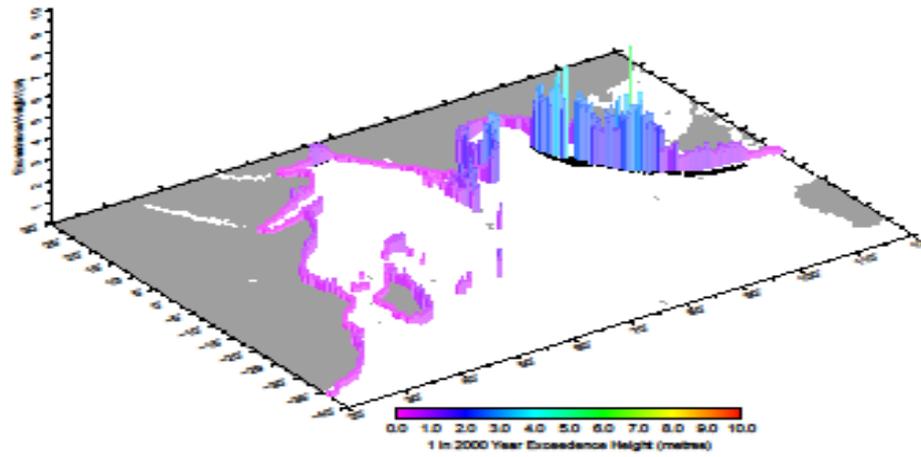


Figure 4: Probabilistic tsunami hazard map – low hazard map²⁴. The information shows the maximum tsunami amplitude with a 1 in 2000 year chance of being exceeded.

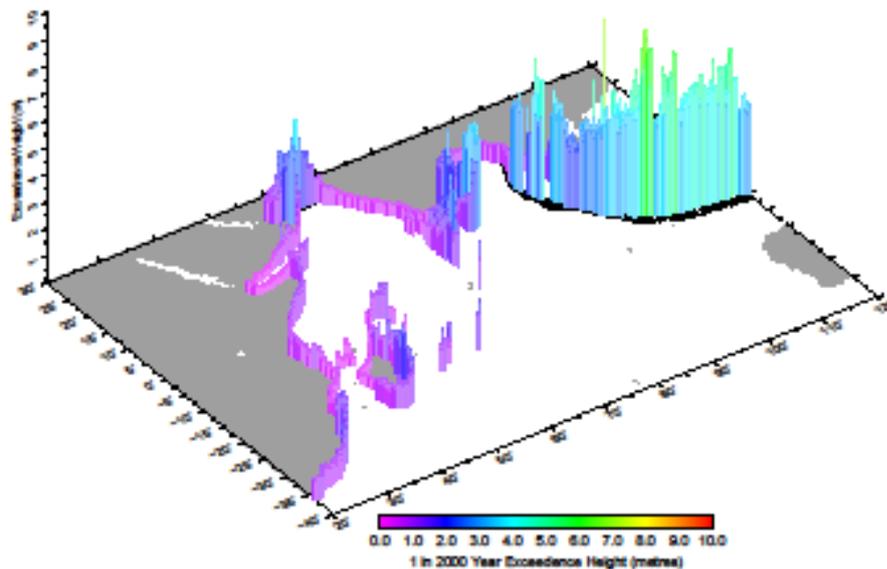


Figure 5: Probabilistic tsunami hazard map – high hazard map²⁵. The information shows the maximum tsunami amplitude with a 1 in 2000 year chance of being exceeded.

The Geoscience Australia report concludes that the Andaman-Sumatra segments of the Sunda Arc are clearly the most important zones to the bulk of the countries in the Indian Ocean for hazard at the 2000 year return period. Shorelines near or perpendicular to this zone have the overall highest tsunami hazard (especially Indonesia, but also countries like India, Maldives, Sri Lanka and Thailand, which were most affected by the 2004 Indian Ocean tsunami). The hazard in countries in the northwest Indian Ocean (e.g., Iran, Pakistan) is dominated by the Makran subduction zone.²⁶

A project supported by the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness and implemented by IOC UNESCO is addressing a knowledge gap

²⁴ Geoscience Australia: Professional Opinion 2009/2011: A Probabilistic Tsunami Hazard Assessment of the Indian Ocean Nations

²⁵ Geoscience Australia: Professional Opinion 2009/2011: A Probabilistic Tsunami Hazard Assessment of the Indian Ocean Nations

²⁶ Geoscience Australia: Professional Opinion 2009/2011: A Probabilistic Tsunami Hazard Assessment of the Indian Ocean Nations

about tsunami risk in countries in the Makran subduction zone. Results are expected by the end of 2011 and will increase the accuracy of tsunami modeling and risk assessment in Iran and Pakistan, as well as other countries in the western Indian Ocean.

4.3.2 Floods

Flooding is the one of the most frequent natural hazards, occurring in almost every country (including landlocked countries) in the region. At present there is no systematic global detection of flood events as there is for cyclones and earthquakes. Information from national disaster loss databases indicates that widespread, smaller-scale disasters like flooding have a significant impact on lives and livelihoods that is insufficiently taken into account in planning and allocating resources for disaster risk reduction measures.

The most common type of flooding is river bursts caused by heavy rain. Other flooding events include storm surges – coastal flooding associated with atmospheric low pressure systems driving ocean water inland – and Glacial Lake Outburst Flooding (GLOF) – when a terminal or lateral moraine fails, releasing glacial melt in a sudden, violent burst.

Every year, more than 48 million people are affected by floods in rural areas in the Asia-Pacific countries alone, 40% of whom are in Bangladesh and 32% in India. The future risk associated with flooding is expected to increase significantly in all regions with high population density.

As is indicated by the following map²⁷, flooding is both a coastal hazard and an inland hazard, although delta regions are highly vulnerable to coastal impacts. The impact of climate change on both sea level and rainfall is expected to increase both the occurrence and the severity of both floods and droughts in the region.

River flood map of South-East Asia and the Pacific

River flood hazard

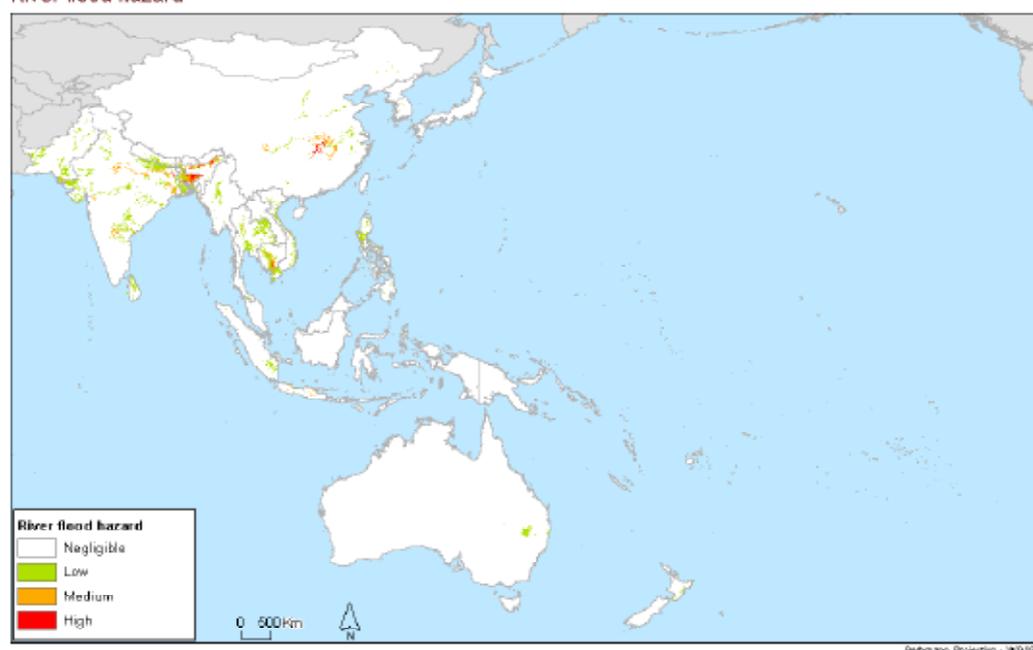


Figure 6: Hazard classification for river floods in Asia-Pacific.

²⁷ UN OCHA Regional Office for Asia and the Pacific Bangkok (2009a) Risk Assessment and Mitigation Measures for Natural- and Conflict-Related Hazards in Asia-Pacific, April 2009

4.3.3 Tropical Cyclones

Tropical cyclones (normally called “typhoons” in Pacific Ocean regions of South-east Asia) are powerful hydro-meteorological hazards. On average, over 83 million people are affected globally by between 50 to 60 events each year. Tropical cyclones are unevenly spread around the globe as their development depends on specific climatic and oceanic conditions.

Historically tropical cyclones have often had catastrophic consequences, such as the 1991 Bangladesh disaster killing more than 130,000 people, and the more recent Cyclone Nargis that caused a similar number of fatalities in Myanmar in May 2008.

Storm surges are a high flood of coastal water moving in land because of wind and low pressure, and most commonly associated with tropical cyclones/typhoons. Storm surges are the most common type of serious coastal flooding events. A storm surge is different from a tidal surge, which is a violent surge of water caused exclusively by the tidal shift in sea level. Typical storm surge heights vary with the cyclone/typhoon’s intensity, but they can range from less than one to more than five metres.

4.4. Hazard, Vulnerability, and Risk Assessment

Coastlines differ in their degrees of exposure to the various hazards. Thus, some countries, and even some coastal communities within countries, are more prone to tsunamis, floods and other hazards than others. The risk of these communities can be analyzed by assessing the probability of the hazards occurring and the vulnerability of the community that would be exposed to the hazard. Risk assessment forms an important input in disaster management, in the design of development plans, and in emergency response planning.

Since the 2004 Indian Ocean tsunami, a number of tsunami risk assessments have been completed or are underway. A number of recent key studies to assist countries in the region to better prioritize the risks they face with regard to tsunami include:

- “A Probabilistic Tsunami Hazard Assessment of the Indian Ocean Nations” by Geoscience Australia. The assessment allows Indian Ocean nations to prioritize which coastlines have the highest tsunami hazard.
- “Tsunami Risk Assessment and Mitigation for the Indian Ocean” Guidelines completed in collaboration between ICG/IOTWS and UNDP.²⁸ The Guidelines describe procedures for assessing and improving awareness of the tsunami hazard and for assessing coastal communities’ vulnerabilities and deficiencies in preparedness.

It is now recognized that these tsunami risk assessments should be broadened to also include other coastal hazards. In 2009, IOC UNESCO launched the *Hazard Awareness and Risk Mitigation in Integrated Coastal Area Management (ICAM)* guidelines to assist policy makers and managers in the reduction of the risks to coastal communities, their infrastructure and service-providing ecosystems from tsunamis and other coastal hazards. Limited information exists on multi-hazard risk assessments and risk maps.

Even though risk assessments are expanding coverage is still low. The analysis and interpretation of existing hazard data needs improvement and new or improved data products need to be provided. Various multi-hazard maps for the Asia-Pacific region have now been produced to highlight the uncertainty regarding the risk of

²⁸ IOC Manuals and Guideline No.52

major hazards from different zones. Even at the broadest level, the high-risk zones and the overall hazard frequency in different parts of the region are still not well known and the knowledge of risk from changes in climate which results in driving degradation of ecosystem is still limited and very much unmapped. Information on social, economic and environmental factors that increase vulnerability is inadequate. The vulnerability of groups who lack effective connections to the early warning systems such as rural and urban poor, ethnic minorities, handicapped persons, elderly, children, and foreigners such as refugees, migrant workers and tourists requires more analysis and inclusion of those groups in discussions of their vulnerability.

To address some of these issues UNDP Asia-Pacific Regional Centre, supported by the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness is implementing a project to improve capacity of practitioners in tsunami-affected countries that will enable them to work together regionally, nationally and locally in conducting and using tsunami risk assessment studies to improve preparedness, public awareness, early warning and response of tsunamis and other coastal hazards.

4.5. Information Storage and Accessibility

At the core of any risk knowledge efforts is the need for reliable and easily accessible data on hazards, vulnerabilities and risks. Disaster loss databases provides for systematic collection of relevant data, and their validation and sharing.

The Centre for Research on Epidemiology of Disasters (CRED) maintains a global database²⁹ of natural disasters that provides useful information and analyses on various parameters of past disaster events. Munichh Re also maintains a database 'NatCatSERVICE'³⁰ for natural catastrophes. The database allows analysis of regional and global hazards as well as trends.

UNDP has supported the establishment of national disaster loss databases in India, Indonesia, Maldives, Sri Lanka, and Thailand. Other countries in the region have established similar databases or are in the process of doing so (e.g., Iran Lao PDR, and Viet Nam).

Some important guidelines and lessons for establishing and institutionalizing disaster loss databases include:³¹

- Disaster loss databases must be developed as an integral part of disaster risk reduction initiatives. The database is a central tool for governments to better understand the disasters and threats in order to effectively mitigate and prepare for them.
- The process of disaster loss database implementation needs to be participatory and inclusive, involving governments and other partners to promote to promote government ownership of the system and its institutionalization.
- Analysis must be professional, clear, understandable and relevant to the target audience. It should comprise quantitative and qualitative information that is user-friendly and supports the decision-making process.

²⁹ <http://www.em-dat.net>

³⁰ http://www.munichre.com/en/ts/geo_risks/natcatservice/default.apx

³¹ UNDP (2009) Risk Knowledge Fundamentals: Guidelines and Lessons for Establishing and Institutionalizing Disaster Loss Databases.

Constraints reported³² in establishing systems for data collection, storage and analysis include difficulties in coordination, sharing information and adopting common data standards and methodologies, and a lack of resources to acquire and maintain equipment and the general lack of human technical capacities. Making information of hazards and risks easily accessible (such as maps of flood plains) is an effective measure allowing populations to make informed decisions.³³

4.6 Priorities and Recommendations

1. Strengthen the capacities of national governments and other organizations to conduct multi-hazard risk and vulnerability assessments through development and application of standardized multi-hazard risk mapping and risk assessment guidelines.
2. Provide support at the national level to integrate risk considerations into development.
3. Promote capacity development for standardized information storage, data accessibility and their use for disaster risk reduction.

³² <http://www.preventionweb.net/english/hyogo/progress/priority2/?pid:224&pil:1>

³³ The World Bank and the United Nations (2010): Natural Hazards, UnNatural Disasters. The Economics of Effective Prevention.

CHAPTER 5

Monitoring and Warning Service

5.1 Introduction

Monitoring and warning services form a central component of an early warning system. There must be a sound scientific basis for predicting and forecasting hazards and a reliable forecasting and warning system that operates 24 hours a day, 365 days a year. The continuous monitoring of hazard parameters and precursors is essential to generate accurate warnings in a timely fashion. Warning services for different hazards should be coordinated where possible to gain the benefit of shared institutional, procedural and communication networks.³⁴

5.2 Institutional Mechanisms

Observing, monitoring, detecting, and forecasting of hazards are resource-intensive and since hazards almost never affect only one country, international and regional cooperation have traditionally been relied upon for national capacity development.

National capacities for detecting and forecasting hazards could be further improved through enhanced inter-agency cooperation and collaboration, within and across countries. Results from surveys conducted by the World Meteorological Organization (WMO)³⁵ and the ISDR Platform for Promotion of Early Warning (PPEW)³⁶ confirm the need for development of standards not only at the national level, but also with neighbouring countries and at the regional level.

Early warning systems for meteorological, hydrological and climate-related hazards such as severe storms, floods, tropical cyclones and storm surges, are enabled through a World Meteorological Organization (WMO) coordinated international network operated by the National Meteorological and Hydrological Services (NMHS).

This operational network includes WMO Integrated Global Observing Network (WIGOS), WMO Global Telecommunication System (GTS), and WMO Global Data Processing and Forecasting System (GDPFS) comprised of three world meteorological centres, 40 Regional Specialized Meteorological Centres (RSMCs), to provide at-risk countries with hazard analysis, forecasts, bulletins and watches.³⁷ Six designated RSMCs together with six Tropical Cyclone Warning Centres (TCWCs) having regional responsibility, provide advisories and bulletins with up-to-date first level basic meteorological information on all tropical cyclones, hurricanes, typhoons everywhere in the world (see map below). This system is being further strengthened and expanded to support other hazards as well.

³⁴ ISDR (2006) Third International Conference on Early Warning, Developing Early Warning Systems: A Checklist.

³⁵ WMO (2007) Survey of National Capacities for Meteorological, Hydrological and Climate-Related Forecasting and Warning Systems. http://www.wmo.int/pages/prog/drr/natRegCap_en.html

³⁶ ISDR PPEW - UNU EHS (2008) Joint Early Warning Questionnaire

³⁷ WMO (2009) Thematic Progress Review Sub-component on Early Warning Systems. 2009 Global Assessment Report on Disaster Risk Reduction.

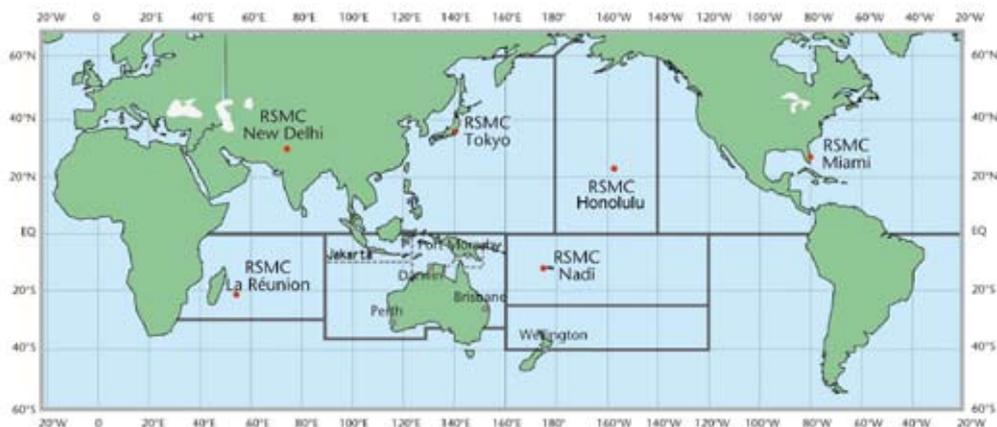


Figure 7: Designated Regional Specialized Meteorological Centres (RSMCs).

For tsunami regional watch advisories, ICG/IOTWS Member States have decided that having several Regional Tsunami Watch Providers (RTWPs) is the preferred mode of operation rather than a single provider. Essentially, the RTWPs will support an interoperable tsunami watch system for the Indian Ocean that aims to emulate the interim service provided by the Pacific Tsunami Warning Centre (PTWC) and the Japan Meteorological Agency (JMA) by mid 2011, with enhanced capability to help advise those countries most at threat.³⁸

5.3 Monitoring and Observing Systems

Global Observing System (GOS)

The Global Observing System (GOS) provides from the Earth and from outer space observations of the state of the atmosphere and ocean surface for the preparation of weather analyses, forecasts, advisories and warnings, for climate monitoring and environmental activities carried out under programmes of WMO and of other relevant international organizations. It is operated by National Meteorological Services, national or international satellite agencies, and involves several consortia dealing with specific observing systems or specific geographic regions. It makes substantial contribution to enabling the delivery of increasingly accurate and reliable warnings of severe events related to weather, water, climate and the related natural environment throughout the world.³⁹

Although the GOS has been, and still is, the foundation on which all meteorologists depend, there has been gradual but steady erosion of the observing networks during the past few years leading to a need for a redesign of the system.

Global Ocean Observing System (GOOS)

The Global Ocean Observing System (GOOS) is a permanent global system for observations, modeling and analysis of marine and ocean variables to support operational ocean services worldwide. GOOS provides accurate descriptions of the present state of the oceans, including living resources; continuous forecasts of the future conditions of the sea for as far ahead as possible, and the basis for forecasts of climate change.

³⁸ IOC UNESCO (2008) Indian Ocean Tsunami Warning and Mitigation System (IOTWS), Implementation Plan for Regional Tsunami Watch Providers, IOC Information Series No.81

³⁹ <http://www.wmo.int/pages/prog/www/OSY/GOS-purpose.html>

Global Seismographic Network (GSN)

The Global Seismographic Network (GSN) is a 150+ station, globally distributed, state-of-the-art digital seismic network providing free, realtime, open access data.

GSN instrumentation is capable of measuring and recording with high fidelity all seismic vibrations from high-frequency, strong ground motions near an earthquake to the slowest global Earth oscillations excited by great earthquakes. The primary focus in creating the GSN has been seismology, but the infrastructure is inherently multi-use and can be extended to other disciplines. Several GSN stations currently incorporate microbarographs, GPS, Geomag, and Meteorological packages.

Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO)

The Comprehensive Nuclear-Test-Ban Treaty Organization has now entered into formal tsunami warning agreements and arrangements with several of its Member States (e.g. Japan, Australia, the Philippines, the United States, Indonesia and Thailand).

The CTBTO is currently contributing data from almost 40 of its monitoring stations to regional and national tsunami warning centres in the countries mentioned above as well as Malaysia. The data can enhance the ability of the centres to identify potentially tsunami-generating earthquakes and provide vulnerable communities with faster warnings so that they can move out of the affected areas.

Core Seismic Stations of IOTWS

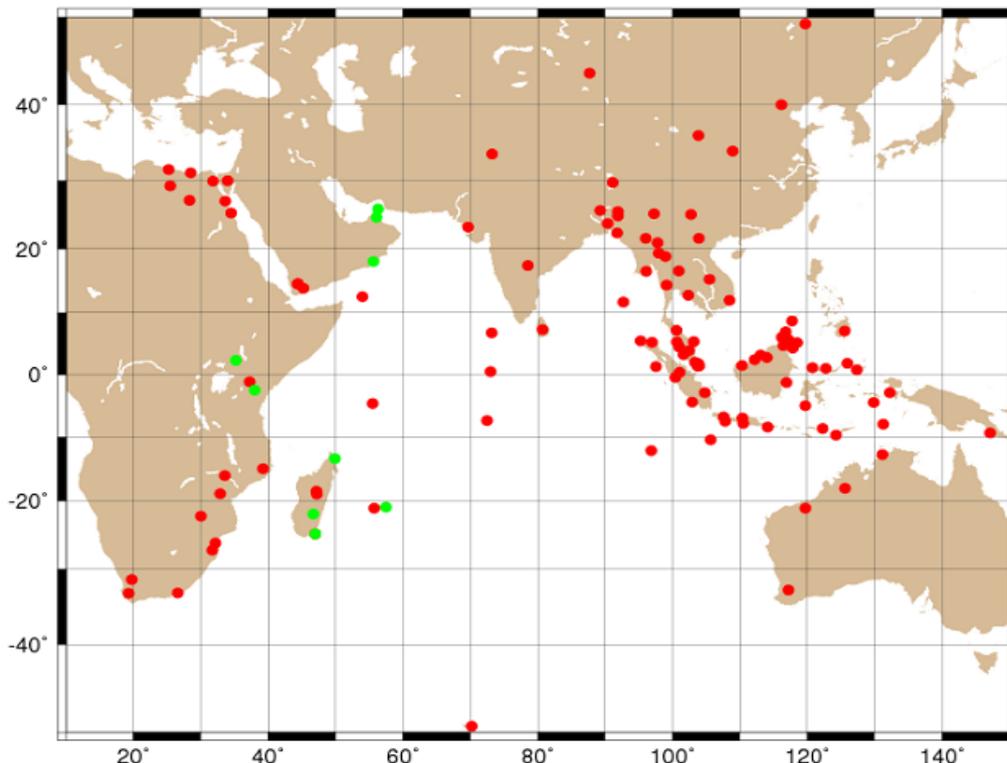


Figure 8: Core Seismic Stations for the Indian Ocean Tsunami Warning and Mitigation System (IOTWS)⁴⁰

⁴⁰ Map of seismic stations is provided by IOC UNESCO.

Seismic stations provide essential and appropriate seismic data relevant to monitoring and detecting earthquakes that can trigger tsunamis. Two categories of seismic stations exist, some form part of the core regional network coordinated by IOC UNESCO, whereas others are additional stations for improved coverage primarily at the national level. In addition to the core network of the Indian Ocean, national seismic networks are necessary to address specific national requirements and constraints in the regional network which is integrated into the global network.⁴¹

Most national seismic networks allow free access to their data and those currently not sharing have been asked to reconsider. Although it is considered to be critical that seismic waveform data is shared in real-time, not all seismic stations are currently available in real-time.

Global Sea Level Observing System (GLOSS)

Sea level data is used to observe the potential occurrence of many coastal hazards such as storm surges, cyclones/typhoons, landslides, coastal erosion, and tsunamis.

The Global Sea Level Observing System (GLOSS) is an international programme conducted under the auspices of the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) of the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC).

The main component of GLOSS is the 'Global Core Network' (GCN) of 290 sea level stations around the world for long-term climate change and oceanographic sea level monitoring. There is a relatively small number of sea level stations to cover the Indian Ocean and South China Sea region. This is due to funding priorities and/or technical difficulties in upgrading and sustaining some of the stations. A major challenge is to maintain and broaden the user base for these observing networks. The ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness has supported the installation of four sea level stations in Philippines and Viet Nam.



Figure 9: Core Sea Level Network of the Indian Ocean Tsunami Warning and Mitigation System (IOTWS)⁴²

⁴¹ IOC UNESCO (2006) Third Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System, Bali, Indonesia.

⁴² Map of sea level stations is provided by IOC UNESCO

The use of global and atmospheric observations from certain instruments can be applied to a number of hazards. For instance, earthquake information is one of the primary sources of information for tsunami warning, and information from sea level sensors can be used to monitor tsunamis, storm surges, tides, as well as sea level rise caused by climate change. The process of addressing gaps in these instrumentation networks is therefore best addressed in partnership with the different user communities. RIMES has indicated it will facilitate resource mobilization, acquisition, and installation of observing and monitoring stations to address existing gaps. Furthermore it plans to develop a data sharing mechanism for the region.

5.4 Forecasting and Warning Systems

The lead time and accuracy related to forecasting of hazards such as tropical cyclones, tornadoes, and floods (including flash floods) has more than doubled over the last ten years. However, these capacities remain under-developed or nonexistent in many developing and least developed countries.

In terms of forecasting and warning systems, several models have been developed to forecast the incidence of hazards and to build scenarios regarding the future global climate. While advances in technology are progressing quickly, the access, costs and technology often associated with these advanced systems result in poorer countries being unable to implement or use the systems and data. Even modest increases in spending and greater sharing of data between countries, can have enormous benefits. Several countries, including some least developed countries have found quick gains from such spending.⁴³

In many countries, National Meteorological and Hydrological Services (NMHS) are among the few authoritative agencies operating on a 24/7 basis and have been mandated to issue warnings for both hydro meteorological and in some cases for geological hazards. However, only few countries have in place an effective system that would ensure appropriate utilization of the warning to assist emergency response and preparedness at the community level.⁴⁴

RIMES assists in building the capacity of NMHS with regard to any of the following:

- Capacity in the generation and application of weather forecast products;
- Technology development and transfer, capacity building in, and application of medium-range forecast products;
- Technology development and transfer, capacity building in, and application of extended-range forecast products;
- Downscaling, capacity building in, and application of seasonal forecast products;
- Analysis of observable trends, capacity building in, and application of climate change information products, using analysis techniques with low and moderate resource requirements.

⁴³ The World Bank and the United Nations (2010): Natural Hazards, UnNatural Disasters. The Economics of Effective Prevention.

⁴⁴ WMO (2009) Thematic Progress Review Sub-component on Early Warning Systems. 2009 Global Assessment Report on Disaster Risk Reduction.

5.5 Priorities and Recommendations:

1. Promote long-term financial and in-kind support to ensure sustainability of seismic and sea level instrumentation networks and their maintenance.
2. Promote the use of the network of sea level and seismic stations for multi-hazard purposes to maximize the likelihood of ongoing maintenance and the continued functioning of the network.
3. Conduct a network-wide effectiveness review to analyze geographic coverage.
4. Promote national support for real-time, timely, free and open access to data, analysis, and other information products for warning purposes.



CHAPTER 6

Communication and Dissemination of Warnings

6.1 Introduction

The purpose of dissemination and communications systems is to ensure that people and communities are warned in advance of impending tsunami and earthquake events. Warnings must reach those at risk and contain clear messages with simple useful information that will enable the appropriate responses to save lives and livelihoods. Regional, national and community level communication systems must be pre-identified with formal confirmation regarding authorities who will issue the messages. The use of multiple communication channels is important to ensure that as many people as possible are warned, to avoid failure of any one channel and to reinforce the warning message. The systems should facilitate national and regional coordination and information exchange.⁴⁵

The post-exercise evaluation undertaken by the IOC Secretariat following the 2009 Indian Ocean Wave (IOWave) exercise⁴⁶ indicated some positive changes in regard to dissemination and communications but there continues to be a clear need to focus on strengthening systems at the downstream level.

6.2 Organizational and Decision Making Processes

A major challenge from an institutional perspective is to clearly define the roles and responsibilities of various government (including the crucial role of local provincial government) entities involved in disseminating a warning message. In most countries, a technical or meteorological agency is responsible for detecting tsunamis, cyclones/typhoons and other related hazards, whereas an emergency response or disaster management agency (often associated with the Ministry of Home Affairs) is responsible for disseminating the message to affected populations/areas and coordinating the emergency response, together with the Police, Army, medical services, etc. Effective coordination between technical/meteorological and disaster response entities is perhaps the greatest challenge in many countries.

Significant progress has been made at both the regional and national levels in recent years to better enable clear structures and appoint and confirm roles and responsibilities. Clear systems and structures defining roles and responsibilities, combined with appropriate resourcing of staff and training are required to complete and enable the institutions to implement early warning systems and disseminate warnings and ensure responses to those warnings are implemented.

Standard operating procedures (SOPs) play a central role in ensuring communication works between all stakeholders and that warning messages are received, understood and that disaster mitigation activities are implemented. Several initiatives have addressed this need for greater clarification of roles including some projects supported by the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness on developing SOPs. The training materials developed during the course of one

⁴⁵ ISDR (2006) Third International Conference on Early Warning, Developing Early Warning Systems: A Checklist.

⁴⁶ IOC UNESCO (2010) Post-Exercise Evaluation Compilation of IOWave 09: Detailed Evaluation Forms Findings, Seventh Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS-VII).

of these projects implemented by IOC UNESCO will be consolidated in an SOP manual. This manual should be available at the end of 2010.

The 2009 Indian Ocean Wave (IOWave) provided an opportunity for Indian Ocean countries to test their operational lines of communications, review their tsunami warning and emergency response standard operating procedures, and to promote emergency preparedness. Results were encouraging but the development of Standard Operating Procedures (SOPs) that link the regional, national, provincial and community levels needs to be strengthened.

Regular exercises are important for maintaining staff readiness for the real events. This is especially true for tsunamis, which are infrequent but require rapid response when they occur. Continual testing of systems (and end-to-end early warning drills) provides essential feedback and greater efficiency in the working of the system as a result of lessons that are learnt from the drills.

6.3 Effective Communication Systems and Equipment

The World Meteorological Organization (WMO) Global Telecommunications System (GTS) is the backbone system for global exchange of data and information in support of multi-hazard, multipurpose early warning systems, including all meteorological and related data; weather, water and climate analyses and forecasts; tsunami related information and warnings, and seismic parametric data. It is a dedicated network of surface-based and satellite-based telecommunication links and centres operated by countries 24 hours a day, seven days a week all year round. It interconnects all National Meteorological and Hydrological Services (NMHS) for round-clock reliable and near-real-time collection and distribution of all meteorological and related data, forecasts and alerts.

Based on data and information received via GTS early warning messages are disseminated by the national decision-makers to communities at risk via numerous means of public notifications and instructions including public radio broadcasts, TV announcements, public announcement systems, cell broadcast, SMS (cell), public call centre, website, telephone, sirens, and door to door announcements.⁴⁷ Other alerting methods include the use of fax, loudspeakers, churches, mosques, and traditional signals like hitting bamboo or drums.

Electronic communications systems are subject to power outages and failure or overloading, so independent alternatives such as manual sirens and loudspeakers are important. A single method of communication will not reach all the people at risk, so a combination of alerting methods and channels is recommended. All communication channels to which different segments of the population have access should be identified especially those that people monitor routinely and those that can reach people rapidly during emergencies.

Warnings should reach the people that will be affected by the disaster, as soon as possible, in order to start the anticipated response and reduce the impact of the oncoming disaster. Some events such as (near-source) tsunamis can reach a community within 10 minutes of the earthquake, others like distant-source tsunamis, storm surges or wind-forced waves, could take hours to reach shore. Based on risk assessments appropriate infrastructure and communication systems must be in place to deal with the risks the community faces.

⁴⁷ IOC UNESCO (2010) Post-Exercise Evaluation Compilation of IOWave 09: Detailed Evaluation Forms Findings, Seventh Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS-VII).

During the Indian Ocean Wave exercise (IOWave) in 2009 the elapsed time until the public would be notified and instructed was assessed.⁴⁸

Activity	Elapsed Time
Making a decision on public warning (from time of receipt of warning)	Participants advised elapsed times ranging from 2 minutes to 60 minutes
Formulation/compilation of public notification (from time of decision)	Participants advised elapsed times ranging from 1 minute to 60 minutes
Activation of public notification systems (from time of notification formulated)	Participants advised elapsed times ranging from 1 minute to 60 minutes

Countries near to a tsunami source or having a strong early warning capability reported the elapsed time as less than 15 minutes. While countries categorized as having a far-field tsunami threat reported a longer elapsed time (30 minutes to 2 hours).

While much progress has been made at global, regional and national levels, reaching the communities and people at risk remains a challenge, particularly in Asia because of its huge population, strong disparities in wealth, culture and living conditions, and the remoteness of many communities.

6.4 Disseminating Warning Messages

“No matter how good the technology or how accurate the forecast and warnings, if the information doesn’t reach people in danger in a timely and understandable manner, the warning system itself will fail.” (UN ISDR Director, Salvano Bricero).

Creating effective warning messages and disseminating can be an extremely challenging task. The appropriate actions to take in response to tsunami and other coastal hazards can be diverse. In response to a flood or tsunami, one may need to evacuate while in response to a typhoon or hurricane one might need to shelter in place.

Warning messages should get people’s attention, motivate them to take action and provide sufficient guidance in order to get them out of harm’s way in time. Warning messages should not evoke curiosity or panicky behavior and rumor control action should be taken. The warning sources should be credible, authoritative and reliable. A clear and phased formulation of warning messages should help to create public trust that warnings are well founded.

A particular problem is the need for interpretation of technical information to the public, otherwise a warning may cause unnecessary panic or the severity of an impending hazard might not be understood. A warning should be followed by subsequent information and an all clear signal given when the threat of disaster has passed. Only in a few countries systems are in place to verify that warnings have reached and are understood by the intended recipients.

Media and especially broadcasters play a crucial role in disseminating warning information to the public. A project currently underway by the Asia-Pacific Broadcasting Union (ABU) Early Warning Media Initiative focuses on the development of audio/visual programming to create understandable warnings for those at risk, while addressing critical issues, such as whether people understand the warnings and if they contain relevant and useful information. With support

⁴⁸ IOC UNESCO (2010) Post-Exercise Evaluation Compilation of IOWave 09: Detailed Evaluation Forms Findings, Seventh Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS-VII).

from the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness this project is being implemented in six pilot countries (Cambodia, China, Malaysia, Philippines, Thailand, and Viet Nam) and results should be available at the end of 2011.

6.5 Priorities and recommendations:

1. Strengthen end-to-end dissemination and response to warnings through the development of Standard Operating Procedures (SOPs) that cover a range of hazards and link the regional, national, provincial and community levels.
2. Continue programmes to strengthen channels of communication for warning messages from the national to local levels. Including policy support to strengthening of communications networkd, where feasible.
3. Improve the effectiveness of warning messages, e.g. through regular user feedback, by involving other stakeholders such as the media in their development.



CHAPTER 7

Preparedness and Response Capability

7.1 Introduction

Response capability is an exceptionally broad area and numerous actors are involved. To give full credit to the complexities of the response systems is beyond the scope of this study. Further, effective response is predicated upon the planning and strategic involvement of many stakeholders and experts, in areas including but not limited to climate change, natural resource management, gender, child protection, poverty reduction, infrastructure planning, military, police, and emergency and health services.

It is essential that communities understand their risks; respect the warning service and know how to react. Education and preparedness programmes play a key role. It is also essential that disaster management plans are in place, well practiced and tested. The community should be well informed on the options for safe behaviour, available escape routes, and how best to avoid damage and loss to property.⁴⁹

The costs associated with building response capability are huge and the political will to put in place such capability is another important factor in the Asia and Pacific region where the population most exposed to the threat of disasters are the poorest and the most vulnerable.

This therefore creates many challenges in the implementation of an end- to-end EWS and especially when one focuses on the last mile. National funding prioritization, land ownership issues and other governance and capacity issues provide major challenges for an effective response capability for those living in the “last mile”.

The response capability of a nation or community is undoubtedly dependent on the quality of planning and capacity building that has taken place before the event, including all measures discussed in previous chapters, such as putting enabling policies and plans in place, strengthening the credibility of regional and national institutions, developing hazard maps and models, monitoring of seismicity and sea level, analyzing and building scientific and community capacity, and communicating information on hazards to the public. Response activities should also feed back into the longer term strategy through sharing of lessons.

7.2 Reaction to Warnings

Research on public response to warnings shows that even in areas where public alerting systems are in place, people might look for additional information from other sources before they take action.⁵⁰ As discussed in chapter 6 national and local television and radio stations can play a major role in disseminating warning messages to the public and provide a interpretation of the technical information.

A recent study on the reactions to the 30 September 2009 earthquake in Padang showed that half of the people interviewed in the survey (200 individuals) evacuated low-lying coastal areas in relatively short time as a reaction to the strong earthquake (15 min after the tremor, 83% of them had left). However, in the absence of other

⁴⁹ ISDR (2006) Third International Conference on Early Warning, Developing Early Warning Systems: A Checklist.

⁵⁰ H, Spahn et al. (2010) *Experiences from three years of local capacity development for tsunami early warning in Indonesia; challenges, lessons and the way ahead*. Natural Hazards and Earth System Sciences.

(official) information, many of those who did not evacuate rushed to the beach to see whether the seawater was retreating.⁵¹

Evacuation after the earthquake in Padang on 30 September 2010 and in response to warnings for Typhoon Ketsana in September 2009 in Viet Nam showed that many people did not immediately evacuate due to several reasons, including protecting their physical and economic assets, and meeting with their family before leaving the hazard area.⁵²

Public awareness campaigns and education should strengthen the understanding of how the early warning system works, what the correct response is to the warnings, but also make clear the limitations of the system with regard to the accuracy of initial warnings.

Public trust in and credibility of the warning system needs to be maintained by further improving accuracy of warning services and forecasts to ensure a proper reaction to warnings in the future.

During the seventh Session of the ICG/IOTWS, 14-16 April 2010, Banda Aceh, Indonesia, Working Group 6 announced it would compile good practices in tsunami warning dissemination. The report "Preparing the Last Mile of the Indian Ocean Warning System" should be available by the end of 2010.

7.3 Disaster Preparedness and Response Plans

National progress reports on the implementation of the Hyogo Framework for Action (2007-2009)⁵³ indicate that emergency plans exist in all countries but the extent to which they are implemented systematically at all levels varies widely.⁵⁴ Countries in the Indian Ocean and Southeast Asian region report constraints due to insufficient financial and human resources, lack of ownership and challenges to integrate disaster risk reduction measures into sustainable development.

Most countries recognize the need to prepare community based disaster preparedness and response plans with well defined linkages and coordination mechanisms with district, province and state levels put in place at each of the levels. This is a gigantic task and a comprehensive programme is not available in most cases. There are numerous actors involved in this area of work and intensive and innovative work is carried out in many countries in selected areas to address remaining gaps.

7.4 Community Response Capacity

Although intensive work has been carried out by a range of stakeholders to support development of community response capacity the results of the 2006 assessment of the gaps and challenges in community response capacity by UN ISDR are still most relevant in 2010:⁵⁵

- Lack of multi-agency collaboration and clarity of roles and responsibilities at national to local levels;
- Lack of public awareness and education for early warning response;

⁵¹ GTZ-GITEWS project publication (2010) *30 minutes in Padang – lessons for tsunami early warning and preparedness from the earthquake on 30 September 2009*.

⁵² JICA (2009) *Viet Nam: Assessment Report on response to Typhoon Ketsana in the Central Region*.

⁵³ <http://www.preventionweb.net/english/hyogo/progress/priority5/?pid:227&pil:1>

⁵⁴ ISDR (2009) *Global Assessment Report on Disaster Risk Reduction*.

⁵⁵ UN/ISDR. 2006. *Global Survey of Early Warning Systems*. An assessment of capacities, gaps and opportunities towards building a comprehensive global early warning system for all natural hazards. United Nations International Strategy for Disaster Reduction.

- Lack of simulation exercises and evacuation drills;
- Limited understanding of vulnerabilities and of the public's concerns;
- Need for a participatory approach and inclusion of traditional knowledge;
- Need for long-term risk-reduction strategies.

The local response actors require further capacity development region-wide to strengthen their ability to meet large and smaller disaster response needs. From a human resources point of view, the needs for management skills are critical in order to effectively utilize the technology and equipment required for efficient response. There are also shortages in human resources especially at the community level to manage the response requirements.

7.5 Public Awareness and Education

Another factor related to the efficacy of early warning systems is deeply rooted in communities' knowledge of their own vulnerability and their capacity to protect themselves and their livelihoods.

Countrywide public awareness strategies are important to stimulate a culture of disaster resilience, with outreach to urban and rural communities. Citizens need to be up to date with current knowledge so they can prepare themselves to react. Statistics do not exist on levels of risk awareness region wide, or on the efficacy of awareness campaigns undertaken, but this information would be extremely useful.

The goal behind any risk-awareness process is to promote among people, their leaders and decision makers an acceptance of the value concerning the management of hazards in order to reduce the risks of future catastrophic losses.

To develop an appropriate campaign strategy to raise risk awareness, ISDR recommended a country needs to:⁵⁶

- secure continued resources for implementing awareness campaigns;
- determine which communication channels will appeal to the widest range of stakeholders, to ensure the campaigns reach women and other high-risk groups;
- seek to engage and inform different age groups so as to build sustained understanding across generations;
- establish relationships for the involvement of media professionals and other commercial and marketing interests;
- engage respected local officials, religious and community leaders, and women's and other special interest groups, in order to disseminate information and encourage participation.

Supported by the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness the UNESCO Office Jakarta, Indonesia is implementing a depository of tsunami hazard information, tools and materials (i.e., assessment tools, public awareness tools, training material, best practice information and other relevant information) in order to optimize the use of these materials for wider public awareness and education. The depository collection will be made available through the website of the Jakarta Tsunami Information Centre (JTIC).

⁵⁶ UN/ISDR. 2006. *Global Survey of Early Warning Systems*. An assessment of capacities, gaps and opportunities towards building a comprehensive global early warning system for all natural hazards. United Nations International Strategy for Disaster Reduction.

7.6 Simulations and Drills

Simulations and drills constitute exercises to test and improve the degree of preparedness of an institution or a community to react efficiently and in a timely manner to an event, to test the soundness of Standard Operating Procedures (SOPs), to improve inter-institutional coordination mechanisms, and to promote awareness regarding how to respond in case of an event of a certain nature.⁵⁷

The 2009 Global Assessment Report on Disaster Risk Reduction indicated an absence of methodical and regular drills and simulations in most countries reporting on progress on implementation of the Hyogo Framework for Action. In most countries affected by the 2004 tsunami drills have been conducted especially in tsunami-affected areas but most require fine-tuning and expansion to include multi hazard components. Drills tend to be rather ad hoc and the high risk areas in most countries are not covered proportionately with hazard-specific drills and evacuation information. While warning response drills are increasing, coordination and resources for coverage are not adequate - some provinces and districts are not able to conduct drills due to budget constraints.

Ideally, simulations, drills and evacuation information need to be supported by regulations, which stipulate frequency, standards for success and procedures covering each area and hazard. Feedback, evaluation or measurement of the effectiveness of drills is still limited. Key influential actors such as education institutions, teachers, village and religious leaders, and local government institutions, as well as NGOs, the private sector and community based organizations and networks should be involved.

The region wide tsunami "IOWave09" exercise, which took place on 14 October 2009, was an excellent example of a simulation that tested systems, processes and procedures from the regional level to the national level and in a number of countries down to the community level. More details on this regional exercise are seen in the text box below. A similar exercise (IOWave10) is planned for late 2010 but would not include evacuations of communities.

Indian Ocean Wave Exercise 2009

On 14 October 2009 the first life-sized tsunami simulation exercise was carried out successfully. The exercise aimed to test and evaluate the effectiveness of the Indian Ocean Tsunami Warning and Mitigation System (IOTWS), and to increase preparedness in the region. More than 20 Member States from the ICG/IOTWS participated in Exercise IOWave09 and were able to test the response capacity of their National Tsunami Warning Centre (NTWC) to bulletins issues by the Pacific Tsunami Warning Centre (PTWC) in Hawaii and the Japan Meteorological Agency (JMA) in Tokyo.

Several countries, including Indonesia and Sri Lanka, conducted end-to-end test on their warning systems, including evacuation drills at selected coastal communities. Regional Tsunami Watch Providers (RTWPs) in Australia, India and Indonesia exchanged bulletins during the exercise and shared these with their NTWC counterparts. This marked an important milestone for the IOTWS as the RTWPs are scheduled to take over regional advisory responsibilities from PTWC and JMA by early 2011.

⁵⁷ IOC UNESCO (2009) Hazard Awareness and Risk Mitigation in Integrated Coastal Management (ICAM). Intergovernmental Oceanographic Commission. IOC Manual and Guides No. 50, ICAM Dossier No. 5.

7.7 Priorities and Recommendations

1. Continue to support the massive task of supporting response capacity at the local level.
2. Support regulations that stipulate frequency for simulations and drills, standards for evaluation and procedures covering each area and hazard, and involving key actors.



ANNEX 1

Bibliography

1. ADPC (2008) Elements of Disaster Risk Communication, Lolita S. Bildan, presentation.
2. ADPC (2008) Proceedings of Tsunami Alert Rapid Notification System (TARNS), Local Level Early Warning and Dissemination Procedures, First Workshop.
3. ADRC (2005). *Natural disasters databook*. (http://web.adrc.or.jp/publications/databook/databook_2004_eng)
4. A.E. Muthunayagam, Ph.D. (Editor) (2006). Environmental Impact of Tsunami in the Kerala Coast, Kerala State Council for Science, Technology and Environment, Sasthra Bhavan, Pattom
5. AGS (2007) Commentary on practice note guidelines for landslide risk management Australian Geomechanics Society. *Australian Geomechanics*
6. Arya A.S., Prof. (2006). Design Criteria for Cyclone shelter, National Seismic Advisor, MHA
7. ASEAN (2004) ASEAN Regional Programme on Disaster Management, 2004-2010.
8. ASEAN (2006) ASEAN Agreement on Disaster Management and Emergency Response.
9. ASEAN (2006) Joint UNHCR/ACDM Workshop on the ASEAN-Hyogo Framework for Action - Regional Capacity Building in Disaster Response and Preparedness, Nakhon Pathom, Thailand.
10. Charitha Pattiaratchi (2008) Indian Ocean Tsunami Warning System: Example from the 12th September 2007 Tsunami, The University of Western Australia
11. CSIRO (2002) *Climate Change and Australia's Coastal Communities*. CSIRO Division of Marine and Atmospheric Research, www.cmar.csiro.au.
12. Disaster Management Centre (Sri Lanka) (2007). Historical Disaster Information Systems in Sri Lanka - Preliminary Analysis (June)
13. Dominey-Howe, Dale (2006) Historic records of teletsunami in the Indian Ocean and insights from numerical modeling, *Natural Hazards*
14. ESCAP (2007) Report on Regional Unmet Needs and Recommendations: Tsunami Early Warning Systems (TEWS) in the Indian Ocean and Southeast Asia, August 2007.
15. ESCAP (2008): Discussion Paper: Mobilizing Resources for Disaster Risk Reduction - 3rd Asian Ministerial Conference on Disaster Risk Reduction.
16. ESCAP (2009) Report on Regional Unmet Needs and Recommendations: Tsunami Early Warning Systems (TEWS) in the Indian Ocean and Southeast Asia, 2009.
17. ESCAP (2009) ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness (Strategic Plan) - ESCAP TF Website and associate documents
18. ESCAP and ISDR (2010): Protecting Development Gains. Reducing Vulnerability and Building Resilience in Asia and the Pacific. The Asia Pacific Disaster Report, 2010.
19. GEO (2006) Ensembles of Global Weather Forecasts
20. Geoscience Australia, Professional Opinion 2009/11. A Probabilistic Tsunami Hazard Assessment of the Indian Ocean Nations.
21. IFRC (2006) International Disaster Response Law, Legal Issues in the International Response to the Tsunami in Sri Lanka; An International Disaster Response Laws, Rules and Principles (IDRL) Program Case Study.
22. IO Consortium (2008) Strengthening National Capacities for Tsunami Early Warning and Response Systems in the Indian Ocean, Progress Report as of 25 March 2008. National information for Comoros, Madagascar, Maldives, Mauritius, Mozambique, Pakistan, Seychelles, Sri Lanka, Tanzania, and Thailand.
23. IOC UNESCO (2005) First Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System, Perth, Australia.
24. IOC UNESCO (2005) Second Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System, Hyderabad, India.
25. IOC UNESCO (2005) Assessment of Capacity Building Requirements for an Effective and Durable Tsunami Warning and Mitigation System in the Indian Ocean. Consolidated Report for Countries Affected by the 26 December 2004 Tsunami. IOC/INF-1219.

26. IOC UNESCO (2006) Third Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System, Bali, Indonesia.
27. IOC UNESCO (2006) Indian Ocean Tsunami Warning and Mitigation System (IOTWS) Implementation Plan, IOC Technical Series 71.
28. IOC UNESCO (2006) Twenty-first Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System, Executive Summary.
29. IOC UNESCO (2006) Communications Plan for the Interim Tsunami Advisory Information Service for the Indian Ocean Region U. S. NOAA Richard H. Hagemeyer
30. IOC UNESCO (2007) Fourth Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System, Mombassa, Kenya.
31. IOC UNESCO (2007) IOC UNESCO Workshop on Indian Ocean Tsunami Hazard Assessment, Bandung, Indonesia, 17-18 July 2007, Final Report.
32. IOC UNESCO (2007) UNESCO-IOC Workshop on Tsunami Risk Assessment for the Indian Ocean, Dubai, UAE
33. IOC UNESCO (2008) 12 September 2007 Indian Ocean Tsunami Event – Post Assessment of IOTWS Performance, Intergovernmental Oceanographic Commission Technical Series 77.
34. IOC UNESCO (2008) Decision-making tools in support of ICAM – the case of marine-related hazards, GEOSS Support for Decision-Making in the Coastal Zone: First Regional Workshop, Athens
35. IOC UNESCO (2008) Fifth Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System, Kuala Lumpur, Malaysia.
36. IOC UNESCO (2008) Indian Ocean Tsunami Warning and Mitigation System (IOTWS); Implementation Plan for Regional Tsunami Watch Providers, IOC Information Series No.81.
37. IOC UNESCO (2009) Tsunami Risk Assessment and Mitigation For The Indian Ocean, Knowing your tsunami risk – and what to do about it
38. IOC UNESCO (2009) Hazard Awareness and Risk Mitigation in Integrated Coastal Management (ICAM). Intergovernmental Oceanographic Commission. IOC Manual and Guides No. 50, ICAM Dossier No. 5.
39. IPCC (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK
40. IPCC(2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
41. ISDR (2006) Early Warning – From concept to action The Conclusions of the Third International Conference on Early Warning 27–29 March 2006, Bonn, Germany
42. ISDR (2006) Global early warning systems for natural hazards: systematic and people-centred, Reid Basher, UN-ISDR Platform for the Promotion of Early Warning (PPEW), Goerresstrasse 30, 53113 Bonn, Germany
43. ISDR (2006) Global Survey of Early Warning Systems.
44. ISDR (2006) Third International Conference on Early Warning, Developing Early Warning Systems: A Checklist.
45. ISDR (2006) Third International Conference on Early Warning, Developing Early Warning Systems, proceedings.
46. ISDR (2008) Guidance on Measuring the Reduction of Disaster Risks and the Implementation of the Hyogo Framework for Action, (Indicators).
47. ISDR (2009) Global Assessment Report on Disaster Risk Reduction. United Nations, Geneva, Switzerland.
48. ISDR (2007) Words Into Action: A guide for Implementing the Hyogo Framework
49. J. Ashmore et al., 'Diversity and Adaptation of Shelters in Transitional Settlements for IDPs in Afghanistan', *Disasters*, vol. 27, no. 4, 2003
50. JMA (2008) Annual Report on Activities of the RSMC Tokyo - Typhoon Center

51. JMA (2008) Outline of the High Resolution Global Model at the Japan Meteorological Agency. Masayuki Nakagawa, Numerical Prediction Division
52. Kruawun Jankaew (2008), Medieval forewarning of the 2004 Indian Ocean tsunami in Thailand, *Nature Magazine* 455, 1228 – 1231, 30Oct 2008.
53. Kumar, C. Raj and D. K. Srivastava (2006) *Tsunami and Disaster Management: Law and Governance*, Thompson and Sweet and Maxwell Asia publishers.
54. Lassa, Jonatan (2008) *Governance for the Sustainability of Hazard Early Warning System. An Interdisciplinary Approach*, GeoForschungZentrum Potsdam.
55. Lassa, Jonatan (2008) *When Heaven (hardly) Meets the Earth: Towards Convergence in Tsunami Early Warning Systems*, Proceedings of Indonesian Students' Scientific Meeting, Delft, The Netherlands.
56. Left, Elizabeth (2006) *Recognizing and Incorporating All Resources – Integrating Private Sector Contributions into Aid Coordination Mechanisms: The Tsunami Case*.
57. Leslie, L. M., Karoly, D. J., Leplastrier, M. and Buckley, B. W. (2007). Variability of tropical cyclones over the southwest Pacific Ocean using a high-resolution climate model. *Meteorology and Atmospheric Physics*.
58. Masami Onoda (2008). *Satellite observation of greenhouse gases: Monitoring the climate change regime*. Graduate School of Global Environmental Studies, Kyoto University, Yoshida-Honmachi, Sakyo-ku, 606-8501 Kyoto, Japan
59. McBride, J., Emanuel, K. A., Knutson, T., Holland, G., Willoughby, H., Chan, J., Lam, C-Y., Heming J. and Kepert, J. (2006). Statement on tropical cyclones and climate change. *Sixth World Meteorology Organization International Workshop on Tropical Cyclones (IWTC-VI)*, 21-30 November 2006, San Jose, Costa Rica.
60. Middelmann, M. H. (Editor) (2007) *Natural Hazards in Australia. Identifying Risk Analysis Requirements*. Geoscience Australia, Canberra.
61. Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well- Being: Current State and Trends: Findings of the Condition and Trends Working Group*. Washington DC. Island Press.
62. Ministry of Home Affairs (MHA) (2006). *Guidelines for Design and Construction of Cyclone/ Tsunami Shelters*, GoI-UNDP Disaster Risk Management Programme, Government of India
63. Monecke, Katrin (2008) A 1,000-year sediment record of tsunami recurrence in northern Sumatra, *Nature Magazine* 455, 1232 – 1234.
64. MWBP (2005) *Vulnerability Assessment of Climate Risks in Attapeu Province, Lao PDR*, A Publication of the Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme, A Joint UNEP- IUCN-MRC GEF Funded Programme, January 2005
65. National Aeronautics and Space Administration (2006). *Assessment of the Benefits of Extending the Tropical Rainfall Measuring Mission: A Perspective from the Research and Operations Community: Interim Report*.
66. Nicholson, William (2005) *Legal Issues: Warning Systems*.
67. New Zealand Climate Change Office (2004) *Coastal hazards and climate change: a Guidance Manual for local government in New Zealand*, New Zealand Climate Change Office, Ministry for the Environment, New Zealand.
68. NOAA (2008), *Aware*. Dissemination News: EMWIN Testing Continues on GOES-R NOAA's National Weather Service. Office of Climate, Water and Weather Services, Volume 3, October 2009
69. NOAA(2008) *Report on Coastal Hazard Resiliency Capacity in the Northeast US Region*, the Coastal Resources Center, University of Rhode Island, January 2008
70. Provention Consortium (2006) *Tsunami Recovery Impact Assessment and Monitoring System (TRIAMS) Risk Reduction Indicators*.
71. PTWC (2008) *Interim Advisory Service Report: Pacific Tsunami Warning Center*, Charles McCreery, Director, presentation at Fifth Session of the Intergovernmental Coordination Group.
72. *Phuket Ministerial Declaration on Regional Cooperation on Tsunami Early Warning Arrangements*, Phuket, Thailand, 29 January 2005.
73. Russell Arthurton(2008). *Raising Awareness of marine-related, physical hazards and risks in coastal management: An IOC-ICAM project*. Coastal Geosaience. UK

74. SEI Asia (2008) From Knowledge to Action: Learning to go the last mile, participatory assessment of enabling conditions for implementing of the last mile in early warning systems in Asia, progress update for stakeholders no. 1.
75. Sphere Humanitarian Charter and Minimum Standards in Disaster Response (Geneva: Sphere Project, 2004); T. Corsellis and A. Vitale, Guidelines for the Transitional Settlement of Displaced Populations. Oxford: Oxfam, 2005
76. The World Bank and United Nations (2010): Natural Hazards, UnNatural Disasters.
77. Tsunami Global Lessons Learned Project: 2009: The Tsunami Legacy, Innovation breakthroughs and Change
78. UNDP (2006) Developing a Disaster Risk Profile for Maldives
79. UNDP (2009) Assessing the Relationship between Natural Hazards and Poverty. A Conceptual and Methodological Proposal
80. UNDP (2009) Institutional and Legislative Systems for Early Warning and Disaster Risk Reduction (Sri Lanka)
81. UNDP (2009) Institutional and Legislative Systems for Early Warning and Disaster Risk Reduction (Indonesia)
82. UNDP (2009) Institutional and Legislative Systems for Early Warning and Disaster Risk Reduction (Thailand)
83. UNDP (2009) Risk Knowledge Fundamental – Guidelines and Lessons for Establishing and Institutionalising Disaster Loss Databases
84. UNFCCC (2008): Technical Paper: Integrating practices, tools and systems for climate risk assessment and management and strategies for disaster risk reduction into national policies and programmes.
85. UN OCHA Regional Office for Asia and the Pacific Bangkok (2009a -b) Risk Assessment and Mitigation Measures for Natural- and Conflict-Related Hazards in Asia-Pacific, January and April 2009
86. WCRP (2005).The World Climate Research Programme Strategic Framework 2005-2015, Coordinated Observation and Prediction of the Earth System (COPES)
87. WMO (2005) World Weather Watch: Twenty-second Status Report on Implementation, Secretariat of the World Meteorological Organization, Geneva, Switzerland
88. WMO (2006) Capacity Assessment of National Meteorological and Hydrological Services in Support of Disaster Risk Reduction, Analysis of the 2006 WMO Disaster Risk Reduction Country-level Survey
89. WMO(2009) Meteorological Component, Typhoon Committee Operational Manual 2009 Edition, Tropical Cyclone Programme
90. WMO (2009) Progress Report on the Implementation of the GCOS in support of the UNFCCC 2004-2008.
91. WMO (2009) Weather Forecasting: WMO's GLOBAL DATA- Processing and Forecasting System : Meteorological services to support humanitarian contingency planning and response, Geneva, 17 April 2009
92. WMO (2009) WMO World Weather Watch Operational Information related to the Exchange of Data from the RBSN/RBCN Stations on the GTS, Atmospheric Observation Panel for Climate Fifteenth Session (GCOS/WCRP), Geneva, Switzerland, 27-30 April 2009.
93. WMO (2010) Implementation plan for the Global Observation system for Climate in Support of the UNFCCC (2010 update), GCOS secretariat.

