

Evaluation and Strengthening of Early Warning Systems in Countries Affected by the 26 December 2004 Tsunami

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ABSTRACT

The objective of this international initiative was to provide an integrated framework for strengthening early warning systems in the Indian Ocean region by building on existing systems and facilitating coordination among specialized and technical institutions. The project supported the development of tsunami early warning systems in collaboration with numerous United Nations and other organizations devoted to disaster risk management and risk reduction. For the practitioner of early warning systems, the project has been divided into two areas - warning system development and preparedness. As a cross-cutting theme, the project promoted multi-hazard end-to-end systems in a regional context by emphasizing (i) risk knowledge, (ii) monitoring and warning service, (iii) communications and dissemination of understandable warnings and (iv) response capability and preparedness. The activities of the project were structured into five components - system implementation, integrated risk management, public awareness and education, community-level approaches and project coordination. Practitioners should note that the work represents a first step for establishing a complete tsunami early warning system within a multi-hazard framework.

Keywords

Tsunami early warning system, disaster risk reduction, preparedness

INTRODUCTION

An earthquake measuring 9.0 on the Richter scale struck the western coast of Sumatra, Indonesia on 26 December 2004, triggering massive ocean waves or “tsunamis”. The resulting unprecedented disaster impacted the lives of millions of people in the Indian Ocean region. The tsunami left more than 270,000 people dead and caused billions of dollars of damage. While many people are believed to have died in the earthquake itself in Indonesia near the epicenter, the main cause of death was trauma and drowning from the flux of seawater and waves pouring into coastal areas without warning. It is widely acknowledged that the death toll would have been drastically reduced if effective early warning systems had been in place in the Indian Ocean region.

On 6 January 2005, the leaders of the Association of South-East Asian Nations (ASEAN) met in Jakarta, Indonesia to discuss the aftermath of the earthquake and tsunami. In the meeting, former UN Secretary General Kofi Annan launched a US\$977 million Flash Appeal for emergency aid, the largest appeal ever made by the United Nations following a natural disaster. The meeting adopted the “Declaration on Action to Strengthen Emergency Relief, Rehabilitation, Reconstruction and Prevention on the Aftermath of Earthquake and Tsunami Disaster of 26 December 2004.”¹ The declaration specifically addressed the need for establishing a regional early warning system as part of efforts to establish regional mechanisms on disaster prevention and mitigation. As well as building and managing the regional early warning system and disaster management, it addressed the need for developing and promoting national and regional human and institutional capacity, transfer of know-how, technology and scientific knowledge through international cooperation and partnership.

In line with the need expressed in the declaration, the United Nations Flash Appeal had proposed, among other humanitarian assistance initiatives, a proposal on early warning to be facilitated and coordinated by the United Nations International Strategy for Disaster Reduction (UN/ISDR) with the objectives of rapidly boosting the

capacities for action and planning for early warning by public authorities. The international project entitled “Evaluation and Strengthening of Early Warning Systems in Countries Affected by the 26 December 2004 Tsunami” aimed to provide authoritative information on early warning needed by the humanitarian community and to establish a sound basis for coordination and implementation of tsunami warning systems in the region. For the early warning systems practitioner the project is an example that provides an overall integrated framework for establishing early warning systems in the Indian Ocean by building on the existing systems, facilitating coordination among various specialized technical institutions and providing overall organizational assistance. It outlined a partnership approach to supporting the integrated development of tsunami early warning systems, recognizing the numerous UN and other organizations that would contribute to improving disaster risk management and risk reduction, including early warning systems of the affected countries.

The importance of early warning systems has been underlined in various resolutions of the General Assembly as a critical element of disaster reduction. When the UN/ISDR was established in 2000² as the successor to the International Decade for Natural Disaster Reduction (IDNDR, 1990-1999),³ promotion of early warning was clearly underlined and included in its mandate. Historically, the significance of early warning for disaster reduction has been repeatedly emphasized in major international agendas including the Agenda 21,⁴ Yokohama Strategy,⁵ the Barbados Plan of Action for Small Island Developing States⁶ and the Mauritius Strategy,⁷ the Johannesburg Plan of Implementation,⁸ the G8 summit in Gleneagles⁹ as well as major multilateral environmental agreements (MEAs) including the UN Framework Convention on Climate Change (UNFCCC) and the UN Convention to Combat Desertification (UNCCD). The Hyogo Framework of Action adopted at the World Conference on Disaster Reduction (WCDR)¹⁰ in Kobe, Japan shortly after the tsunami of December 2004, highlighted early warning as one of the major elements of disaster risk reduction which could both save lives and help protect livelihoods and national development gains. Early warning has been recognized as an effective tool to reduce vulnerabilities and to improve preparedness and response to natural hazards. As a thematic platform of the ISDR system, Platform for Promotion of Early Warning (PPEW) was established in 2004 to specifically undertake global advocacy and coordination on early warning.

OBJECTIVES OF THE INTERNATIONAL PROJECT

The objectives of the project were to link the available technical capacities on tsunami early warning systems with humanitarian and emergency management capacities in order to quickly implement the first steps of establishing an effective tsunami warning system in the region. For the early warning practitioner the project aimed at facilitating an interim warning system based on existing national and international capacities, achieving technical and political consensus on the design of an appropriate system, developing networks among practitioners and authorities concerned with all hazards, providing necessary coordination for the affected countries and developing educational support and demonstration projects. Although the original UN Flash Appeal was confined to a sub-set of affected countries, a series of consultation meetings led to a general agreement by implementing agencies and donors that all countries affected by the 24 December 2004 tsunami and other countries at risk to tsunami should be involved in this project for the establishment of tsunami early warning system in the Indian Ocean Region.

At the national level, the project not only targeted national governments but also their disaster management agencies, local authorities, scientific and technical institutions, the broadcasting sector as well as other practitioners from the civil society and communities at selective locations. The initiative was originally designed by the PPEW in order to support the technical coordination role of the UNESCO/IOC for the establishment of the TEWS. One of the most significant aspects of the project was the establishment of partnerships and coordination mechanisms across a wide range of partners and donors. It provided an example of an integrated vehicle for supporting the implementation of the Hyogo Framework for Action (2005). This partnership approach has brought an added value to the diversity of activities and a more coherent and coordinated solution to the region’s urgent need for establishing an early warning system, thus maximizing the effectiveness of inputs and resources. Sixteen institutions led the activities with their specific expertise in the project jointly with more than 50 collaborating institutions. The PPEW provided the overall coordination of the initiative, with emphasis on the strategic overview, planning, monitoring and evaluation, facilitating partnerships, meeting donor requirements and disseminating information. The approach was multi-disciplinary in nature, designed to integrate the tsunami early warning system development into the countries’ other natural hazard warning systems and disaster risk management and reduction activities.

KEY COMPONENTS

The process of establishing and strengthening the tsunami early warning system began at the WCDR in 2005 with the reconfirmation by the Indian Ocean countries that a system should be established in the region. In order to reach basic agreement on the technical design and roles of relevant institutions for capacity building as well as for implementation, several high level consultations were held at the global and regional level during the first three months of the project. The regional coordination and efforts for mobilizing resources for a complete Indian Ocean early warning system have continued since then. At the same time, national level assessment, capacity building as well as awareness-raising and various community based activities on enhancing preparedness and disseminating good practices have taken place at the local and community levels.

The project components were identified in two areas, namely warning system development and preparedness. As the duration was relatively short, consideration was given to how the assistance could be most effective, while promoting an integrated approach to the tsunami warning and mitigation system, including linkages to other hazard warning systems. Efforts were made to ensure that the concept of an “end-to-end” tsunami early warning system would be adopted by national tsunami early warning centers and that the warnings issued at the national level are followed by an efficient anticipated response in terms of evacuation to safe areas prior to the arrival of a tsunami. End-to-end early warning systems emphasize (i) risk knowledge, that is, prior knowledge of the risks faced by communities, (ii) monitoring and warning service, (iii) communications and dissemination of understandable warnings to those at risk and (iv) response capability and preparedness to act by those threatened aspects.

The activities of the Early Warning Strengthening Project were structured into the following five key components: core system implementation; integrated risk management; public awareness and education; community level approaches; and project coordination.

Core system implementation

As a first step, regional consensus was required on the nature of the TEWS and the design of its core technical elements. These elements included the observing system, setting up an interim TEWS for immediate use, strengthening the institutional base for the operation of the TEWS including supporting the designation of national tsunami focal points and establishing regional coordination mechanisms, which would lead to the establishment of a fully-operational TEWS for the Indian Ocean countries in the longer term.

A number of events and intergovernmental processes contributed to reaching a regional consensus and agreement during the first three months of the project. The WCDR which occurred within one month after the December 2004 tsunami with participation by national governments, UN agencies, regional and other specialized institutions, non-governmental organizations and media, created political momentum and attracted attention to early warning. The special session of the WCDR resulted in a “Common Statement”¹¹ by the participants including the countries affected by the tsunami tragedy and recognized the importance of enhancing national capacity and sharing experiences on natural hazards, disaster relief and post-disaster rehabilitation. Participants recommended that necessary regional disaster response mechanisms be established and strengthened as soon as possible for all relevant natural hazards, which should include early warning systems, collaborative regional centers, and the use of science and technology.

By December 2006, a total of 25 of the 28 Indian Ocean countries had established national tsunami focal points to be able to receive interim tsunami advisory information and alert the existing national warning centers such as national meteorological and hydrological services. A series of national coordination meetings both in Asia and Africa contributed to strengthening institutional set-up for receiving and disseminating the warnings at the national level. Based on the initial agreement among the tsunami affected Indian Ocean countries and the partners, an interim IOTWS was established, relying exclusively on seismic data from earthquake monitoring stations. The interim system became operational in April 2005 with the Japan Meteorological Agency and the Pacific Tsunami Warning Center in Hawaii providing interim tsunami advisory information to the designated national tsunami focal points. The UNESCO/IOC led the enhancement of the existing Global Sea Level Observing System (GLOSS) network. The sea-level stations deployed in countries of the Indian Ocean represent core elements of the GLOSS network and constitute a fundamental basis for the monitoring and detection of tsunamis in the Indian Ocean. Training courses on sea level observation and data analysis for the Indian Ocean countries were organized by UNESCO/IOC in Japan (May 2006) and in Belgium (November 2006).

The WMO assisted in upgrading the Global Telecommunication System (GTS) to enable faster communication via telecommunication satellite. Operational satellite agencies have provided communication channels for the new instruments and have been engaged in supporting the process. After fact-finding missions to eight countries, three countries (Bangladesh, Myanmar and Pakistan) were identified and their GTS was upgraded under the Early Warning Strengthening Project.

After the establishment of the interim TEWS in the Indian Ocean, national assessment missions¹² were carried out by international interdisciplinary teams in response to the requests received from the countries in the region. In the period from May to September 2005 experts from UNESCO/IOC, WMO, Asian Disaster Reduction Center (ADRC), United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), United States Geological Service (USGS) and the UN/ISDR secretariat identified existing and necessary capacity for the establishment and operation of a national tsunami warning and mitigation system within a multi-hazard framework.

Integrated risk management

In order to lay a foundation for medium-term capacity building at the national level, the practitioner should include a component for integrating the tsunami early warning system into national disaster risk management and reduction mechanisms, seeking synergies with other hazard early warning systems and strengthening national capacities for tsunami-related disaster risk management and risk reduction. This component of the international project was composed of activities having the goal of achieving longer term objectives which went beyond the project duration. This included supporting national efforts in assessing current national and local risk management capacities, setting up institutional and legislative frameworks, increasing multi-sector capacities, development of national and regional multi-hazard early warning systems, strengthening capacity for warning dissemination and preparedness and achieving vertical integration between national authorities and local communities. These activities are expected to be pursued by establishing and strengthening national platforms for integrated risk management and risk reduction.

It was found that most countries did not have appropriate national frameworks, mechanisms and capacities for disaster risk management relevant to tsunamis to ensure the integration of tsunami early warning system. Subsequently the UN/ISDR developed a publication “Developing Early Warning Systems: A Checklist”¹³ to build capacity at the local level and support implementation of effective people-centred early warning systems. The original English version of the checklist was translated into the 19 major languages of the Indian Ocean region.

Another important aspect of integrating tsunami early warning into national disaster risk management and reduction mechanisms was the promotion of TEWS within a multi-hazard framework. The UNESCO/IOC reviewed and stressed the possible linkage between tsunami early warning systems and early warning systems for ocean related hazards such as tropical cyclones and other coastal hazards during the 18 national assessment missions and regional consultations through the ICG/IOTWS.

At the local and community level, the United Nations University - Institute for Environment and Human Security (UNU-EHS) tested a method for rapid multi-sector vulnerability and risk assessment to promote the integrated approach. A mapping of critical infrastructure was carried out focusing on buildings associated with different sectors such as health sector. Theoretical risk was compared with the observed damages in the city of Galle, Sri Lanka to identify the strengths and weaknesses of the proposed model. The results from testing this model showed that more precise information regarding tsunami-related hazard and vulnerability would be needed prior to the multi-sector risk assessment. It was found that the integrated approach for risk management would require substantive national commitment and international support.

Public awareness and education

While the high-level political dialogue continued at the global and regional levels, public awareness-raising activities and other locally-focused education and training activities were carried out for the most affected communities. Various information products on tsunami, early warning and risk reduction were developed in English and later tailored to local languages and cultures targeting key intermediaries such as public officials, teachers, and community leaders. Mass media materials were developed and media campaigns were launched. A considerable number of awareness-raising and educational materials were published in various local languages by the projects partners including UNESCO/IOC, United Nations Development Programme (UNDP) and ADRC. The UN/ISDR secretariat delivered 35 Disaster Reduction Field Libraries¹⁴ to the countries most affected by the tsunami through the Asian Disaster Preparedness Center (ADPC), National Disaster Warning Center of Thailand (NDWC),

Sustainable Environment and Ecological Development Society (SEEDS), UNESCAP and UNDP Country Offices. In coordination with partner agencies and collaborating organizations, the lessons learned from the tsunami of 26 December 2004 were compiled by drawing on the experiences of numerous organizations and individuals. The Asia-Pacific Broadcasting Union (ABU), a professional association of 102 radio and television broadcasters in the Asia-Pacific region, organized two workshops jointly with the UN/ISDR secretariat and UNESCAP in Bangkok in June 2005, bringing broadcasters together with technical experts from the tsunami and weather warning fields to improve dialogue and understanding in respect to warning dissemination and public education.

Community-level approaches

For the early warning system practitioner “community-level approaches” should be aimed at implementing selected community-level pilot activities to test and demonstrate good practices, including hazard and vulnerability assessment, organizational strengthening, community participation, warning system operation, capacity building, evacuation planning, and the design and construction of shelters and other works. Better understanding of the impacts of the tsunami of 26 December 2004 on the vulnerable communities is crucial in order to strengthen resilience of these communities for such future natural hazards. Various sample data collected in selected locations on the impacts of the tsunami and local vulnerability were analyzed by UNU-EHS, Centre for Research on the Epidemiology of Disasters (CRED) and ADRC, in collaboration with national and local authorities and local experts. The UNU-EHS, together with the universities and local authorities in Sri Lanka, conducted vulnerability assessments in two locations, the city of Galle and Batticaloa, Sri Lanka in 2005. The UNU-EHS in the above-mentioned vulnerability assessment in Sri Lanka, tested four different methodologies for rapid vulnerability assessment using satellite images, critical infrastructure, individual household surveys and the data generated by the Census Bureau of Sri Lanka. The results showed that satellite imagery and census data from the government served only as limited tools to assess vulnerability and that the analyses of the critical infrastructure and the household surveys gave a more precise picture regarding vulnerabilities and coping capacities. In addition, a drill was conducted in a public school in the city of Galle with the support from the Geological Survey, the Disaster Management Centre of Sri Lanka, and its local Galle District Disaster Management Committee to promote awareness in the education sector regarding how to be better-prepared to react to tsunami warnings.

The UNDP in India and Sri Lanka implemented selected community-based activities within their post-disaster support in order to institutionalize early warning systems within the work of disaster management authorities and to strengthen dissemination mechanisms of warnings to communities. The UNU-EHS also provided technical assistance to Sri Lankan authorities on policy design, work planning, and establishing linkages with the activities of other UN agencies on early warning and disaster preparedness. The UNESCO Jakarta supported community-based activities in Indonesia to enhance resilience and preparedness for natural and human disasters, with a special emphasis on earthquakes and tsunamis. During the period from June 2006 to August 2006, four national workshops were organized by ADPC in Maldives, Myanmar, Sri Lanka and Thailand with the goal of improving community response to warnings. The UNEP assisted environmental authorities in Indonesia, Sri Lanka and Maldives to identify environmental factors contributing to risk in coastal areas vulnerable to tsunamis, to manage environmental features in coastal communities vulnerable to tsunamis and to link local risk information, preparedness plans and risk reduction activities to national and regional warning systems.

Project coordination

Within the context of this international early warning project, coordination referred to establishing mutual understandings and agreements among partners, sharing information and building networks, supporting capacity building and decision-making mechanisms to ensure the effective implementation of early warning system objectives. Main elements of the project coordination included defining roles and responsibilities for each implementing partner, providing information on project activities, monitoring and evaluating the project activities, advocating “people-centred early warning” in tsunami related policy dialogue, assisting regional coordination processes and meetings, assisting needs assessments and compiling lessons learned.

As this multi-partner initiative involved 16 leading implementing partners and a considerable number of collaborating national and local institutions, clarification of roles and responsibilities of each implementing partner was crucial for avoiding duplication and maximizing synergy between the partners. The multi-partner context and multi-disciplinary approaches was stressed during the project implementation.

CAPACITY BUILDING AND SUSTAINABILITY

Although core technical elements of the tsunami early warning system were defined at a relatively early stage of the project, the establishment of the actual warning systems and ensuring their quality and conducting necessary training required considerable support and resources. Lack of capacities in the most tsunami-affected Indian Ocean countries negatively affected some national and local level activities. Some countries were overwhelmed by the number of tsunami recovery initiatives by different international entities. As a result, the same national and local institutions were overstretched in carrying out many different activities. To cope with this challenge, the implementing agencies provided tools, training and technical expertise to the national governments and local authorities to enhance their capacities. A large number of publications and materials for awareness-raising and education were produced under the Early Warning Strengthening Project for this purpose. The Hyogo Framework for Action 2005-2015 has provided the basis for identifying and addressing these key regional and national priorities.

Political constraints affected regional coordination and implementation due to a degree of competition among countries, national concerns about sovereignty over data and warnings and varied policies of bilateral donors toward different countries. These political constraints created some challenges for project implementation, and some aspects still need to be resolved within the framework of establishing effective national platforms on disaster risk reduction. However, within the limited scope of the Early Warning Strengthening Project activities, the difficulties were largely overcome by the coordinated support to all Indian Ocean countries.

Substantial efforts were required to integrate the tsunami early warning system into national disaster risk management and disaster risk reduction policies and procedures. The UN/ISDR secretariat and the implementing partners will continue to support the Indian Ocean countries through various mechanisms to ensure sustainability of the project. The Early Warning Strengthening Project has created an enabling environment for coordination and partnership-building necessary for the development of “end-to-end” and “people-centred” early warning systems in the Indian Ocean region. However, the project activities are only the first step for establishing a fully operational TEWS within a multi-hazard framework. Strong political commitment by the Indian Ocean countries, combined with substantial financial and technical support from the international community, is crucial in building capacity and achieving a sustainable TEWS. Regional coordination for TEWS will continue mainly through ICG/IOTWS and technical support will continue to be provided through the UNESCO/IOC and WMO. The UN/ISDR-PPEW will also provide follow-up within its activities for the establishment of a global multi-hazard early warning system mandated by the United Nations General Assembly in November 2007.

LESSONS LEARNED

The project faced some administrative challenges arising from the multi-partner and multi-donor nature of the project. The Early Warning Strengthening Project was implemented as a single integrated project, with all financial resources channelled through a single sub-account of the Tsunami Trust Fund managed by the UNOCHA. However, in addition each donor to the project had specific requirements and administrative procedures for written agreements, transfer of funds, reporting, monitoring and evaluation. The Flash Appeal process of the UNOCHA itself was also managed outside the control of the UN/ISDR secretariat. Other challenges included difficulties in monitoring the progress of all of the project activities that were implemented by respective partners and in obtaining substantive and financial progress reports in a timely manner.

Substantial parts of the capacity building and community preparedness were undertaken toward the end of 2005 and in 2006. As a result, some partners including UNDP Sri Lanka, UNESCO Jakarta and UNESCO/IOC could not complete project activities by 31 December 2006. It was a challenge for the project to provide rapid assistance to the countries when requested, and to assist in longer-term enhancements of national and local capacities. This latter task requires considerable time for preparation and consultation with a much wider range of stakeholders including disaster management authorities and development planning agencies.

The project assisted in strengthening coordination, partnerships, linkages and synergies among the implementing agencies and donors. Various project activities have led to new opportunities for further contributing to the development of TEWS in the Indian Ocean region. In addition, the UN/ISDR secretariat and the implementing partners collaborated with a much wider group of UN agencies and national and local institutions with the common goal of establishing an effective TEWS in the region. The project also contributed to maximizing effectiveness of inputs and resources by providing strategic direction for the implementation and monitoring of the project activities

and avoiding overlaps between the implementing agencies. It was the first time that the UN/ISDR secretariat had provided overall coordination to a project under a UN Flash Appeal for humanitarian assistance. For practitioners the integrated approach and coordination proved to be effective at linking immediate short term needs for early warning systems with longer term needs for risk reduction.

Although occurrence of tsunamis and earthquakes has not been frequent in 2006 and 2007, some success stories have already been reported. The interim warning system established under the project has proven to be effective not only for tsunamis but also for other hazards. The UNESCO/IOC and WMO reported that the GTS demonstrated its effectiveness for the July 2006 tsunami in Java. Interim tsunami advisory information issued from the Pacific Tsunami Warning Center (PTWC) and Japan Meteorological Agency (JMA) was received by several national warning centres in the Indian Ocean region, including the one in Jakarta, Indonesia soon after the 2006 earthquake took place. The UNDP Sri Lanka office reported that the enhanced capacity for early warning and dissemination as well as the in-country partnership among relevant institutions saved some vulnerable communities in Sri Lanka on the occasion of a landslide in January 2007. The UNESCO Jakarta office reported that the Standard Operational Procedures (SOP) developed under the project in cooperation with KOGAMI, a local NGO, were effectively applied by the disaster control authority in Padang, Indonesia when an earthquake hit West Sumatra in March 2007.

CONCLUSION AND RECOMMENDATIONS

The international, regional and national efforts in response to the tsunami disaster provided a sound basis for strengthening early warning systems in the Indian Ocean region including substantial progress toward the development of capacities and intergovernmental processes. Despite the challenges described above, the Early Warning Strengthening Project succeeded in achieving its original objectives and intended outcomes of defining core technical elements of the TEWS for the Indian Ocean region, quickly setting up an interim warning system, establishing regional coordination mechanisms, starting the process of integrating early warning into national disaster risk reduction and preparedness efforts, raising public awareness, strengthening the role of communities and local authorities and starting the resource mobilization necessary for the establishment of fully operational TEWS within a multi-hazard framework. Substantial support is still needed to establish the TEWS in the Indian Ocean region with a sound technical base and strengthened community response. In order to realize the TEWS with a close linkage to other ocean related hazards, the following actions are recommended:

- 1) The UN/ISDR, UNESCO/IOC, WMO as well as other UN, international and regional institutions working on early warning should continue their assistance to the Indian Ocean countries in enhancing capacities and mobilizing resources necessary for establishment of the TEWS.
- 2) To generate an enabling environment for TEWS in the Indian Ocean region, the UN/ISDR and members of the ISDR system should continue to assist the countries in Asia and Africa to establish and/or strengthen national platforms for disaster risk reduction to effectively implement the Hyogo Framework for Action. Low capacity, high risk countries require more international support.
- 3) The regional coordination mechanism for the tsunami warning systems through the UNESCO/IOC should be strengthened through activities of working groups on mitigation, preparedness and response in order to ensure integration of tsunami early warning systems into national and regional mitigation, preparedness and response capability building efforts within a multi-hazard framework.
- 4) Understanding of vulnerability and risk should be deepened through strengthening the multi-sector approach. Methodologies and tools for enhancing community-preparedness need to be adapted to specific local conditions and context despite its complexity. Methodology and tools for enhancing community preparedness need to be adapted to local-specific conditions and context as the local capacity and socio-economic conditions differ from community to community.
- 5) Before the 26 December 2004 Tsunami, many of the countries in the Indian Ocean region did not have a well-organized disaster management system except for tropical cyclone-prone countries such as India and Bangladesh. National Disaster Management Offices in most countries were very weak, and there were few established national platforms for disaster risk reduction in the region. The roles of the National Disaster Management Offices should be enhanced for better coordination within a country.
- 6) Constructing measures such as sea walls and shelters should be considered to protect lives, properties, and significant infrastructures from tsunami. Currently, very few countries have implemented the structural measures mainly due to lack of information on risks. Countries need to have access to such information.

- 7) Accurate tsunami risk assessments based on paleo-tsunami research in the Indian Ocean region are needed. Sufficient scientific information is not available on the historical occurrence of natural hazards in the region, except for Indonesia where some records are available for the past two hundred years. Research outcomes should facilitate the policy-making process in each country. In addition, historical and geographical research should be promoted to analyze what happened in the region in the past.

ACKNOWLEDGMENTS

The authors gratefully acknowledges the financial contributions by the Governments of Finland, Germany, Japan, Netherlands, Norway, Sweden, and the European Commission Humanitarian Aid Office (ECHO) for the project. The ISDR secretariat extends special thanks to the United Nations Office for Coordination of Humanitarian Affairs (UNOCHA), the UN Flash Appeal coordinator, and 16 implementing partners. The ISDR secretariat extends gratitude to a total of more than 50 international, regional, national and local collaborating institutions and the governments of 28 member countries of the UNESCO/IOC for the Indian Ocean region. This report was compiled by the UN/ISDR Platform for the Promotion of Early Warning based on the final reports of the above-mentioned 16 direct implementing partners.

REFERENCES

- ¹ Special ASEAN Leaders meeting on aftermath of Earthquake and Tsunami (Jakarta, Indonesia) (January 2005). Declaration on Action to Strengthen Emergency Relief, rehabilitation, Reconstruction and Prevention on the Aftermath of Earthquake and Tsunami Disaster of 26 December 2004. (ASEAN Leaders Meeting) January 2005, (unisdr.org), <http://www.unisdr.org/ppew/tsunami/pdf/jakarta-6-january-declaration-on-action.pdf>
- ² General Assembly Resolution A/RES/54/219 describes the International Decade for Natural Disaster Reduction: successor arrangements (3 February 2000), (unisdr.org), http://www.unisdr.org/eng/about_isdr/basic_docs/GA-resolution/a-res-54-219-eng.pdf
- ³ General Assembly Resolution A/RES/44/236 proclaimed the 1990's as the International Decade for Natural Disaster Reduction (22 December 1989). (un.org), <http://www.un.org/documents/ga/res/44/a44r236.htm>
- ⁴ Agenda 21, the Rio Declaration on Environment and Development, and the Statement of Principles for the Sustainable Management of Forests were adopted by more than 178 Governments at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, (June 1992.), See (un.org), <http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm>
- ⁵ "Yokohama Strategy and Plan of Action for a Safer World." World Conference on Natural Disaster Reduction Yokohama, Japan, (May 1994), (unisdr.org), http://www.unisdr.org/eng/about_isdr/bd-yokohama-strat-eng.htm
- ⁶ A/CONF.167/9 Global Conference on the Sustainable Development of Small Island Developing States, "Barbados Plan of Action for Small Island Developing States" (1994), Bridgetown, Barbados (1994), (un.org), <http://www.un.org/documents/ga/conf167/aconf167-9.htm>
- ⁷ A/CONF.207/11 Report of the International Meeting to Review the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States (Port Louis, Mauritius) (January 2005), (un.org), <http://www.un.org/smallislands2005/documents/documents.html>
- ⁸ "Plan of Implementation" from the World Summit on Sustainable Development (WSSD), Johannesburg, South Africa (2002), (un.org), http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf
- ⁹ For information on the Gleneagles "G8 Response to the Indian Ocean Disaster, and Future Action on Disaster Risk Reduction" (2005) see (g8.gov.uk), http://www.g8.gov.uk/Files/KFile/PostG8_Gleneagles_Tsunami.pdf
- ¹⁰ Through its resolution A/RES/58/214, the United Nations General Assembly convened a World Conference on Disaster Reduction in Kobe, Japan (January 2005), (unisdr.org), <http://www.unisdr.org/wcdr/>
- ¹¹ The full text of the statement is available on (unisdr.org), <http://www.unisdr.org/wcdr/intergover/official-doc/L-docs/special-session-indian-ocean.pdf>
- ¹² As of 31 December 2006, the assessment was conducted for 18 countries namely Bangladesh, Comoros, Indonesia, Islamic Republic of Iran, Kenya, Madagascar, Malaysia, Mauritius, Mozambique, Myanmar, Oman, Pakistan, Seychelles, Somalia, Sri Lanka, Tanzania, Thailand and Yemen. The national reports and a consolidated report are available at (ioc3.unesco.org), <http://ioc3.unesco.org/indotsunami/nationalassessments.htm>

¹³ Third International Conference on Early Warning, March 2006, Bonn, Germany, <http://www.unisdr-earlywarning.org>

¹⁴ The ISDR Field Library, a blue metal trunk on wheels, is packed with books and journals.