Chapter 10
Walking the Last Mile: Contributions to the Development of an End-to-End Tsunami Early Warning System in Indonesia

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Abstract Establishing the Tsunami Early Warning System in Indonesia (InaTEWS) has been a process of learning and innovation. Three different initiatives, implemented by the German-Indonesian Cooperation for a Tsunami Early Warning System (GITEWS), the Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesian—LIPI) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), contributed to the learning and innovation process with a strong focus on tsunami preparedness at the community level during the implementation phase of InaTEWS. The lessons learned as well as the tested and validated procedures resulting from this innovative process have been documented and are currently being extended to make them available nationwide. Experiences from the pilot phase show that there is still a great need to strengthen the capacity of national government insti-

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tutions, local governments and civil society in order to provide the services necessary for sustainable tsunami preparedness. Key points for the way ahead are building a better understanding of the system, the warning service and the contents of warnings, strengthening the role of local disaster-management agencies and governments as well as the institutionalization of early warning at all levels and to systematically scaling up the successful experiences from pilot areas.

Abbreviations

BMKG	Badan Meteorologi Klimatologi dan Geofisika (National Agency for Meteorology, Climatology and Geophysics)
BNPB	Badan Nasional Penanggulangan Bencana (National Disaster Management Agency)
BPBD	Badan Penanggulangan Bencana Daerah (Local Disaster Management Agency)
CBDRM	Community-based disaster-risk management
CD	Compact Disc
CIDA	Canadian International Development Agency
COMPRESS	Community Preparedness
CSO	Civil society organisation
DMO	Disaster management organization
DRR	Disaster risk reduction
GFZ	German Research Centre for Geosciences
GITEWS	German-Indonesian Cooperation for a Tsunami Early Warning System
GIZ/GTZ	German International Cooperation (since 2011) / German Technical Cooperation (prior to 2011)
GPS	Global Positioning System
ICG IOTEWS	Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning System
IFRC	International Federation of Red Cross and Red Crescent Societies
InaTEWS	Indonesian Tsunami Early Warning System
INGO	International non-governmental organisation
IOC	Intergovernmental Oceanographic Commission
ITIC	International Tsunami Information Centre
JTIC	Jakarta Tsunami Information Centre
Kemdiknas	Kementerian Pendidikan Nasional (Ministry of Education)
KOGAMI	Komunitas Siaga Tsunami (a local NGO in Padang)
LIPI	Lembaga Ilmu Pengetahuan Indonesia (Indonesian Institute of Sciences)
NGO	Non-governmental organisation
NTB	West Nusa Tenggara province
NTWC	National Tsunami Warning Centre
PROTECTS	Project for Training, Education and Consulting for a Tsunami Early Warning System
SOP	Standard operating procedure
TDMRC	Tsunami Disaster Management and Research Centre
TEW	Tsunami Early Warning
TIC	Tsunami Information Centre
UN	United Nations
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific

UNESCO United Nations Educational, Scientific and Cultural Organization
UNISDR United Nations International Strategy for Disaster Reduction

10.1 Introduction

Tsunami early warning is more than just science and technology—it is about people. People who are involved in designing, operating and maintaining the warning system; people who are in charge of providing services related to the system and, last but not least, people who live in at-risk areas, who require quick, clear and reliable information from the system to support them in taking the right decisions during an emergency.

Implementing an effective "end-to-end" tsunami early warning system is a complex task and requires both the contribution and coordination of a wide range of individuals and institutions in different fields, such as science and engineering, governance and public service delivery and disaster risk management, as well as from the private sector and civil society. A sustainable system must be integrated into institutional frameworks and policies at international, national and local levels.

Establishing the Tsunami Early Warning System in Indonesia (InaTEWS) has been a process of learning and innovation. Concepts and mechanisms have been tailored in order to respond to the specific characteristics and requirements of the Indonesian archipelago and to allow communities at risk to benefit from the warning services so that casualties may be reduced during future tsunami events. The lessons learned as well as the tested and validated procedures resulting from this innovative process have been documented and are currently being extended to make them available nationwide.

This paper—based on practical experience—intends to contribute to the discussion about important aspects that should be considered when developing effective national end-to-end tsunami early warning systems. It addresses issues of the so-called "last mile", focusing on the downstream process and follows a people-centred perspective, which looks at the needs of communities at risk. It starts with a discussion of general concepts and the overall framework for the development of a people-centred tsunami early warning system. In the following section, it analyses the specific conditions in Indonesia for designing and operating InaTEWS as an effective end-to-end system. The authors then describe the contributions and lessons learned from the three different initiatives mentioned above, which have supported the learning and innovation process since 2006, as well as the ongoing expansion process to make the experiences available across the country.

10.2 Putting InaTEWS into Perspective: Framework and Related Concepts

The devastating tsunami that hit Indonesia and other Indian Ocean countries in 2004 led to the development of tsunami early warning for the Indian Ocean region. The Intergovernmental Oceanographic Commission (IOC) under the auspices of UNESCO coordinates this initiative. Each country is responsible for establishing its own national warning system. Selected countries are designated as Regional Tsunami Service Providers for the Indian Ocean region. Indonesia started its development of a national tsunami early warning system in 2005 and the system was officially inaugurated in late-2008.

The need to develop and strengthen early warning became a central theme during the World Conference on Disaster Reduction that took place in Kobe only a month after the devastating tsunami on 26 December 2004. The main output of the conference, the Hyogo Framework for Action 2005–2015, put developing and strengthening early warning systems that were people-centred as one of the priorities for action (UNISDR 2009). "People-centred early warning suggests that rather than being vulnerable, people can be capable, resilient and able to protect themselves" (IFRC 2009). The main objective of a people-centred early warning system like InaTEWS is "to enable individuals, communities and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss" (UNISDR 2006a). Only if it actively engages institutions as well as the people at risk and is tailored to their needs, will a warning system be able to save lives. Warnings need to be understood by those at risk, taking into account the social and cultural characteristics of the target audience, and need to include guidance on how to act upon them (United Nations 2005).

Developing and running such a system demands the contribution and coordination of a wide range of individuals, institutions and many specialties—science and engineering, governance and public service delivery, disaster risk management, news media and public outreach. Without the involvement of all stakeholders—authorities and government institutions from various sectors and at all levels, communities at risk, NGOs and the private sector—an early warning system will not be effective (Sorensen 2009; UNISDR 2006a).

This means that InaTEWS has to operate end-to-end to trigger the expected reaction along Indonesian shorelines. The monitoring and detection technology of InaTEWS is a combination of earthquake, sea-level and land monitoring. The incoming data feeds into a decision-support system that enables the National Tsunami Warning Centre (NTWC, hosted by the Meteorology, Climatology and Geophysics Agency—BMKG) to disseminate a sequence of warning messages to selected interface institutions, local governments and national media stations. Local authorities need to make sure they can receive the warnings, as they are in charge of disseminating warnings and guidance to their communities. Preparedness and sufficient response capacity are the vital preconditions for an appropriate reaction to warnings

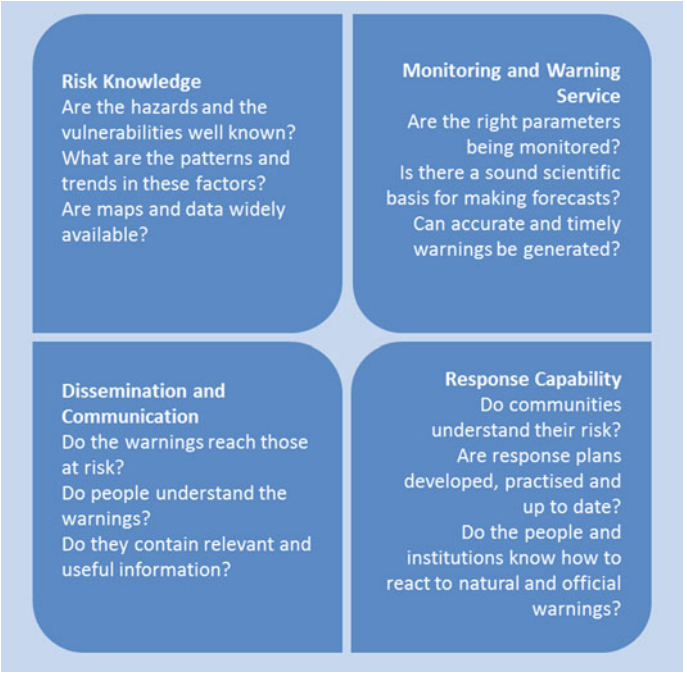

Fig. 10.1 The four elements of a people-centred tsunami early warning system (modified from UNISDR (2006a, b))

and guidance. Shortcomings in any one of these elements can mean the failure of the whole system (Spahn et al. 2010).

The Third International Conference on Early Warning, held in Bonn in 2006, produced a tool for practitioners entitled "Developing Early Warning Systems: A Checklist" (UNISDR 2006a), which assists governments and communities to develop and evaluate their systems in order to ensure that all components work properly. The checklist assesses the sufficiency of the four key components of a warning system: risk knowledge, monitoring and warning services, dissemination and communication and response capability (Fig. 10.1).

The concluding statement at the conference in Bonn highlighted that "effective early warning systems must be an integral part of disaster risk-reduction strategies in national development frameworks", and emphasised the important role of local communities (UNISDR 2006b). Within the overall concept of disaster risk reduction (or management), early warning is part of the preparedness efforts before a disaster (Fig. 10.2). To work effectively, InaTEWS needs to be integrated with disaster-management structures at all levels of government and within the community. This is to ensure its long-term effectiveness.

Community-based disaster risk management (CBDRM) in the context of InaTEWS is related to the people-centred character of early warning. It includes

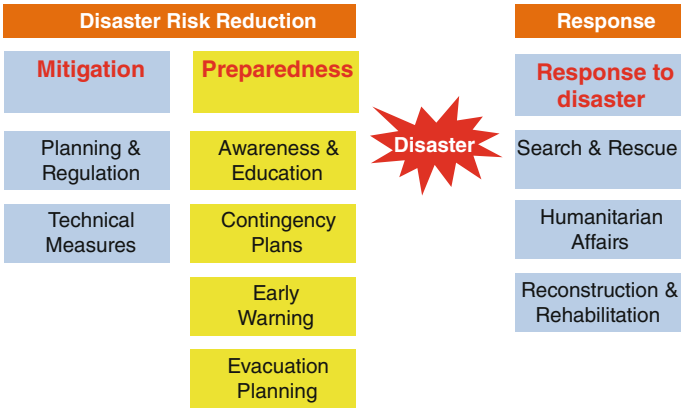

Fig. 10.2 Early warning as part of preparedness and disaster risk reduction

measures in risk analysis and planning, e.g. evacuation planning and the setting up of local warning arrangements as part of a national disaster-risk management system. CBDRM within InaTEWS stresses the special role attached to district or city authorities, particularly in the enforcement of early warning procedures and clear policies that will help people to react consistently in the event of a tsunami threat (Fig. 10.3).

A people-centred early warning system with CBDRM aims to empower local stakeholders by granting them ownership of the system, which should lead to a sustainable reduction in disaster risks. However, people's full potential can only be utilised if government and civil society build partnerships, based not only on local participation and ownership but also on political and economic support from national institutions (UNISDR 2009). These partnerships are particularly important as the development of certain references, such as designing tsunami-hazard maps, cannot be delegated entirely to communities, as it requires expert input. However, communities have to be able to use these references to develop their own preparedness plans. People simply have to be better prepared and trained as the system is considered effective only if warnings can trigger appropriate reactions and people are able to save themselves before the tsunami waves reach the shore (Bollin 2003; Spahn et al. 2010).

10.3 InaTEWS: Context and Challenges

10.3.1 The Challenge of Near-Field Tsunamis

Coastal communities in Indonesia have to cope with the threat of near-field tsunamis. The very short travel time of this kind of tsunami from its source—a nearby epicentre—to the shore generally limits warning and evacuation times to 20–40 min.

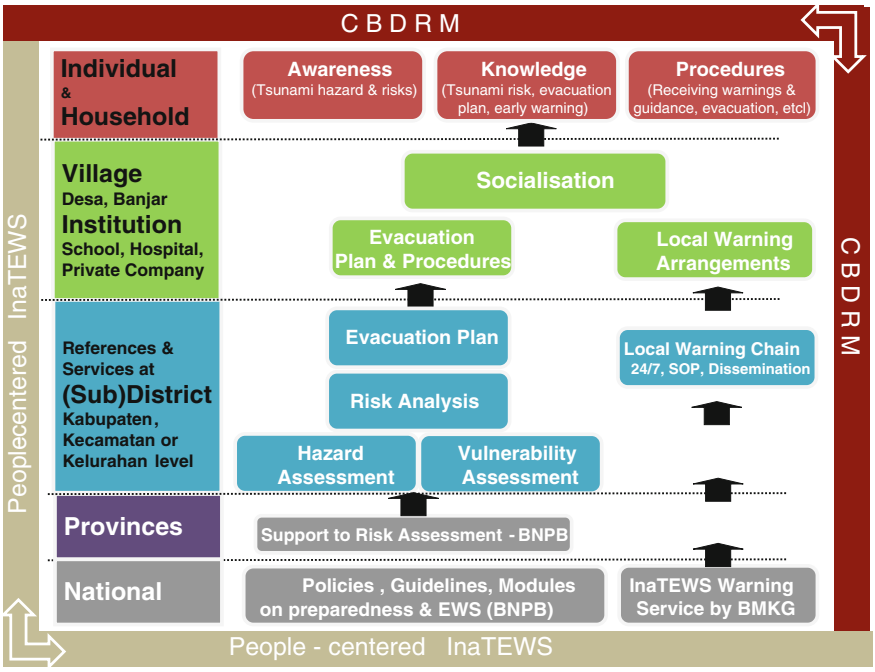

Fig. 10.3 Tasks and responsibilities in tsunami early warning and community-based disaster risk management at various levels

Specific local tectonic, seismic and bathymetric conditions may make warning and evacuation times even shorter in some areas. It was often questioned whether under such circumstances an early warning system could make a difference.

Experiences in Indonesia provide a reference for what a tsunami early warning system can do vis-à-vis near-field tsunamis and what it cannot do (Fig. 10.4). There are certainly scenarios in which the system cannot provide any protection. Following the 2010 Mentawai earthquake, InaTEWS issued a tsunami warning within five minutes, but it didn't reach at-risk communities on time as affected coastal areas, which were located at too short a distance to the tsunami source, were inundated by waves before the warning was received (Yulianto et al. 2011). Similar conditions can be found all across the island chain west of Sumatra and coastlines facing back-arc faults, such as the north coast of Bali, West Nusa Tenggara and East Nusa Tenggara provinces (for example, the Flores tsunami in 1992). People in these areas will have to rely on natural warning signs alone. Self-evacuation after strong ground shaking should be the standard procedure. Nevertheless, these communities can benefit from InaTEWS as the system provides "No Threat" information when a strong earthquake does not have the potential to trigger a tsunami, and "End of Threat" messages once an existing tsunami threat has ended so that people can return to their homes.

Unfortunately, nature does not always provide clear warning signs. Indonesia experienced several “slow earthquakes”, or “tsunami earthquakes”, (Banyuwangi tsunami 1994; Pangandaran tsunami 2006; and Mentawai tsunami 2010), which were strong enough to trigger tsunamis but weren’t felt strongly by those most at risk due to the fact that the seismic energy was released over a longer period of time, resulting in swaying movements rather than the usual strong ground shaking. In all these cases, people were caught by surprise. As the epicentres of the Banyuwangi and Pangandaran tsunamis were located around 200 km off the coast of southern Java, there would have been enough lead time to provide warnings to the communities at risk. In both cases, a functioning early warning system would most probably have saved lives. Although a tsunami warning was generated in the 2006 event, it didn’t reach the communities as the requisite links hadn’t yet been established.

Coastlines around Sumatra, Java and Bali, which are vulnerable to tsunamis caused by megathrust earthquakes, can expect to have lead times of around 20–40 min. Although this is an extremely short time frame, it does allow for the issuing of tsunami warnings and the execution of evacuation processes. Consequently, InaTEWS policy obliges the NTWC to disseminate a first tsunami warning within five minutes after the occurrence of an earthquake with tsunami potential. During these first few minutes, the NTWC relies on seismic and land-based Global Positioning System (GPS) real-time data, as well as on predetermined flooding scenarios for the potentially affected coastal areas, which are processed by a decision-support system. The actual generation of a tsunami is not confirmed when sending out the first warning. Subsequently, data from sea-level monitoring provides updates on the occurrence of tsunami waves (Lauterjung et al. 2010). This means that over time the situation becomes clearer and the NTWC can provide updated warnings.

Decision making in calling for an evacuation and the dissemination of guidance at local levels are important steps during the downstream process and are mandated to local authorities. This remains one of the major challenges as it requires the implementation of local 24/7 services, quick decision-making processes as well as procedures and technologies to disseminate a call for evacuation. This part of the warning chain has been developed and tested successfully in a number of pilot areas but it is far from being implemented nationwide. As the provision of guidance by local authorities is not yet reliable, the role of public media in disseminating warnings from the NTWC, together with the ability of people in affected communities to understand the broadcasted information and to quickly make a decision on how to react, will be decisive factors in making the warning system effective (Thomalla et al. 2009).

Early warning in the context of near-field tsunamis requires dealing with a considerable degree of uncertainty. Due to the limited time for evacuation, officers with the NTWC as well as local authorities need to decide whether to send out a warning and to call for evacuation, even though they cannot be sure that a tsunami was actually generated. It is obvious, therefore, that under such conditions Indonesia will face situations when warnings are issued but in fact no tsunami occurs. Often, people mistakenly tend to interpret this as a “false alarm”. It is necessary, however, to address the issue of “uncertainty” openly in order to maintain public trust in and the credibility of the warning system (Mileti et al. 2004).

The experiences in Indonesia show that it is necessary to combine approaches based on natural warning signs and the early warning system. Understanding and reacting appropriately to natural warning signs should always be the first line of defence, while official tsunami warnings and guidance are important to reinforce or cancel evacuations.

10.3.2 The Institutional Setting

The foundation for the successful development and sustainability of an early warning system relies on well-developed governance and institutional arrangements supported by effective management structures and solid institutional regulations. Whether or not a warning reaches those in an area at risk largely depends on whether all the stakeholders in the warning chain are aware of, and are able to carry out, their roles and responsibilities. Early warning is the responsibility of government and needs adequate planning and funding and political commitment at all levels. However, the complexities of the early warning system require intensive exchange, coordination and collaboration among many sectors and disciplines (UNISDR 2006b).

The devastating disaster caused by the 2004 tsunami was the starting point for a huge effort in tsunami preparedness in Indonesia. Besides the development of InaTEWS, it also triggered the setting up of a new institutional framework for disaster management. Following the issuance of the Disaster Management Law (2007), the National Disaster Management Agency (Badan Nasional Penanggulangan Bencana—BNPB) was founded in 2008.

Despite the fact that most provinces and districts have now established a Local Disaster Management Agency (Badan Penanggulangan Bencana Daerah—BPBD) in their respective areas, local authorities generally still lack an understanding of their role in local preparedness planning and tsunami early warning; particularly in terms of determining how to react and how to disseminate official calls for evacuation to their communities based on warnings from the NTWC. Many of the newly established BPBDs still struggle with a lack of skilled personnel at management and operational levels (Civil Society Organisation 2009; Thomalla et al. 2009).

The Indonesian legal framework regarding tsunami early warning assigns roles to various actors. Law 31/2009 authorises the BMKG to issue tsunami early warnings. Government Regulation 21/2008 and the Decree by the Head of the BNPB, 3/2008, clarify that local governments are responsible for issuing immediate public announcements containing clear guidance and instructions to support the inhabitants and visitors in a threatened area to react quickly and appropriately. The Decree by the Minister of Communications and Information, 20/2006, requires that national and local television and radio stations (commercial and public) immediately interrupt programmes to broadcast tsunami early warnings and advice from the BMKG (GTZ-GITEWS 2010b).

However, developing effective governance is still a major challenge for the Government of Indonesia. While InaTEWS' technology for earthquake monitoring,

ocean observation and forecasting has been declared fully operational since March 2011, the major challenge for the end-to-end early warning system is to define clear institutional arrangements and responsibilities for the long-term development of both institutional and public response capabilities among the end-users of the warning system, namely the local authorities and communities in tsunami-prone regions (Spahn et al. 2010).

10.3.3 Limitations for Preparedness Planning

Although Indonesia had experienced a number of devastating tsunamis in the past, a more comprehensive approach in tackling tsunami hazards was not adopted until the 2004 Indian Ocean tsunami. During InaTEWS' initial development stage, efforts focused more upon the upstream side (monitoring and warning services and warning dissemination) of the system. The development of the downstream side (dissemination and communication as well as response capability), which addresses community preparedness and capacity building, was not as well defined and faced a number of limitations, such as lacking the involvement of the National Disaster Management Agency. Due to the prevailing response and recovery paradigm in disaster management in Indonesia, there had never been a clear and structured programme for capacity building in tsunami preparedness. Only since 2008 has the new disaster management agency, the BNPB, adopted an approach that extends beyond merely coordinating emergency relief efforts to encompassing all phases of pre-disaster prevention and preparedness and post-disaster recovery.

As around 50 % of the 80,000 km of coastline in Indonesia is prone to tsunamis and communities are scattered across vast and often remote areas, it is a real challenge to build preparedness in all of these communities. The BNPB has already identified areas that face higher tsunami risks, which will be prioritized in the National Action Plan (BNBP Regulation 2010).

Tsunami-preparedness planning needs to be based on realistic hazard and risk assessments. In Indonesia, such information is often unavailable, meaning that most of the preparedness activities at a community level are based on assumptions derived from rule of thumb and limited information. Although a minimum standard for tsunami risk assessment has been developed (BNPB Regulation 2012), implementation is still a big challenge due to the limited availability of experts and adequate data to support local processes. Therefore, community evacuation plans are often developed based on rough contour maps without reliable information on tsunami inundations, which in turn results in non-specific, generalised tsunami awareness, preparedness and education materials being used for community trainings.

Preparedness activities at the community level in Indonesia are conducted by various actors. Besides government institutions, many come from the NGO, INGO or civil society sectors. This poses another challenge as each organisation usually follows its own approach, often with limited knowledge and information about tsunami issues, especially regarding early warning arrangements and procedures. This leads

to cases where differing or conflicting information confuses people living in high-risk areas. The assessment following the Mentawai tsunami, for instance, revealed the impact of misleading information about tsunami arrival times on local evacuation behaviour (Yulianto et al. 2011).

10.3.4 Vulnerability in the Context of Tsunami Preparedness

Tsunami preparedness in relation to near-field tsunamis is mainly about survival. As experience shows, the chance of surviving a tsunami are not equally distributed. Many who were killed in the 2004 Indian Ocean tsunami were women and children. In Indonesia, in four villages in the Aceh Besar district only 189 of 676 survivors were female. Male survivors outnumbered female survivors by a ratio of almost 3:1. In other villages, 77–80 % of accounted deaths were female (Oxfam International 2005). During the Japan tsunami in March 2011, the highest death toll was among the elderly.

When designing early warning systems, it is essential to recognise that different groups have different vulnerabilities according to culture, gender or other characteristics that influence their capacity to effectively prepare for, prevent and respond to disasters (UNISDR 2006b). While InaTEWS has made significant progress, approaches to systematically consider the needs of vulnerable groups have not yet been implemented. Although a number of preparedness initiatives address the school sector, the Ministry of Education (Kementerian Pendidikan Nasional—Kemdiknas) hasn't been substantially involved.

Chances of survival are also related to the level of knowledge about tsunamis and how to react. In spite of an increased dissemination of knowledge following a series of recent tsunami disasters in Indonesia and also in Japan by the media and through public education, it is presumed that a large number of coastal residents remain unaware about the nature of this threat and how to mitigate risk. Compared to other hazards, tsunamis are a more complex natural phenomenon that can cause massive destruction. The complexities involved in a tsunami threat may in themselves be factors that discourage many disaster management institutions as well as individual practitioners from becoming proactive motivators to increase knowledge and change attitudes in the community.

10.3.5 Challenges and Strengths Related to Sociocultural Heterogeneity and Religious Perspectives on Disaster Risk Reduction and Tsunami Warning

Indonesia as the fourth most-populated country in the world has followers of at least five major religious faiths. Islam is the majority religion, followed by Christian

Protestantism, Catholicism, Hinduism and Buddhism. The strong belief in God within these faiths has created a set of values that determine how nature is understood and how risks are perceived, which need to be taken into account when developing InaTEWS. Muslims, for example, generally perceive natural disasters as the will of God, which thus generates a certain level of acceptance and resilience regarding a disaster event, even one as catastrophic as the Indian Ocean tsunami in 2004. In some cases, the level of acceptance may also lead to fatalistic beliefs that nothing more can be done once God has commanded a disaster to occur. Hindus practise the Tri Hita Kirana, which emphasises the importance of balancing the relationship between human beings, God and nature. It generates the particular belief, for example, that if human beings destroy nature, disasters will occur.

Faiths and beliefs are also influenced by traditional culture and social settings, and vice versa. A source of strength among some communities, which still persists to this day, is the tradition of *gotong royong*, or voluntary collective action in which all community members assist one another. This idea of self-help was in fact formally adopted as one of Indonesia's guiding ideological principles. The more a community maintains the values of *gotong royong*, the less vulnerable it is to certain disasters because there is a greater interdependency in the community's recovery mechanisms (Hidayati 2011). It is a great challenge to maintain these values in urban or modern communities, which possess more independent and individualistic features.

In traditional cultures, such as on the remote Simeulue Island in Aceh, local knowledge played a decisive role in saving lives in 2004. This particular island became well-known at the time, as 95 % of its population survived the giant tsunami wave, although the community was geographically closest to the epicentre of the earthquake (Yogaswara and Yulianto 2006). Traditional local knowledge, known as *Smong*, recorded experiences from former tsunamis and taught the island's population how to recognise a tsunami threat and to run to higher ground. *Smong* was traditionally passed down through the generations through songs and lullabies. Interestingly, during a recent study, it was found that Simeulue children of primary-school age were no longer familiar with *Smong*. If a large tsunami does not occur until the next generation, this local knowledge may well disappear in the meantime.

10.3.6 Understanding the System

Ultimately, the performance of the end-to-end warning system will be measured by the ability of at-risk communities and local authorities to translate warnings into protective action. This will only work if the end-users of the system, i.e. those people at risk, thoroughly understand the warnings and guidance and know what to do. Raising community awareness, communicating both the benefits of the system and how it can save lives and building trust in the system are still major challenges for InaTEWS.

There is a lack of knowledge not only about the role of the NTWC and the responsibility of local authorities but also about the technical functionality of the

system. Often the "system" is seen as a network of technical devices rather than a system that, in fact, depends greatly on human capacities and skills, systematic local preparedness planning, agreed procedures, decision-making capacity and a common understanding of what to do and how to react (Spahn et al. 2010). To enable local governments to establish the requirements for an end-to-end system and to provide their communities with a clear picture of how it works, official guidelines from the national level on the particularities of tsunami early warning and a dialogue between entities at all levels are needed.

Experience shows that knowledge about tsunami early warning among news media personnel is still limited and their understanding of the system and the risks involved tend to be on a par with the public's understanding rather than that of the NTWC personnel and disaster managers (Spahn et al. 2010). When explaining how the system works, public education activities need to make clear the limitations of the system with regards to the accuracy of initial warnings, given the fact that the first warning is the only information available that can be used to reinforce community response after an earthquake. Overstating what InaTEWS can do or being less than clear about what it cannot do will ultimately decrease people's trust in the system and damage its credibility.

10.4 Developing and Building the System: Learning and Innovation

During the set-up phase of the system, a learning process was required to develop the concepts, tools and processes related to risk knowledge, monitoring and warning services, dissemination and communication of warnings and the response capability and preparedness by authorities and those at risk, in accordance with specific Indonesian conditions. All these processes need to function across multiple levels (Fig. 10.5), involving all the respective stakeholders, and they also need to include clearly-defined governance and institutional arrangements.

This chapter describes the approaches, lessons learned and knowledge management utilised in the three different initiatives implemented by GITEWS, LIPI and UNESCO's Jakarta Tsunami Information Centre (JTIC), which contributed to the learning and innovation process with a strong focus on tsunami preparedness at the community level during the implementation phase of InaTEWS.

10.4.1 The GITEWS Pilot Project

As part of the German-Indonesian Cooperation for a Tsunami Early Warning System (GITEWS), the *Capacity Building in Local Communities* project was implemented from 2006 to 2011 by the German International Cooperation (GIZ) and its Indonesian

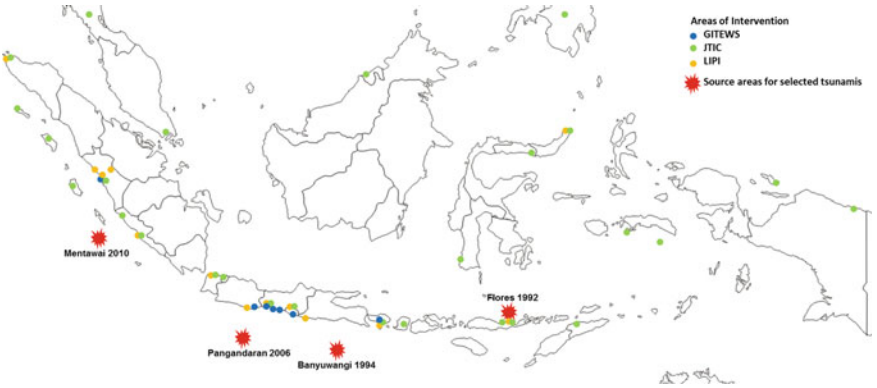

Fig. 10.4 Map showing sources of several selected tsunamis and areas of intervention by GITEWS, LIPI and the JTIC (Base map for Fig. 10.4 was taken from d-maps.com (property of Daniel Dalet). http://d-maps.com/carte.php?lib=indonesia_map\&num_car=301\&lang=en)

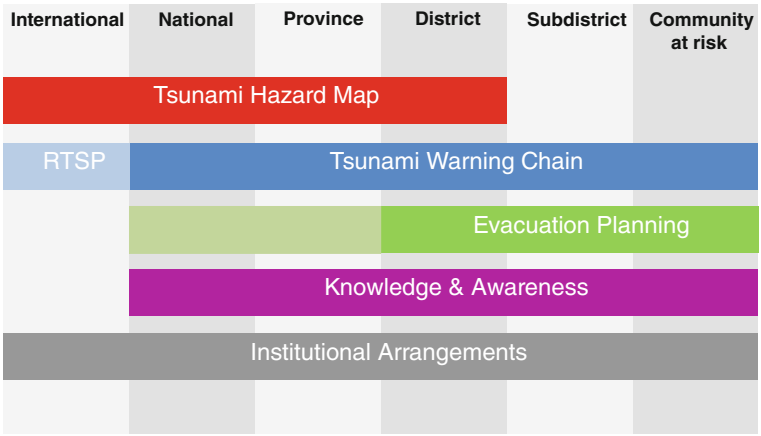

Fig. 10.5 Multiple-level approach

partners at national and local levels. The project aimed to support the development of mechanisms and strategies to enable people in high-risk areas to receive prompt alerts in order to be able to quickly execute adequate life-saving responses. It was designed as a pilot project with pilot locations being the city of Padang in West Sumatra; the province of Bali including selected districts on the island; and five districts in the regions of Yogyakarta and Central Java along the southern coast of Java (Fig. 10.5).

In these pilot areas, the project collaborated with local government institutions from various sectors (disaster response and civil defence as well as local planning boards) and worked together with actors from civil society, such as the Indonesian Red Cross, local non-governmental organisations (NGOs), and the private sector. To strengthen multi-sector and multi-stakeholder coordination for preparedness and

to facilitate cooperation with GIZ, the local government partners in the pilot areas appointed local multi-stakeholder working groups. Through workshops, trainings and exercises as well as learning from others experiences, these groups developed applicable solutions for tsunami early warning and preparedness at local government and community levels. These processes were supported by the provision of technical advice and small funding allowances for local preparedness activities including testing dissemination technology, developing awareness material and supporting outreach and community-awareness programmes. The implementation of the developed solutions lies exclusively with the local partners, primarily local governments, since they are responsible for warning and guiding their people in the event of an emergency.

According to its strategy as a pilot project (Fig. 10.6), the objective of the initiative was threefold (GTZ-GITEWS 2010b). GIZ introduced existing know-how on early warning and preparedness, in line with the overall requirements of InaTEWS as well as the local context of the pilot locations. Based on an assessment of existing local strategies and conditions, the project accompanied its partners during a lengthy working process, providing technical advice on appropriate tools and procedures, helping to clarify roles and responsibilities, and supporting local stakeholders during the implementation process. Experience and good practice information from the pilot areas was validated and translated into concepts, manuals and tools. Thorough documentation of the project's experiences and outputs was recorded in order to make the information available to national institutions mandated with guiding other tsunami-prone regions in their preparedness processes, with the objective of building a reliable end-to-end early warning system throughout Indonesia.

The learning process during the GITEWS pilot project led to the development of a step-by-step approach towards tsunami preparedness across multiple levels (Fig. 10.3). The specific conditions in the context of near-field tsunamis (short lead-times, high level of uncertainty) require that individuals are enabled to quickly take decisions and correct actions based on basic but solid knowledge of local tsunami risks and preparedness plans, even in the absence of guidance from local authorities or the failure of warning services during an emergency. To provide people in communities at risk with more than thumb rules or general instructions on how to react to a tsunami threat, it is necessary to develop local evacuation maps and procedures. Developing such plans at a village level usually requires references regarding hazardous and safe zones and recommended evacuation strategies, as well as the development of local warning services. The responsibility to provide such references, including risk assessments, evacuation plans and the setting up of mechanisms for decision making and disseminating warnings lies with district governments. It is essential, therefore, to develop the required capacities at district level, especially in local disaster-management agencies.

Experiences from the learning and innovation phase resulted in concepts, procedures and products related to the warning chain being provided by the NTWC to the communities at risk. The project played a major role in providing lessons learned as well as facilitating dialogue and an exchange of experiences to adjust the warning system to the needs of the end-users. Many of the experiences from the

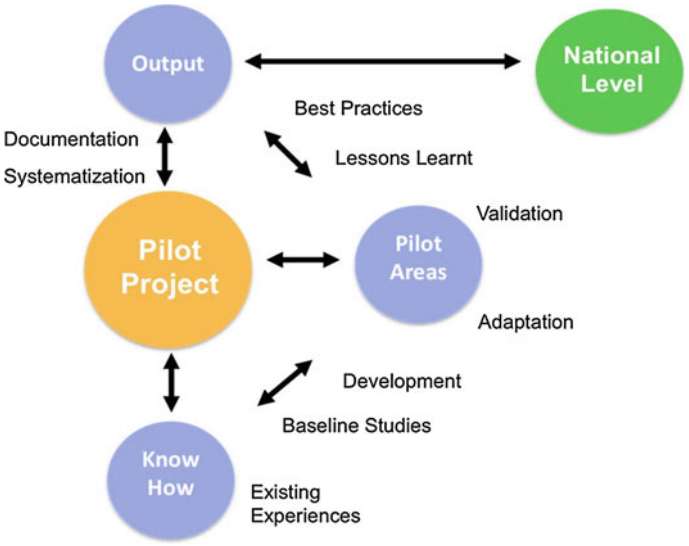

Fig. 10.6 Pilot project strategy

pilot areas were incorporated into the National Warning Service Guidelines (BMKG 2012). Other important outputs developed during the pilot project were manuals and tools to develop basic tsunami-hazard maps and evacuation plans and to set up local warning services and dissemination systems—including 24/7 services—at district levels, to be applied by local actors.

As part of the scheme's knowledge management and in order to make the experiences and results available to other coastal communities and their governments in tsunami-prone areas, the project developed comprehensive documentation—the TSUNAMI*Kit* (Fig. 10.7). The content of the kit is organised according to the key elements of tsunami early warning (Risk Knowledge, Monitoring and Warning Services, Dissemination and Communication, Response Capacity, Knowledge and Awareness, Governance and Institutional Arrangements). For each of these six elements different types of documents were prepared, providing background information (reference and introduction documents, fact sheets) and support for local stakeholders to plan and implement tsunami warning systems and to strengthen preparedness (checklists, manuals, guidebooks and guidelines). Additionally, a collection of materials for public education was included.

10.4.2 Science-Based Preparedness Initiatives by the Indonesian Institute of Sciences (LIPI)

LIPI's role as a governmental research institution takes the form of conducting research, developing innovations and forwarding its findings in the most appro-

Fig. 10.7 Project documentation—TSUNAMI*Kit*—www.gitews.org/tsunami-kit

priate way to influence national policy. Research into natural hazards along with other natural science phenomena was already one of LIPI's strongest competencies a decade before the Indian Ocean tsunami in 2004. Since then, LIPI has gradually shifted its focus towards applied research within a wide array of disciplines, such as geoscience, oceanography, socioeconomics, cultural studies, education and communications.

LIPI believes that the best way to systematically broaden out good practices in disaster risk reduction (DRR) is to establish a collaborative system with dynamic interaction between scientists, practitioners, disaster-management authorities and communities at risk (Fig. 10.8). Indonesia has more than 227 million people who are exposed to earthquake hazards, and more than 5 million exposed to tsunami hazards (BNPB Regulation, 2012). Most communities live in areas with scarce intervention and assistance from local disaster agencies in building preparedness, and some inhabit remote islands with even higher levels of vulnerability but where local populations do not possess an adequate understanding of the underlying risks. The extension of LIPI's role to promote scientific communication and education was therefore an attempt to fill the often wide gap between perceived risks and knowledge.

With its objective being to improve the understanding of risks, disaster-management planning, community preparedness and education, LIPI established the Community Preparedness (COMPRESS) unit to facilitate integration between research and educational efforts. LIPI chose to recruit recent graduates and non-governmental staff to learn and develop skills in providing innovative science-based preparedness interventions and approaches. The programme, which nurtured close collaboration between scientists and educational practitioners, covered many aspects of disaster risk reduction, including risk and community preparedness assessments, school-based preparedness models, the development of standard operating proce-

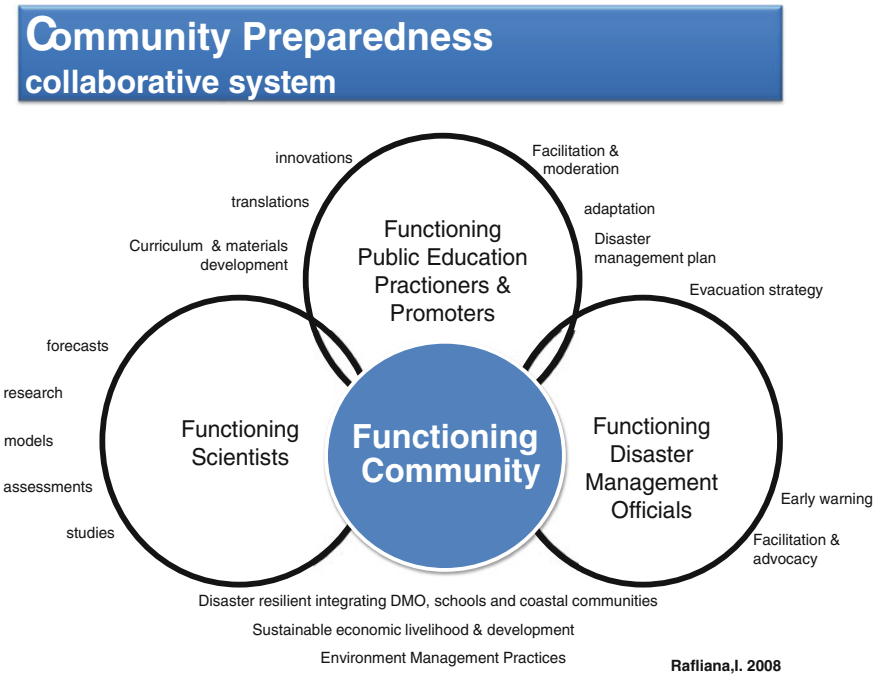

Fig. 10.8 LIPI's four pillars of a collaborative system for community preparedness

dures (SOPs), tsunami exercises, early warning services and community preparedness activities. The results from these efforts enabled the public education unit within COMPRESS to synthesise critical messages that were then made available to the public and the system's users.

The outputs and lesson learned from the programme were documented in the form of guidebooks, minimum requirements and checklists, interactive games and exercises as well as comics for users in schools, communities and local authorities. One highlight was the media guidebook for tsunami warning dissemination, which was the result of a joint collaboration between LIPI, the JTIC, the BMKG, the Ministry of Communications and Information and the BNPB. LIPI has also engaged artists and musicians in preparedness discussions and presentations, helping to organise national exhibitions and the production of songs that emphasise the importance of developing a preparedness culture. A compilation CD entitled *Science in Music* has become one of the tools utilised to encourage people to become more aware and better informed about earthquake and tsunami risks. Overall, COMPRESS worked in more than nine districts and cities in Indonesia, reaching more than 200,000 people including schoolchildren, media personnel, government officials, coastal communities and the general public.

The overriding factor behind LIPI's chosen strategy was the assumption that preparedness should require only limited financial investment as opposed to the

high levels of funding found in most structural-mitigation programmes, which many provinces and districts in Indonesia would not be able to meet. The strategy's main challenges, meanwhile, are the need for sufficient time and providing ongoing assistance to allow the processes to become norms and to build a new culture of preparedness within communities. Meaningful collaboration with organisations that have a similar approach, such as GIZ, the JTIC and UNESCO, is benefitting many districts by assisting them to make the most realistic investment choices concerning preparedness. This collaboration also supports national policies for tsunami preparedness, especially on risk assessments, evacuation planning, early warning and public education.

The evolving processes in developing preparedness capacity in a number of tsunami-prone districts have been noted and some have recorded significant efforts and progress. Nevertheless, the primarily sporadic initiatives throughout Indonesia have for the most part been implemented with significant intervention by external organisations, both national and international, with a marked lack of standardisation by the BNPB.

10.4.3 The Jakarta Tsunami Information Centre

UNESCO's Intergovernmental Oceanographic Commission (IOC), with its vast experience and knowledge regarding the establishment and coordination of the Tsunami Warning System in the Pacific, recognised the important role of a Tsunami Information Centre (TIC) as one of the essential and critical components in supporting the successful operation of a Tsunami Warning System. In 2007, with funding from the Canadian International Development Agency (CIDA), UNESCO-IOC took the initiative to establish the Jakarta Tsunami Information Centre (JTIC), which is housed in the UNESCO office in Jakarta.

The JTIC's mission consists of three fundamental elements: information clearing house, capacity building for preparedness and awareness, and information management and services. As an information resource, the JTIC shared information and publications, and distributed educational and preparedness materials on tsunami and tsunami hazards via its website, www.jtic.org. However, as many of those who needed preparedness and awareness information did not have access to the Internet, the JTIC began to introduce on-site activities.

Between 2007 and 2009, the JTIC implemented a number of initiatives, such as workshops, seminars, trainings, exhibitions and site visits, to strengthen tsunami preparedness within communities in around 20 districts (Fig. 10.4), paying special attention to schools. These initiatives included collaborations with LIPI on a Children's Science Support and Public Education programme in Muko-Muko city, Bengkulu province and a School-Based Preparedness Model (SDPM) training in Maumere, Flores, which also involved a local environmental NGO and local students. In cooperation with a Padang-based NGO, Komunitas Siaga Tsunami (KOGAMI), in West Sumatra, the JTIC implemented a community-based capacity-building programme

for integrated disaster preparedness in two communities and organised 47 SDPM trainings in the province. The results obtained helped form a model for DDR strategy at district and city levels, a training module for earthquake and tsunami evacuation exercises in schools and practical guidelines for communities on how to survive earthquakes and tsunamis. They were also utilised to strengthen school-based disaster preparedness in Banda Aceh in conjunction with the Tsunami Disaster and Mitigation Research Centre (TDMRC) at Syahkuala University.

The main lessons learned from these on-site activities were the importance of actively involving local organisations in order to achieve continuity in preparedness activities and the need to develop locally-adapted educational, awareness, and preparedness materials that reflected and respected particular local cultural contexts.

Furthermore, the JTIC produced a number of information and educational materials to build awareness and strengthen capacities for tsunami preparedness and mitigation at various levels. Several resources from UNESCO-IOC's International Tsunami Information Centre (ITIC) were translated into Indonesian, including the "IOC Tsunami Teacher" DVD and the "Tsunami Glossary". In collaboration with the BMKG, the ITIC's tsunami comic book was adapted to the Indonesian context to provide a highly readable and easy-to-understand booklet on tsunami hazards and warnings.

Flyers, leaflets, stickers and posters were also developed to provide practical information for both the general public and specific target groups, such as boat operators and fishermen. A poster series was published to educate people on how to safeguard and properly maintain tsunami early warning devices, as Indonesia had faced problems of vandalism, thefts and damage to early warning equipment on land and at sea. These posters have been placed in areas where such equipment is installed. The JTIC also published a booklet, "Where the first wave arrives in minutes", which presents survival lessons based on eyewitness accounts of two near-field tsunamis in Indonesia (Aceh 2004 and Java 2006). The booklet is intended for people who live, work or vacation along coastlines where fast-approaching tsunamis may strike.

As part of the joint JTIC—LIPI programme, the JTIC published a lessons-learned booklet derived from the experiences in three schools in Maumere, Flores and Banda Aceh. The booklet provides step-by-step guidelines on how to develop school preparedness based on five parameters: knowledge and attitude; school policy; emergency planning; a school's early warning system; and resource-mobilisation capacity.

In response to the need for locally-adapted materials, the JTIC, supported by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP 2009–2011), adapted existing awareness, preparedness and educational materials in terms of context, culture, language and design for the Philippines, Thailand and Timor Leste (Fig. 10.9).

With the establishment of TICs in other tsunami regions (the Caribbean, North-East Atlantic and Mediterranean seas), the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning System (ICG IOTWS) endorsed the JTIC's 2011 proposal to expand its role to support other Indian Ocean states.

Fig. 10.9 JTIC information materials for tsunami awareness and preparedness

10.5 From Project Work to Service Provision

InaTEWS was designed and set up through the joint efforts of a number of Indonesian institutions and projects by international partners. This initial phase involved a learning and development process, which was mainly project-driven. While the upstream part and the implementation of the NTWC required specialised input from science and technology, the learning and innovation process in the downstream part and at the community level was facilitated by pilot projects in different areas of the archipelago.

Although the system was officially inaugurated in November 2008, further project activities to complete and fine tune the system were still ongoing until 2011. Since then, the character of the activities by the main actors involved in InaTEWS has shifted from time-limited project work to continuous service provision. Core services related to InaTEWS are the provision of tsunami early warnings by the NTWC to interface institutions (the BNPB, the BPBDs and the media), the dissemination of warnings by the national mass media to the general public and the provision of guidance—especially calls for evacuation—by local governments to communities at risk. Other related services include the provision of reference tools for community preparedness, such as tsunami-hazard maps and evacuation plans provided by the BPBDs, as well as information campaigns to raise knowledge and awareness at the grassroots level.

Experiences from the pilot phase show that there is still a great need to strengthen the capacity of national government institutions, local governments and civil society actors in order to provide the services necessary for sustainable tsunami preparedness. The GITEWS review process in 2010 (GITEWS 2010) concluded that integrating the requirements of the warning system (e.g. procedures) within local institutions was a precondition to achieving sustainability. The reviewers also concluded that InaTEWS could not be considered "complete", as the majority of tsunami-prone districts and communities in Indonesia had yet to be linked to the system. Thus, the need for a strategy that would link these districts and communities to InaTEWS and would strengthen local response capabilities to enable communities to react adequately to warnings was also pointed out.

10.5.1 Contributions to the Development of National Standards, Guidelines, Instruments and Procedures for Community-Oriented Tsunami Preparedness

The development of national standards, guidelines, instruments and procedures is a crucial step in expanding upon the successful experiences from the pilot processes in order to provide much-needed references to service providers related to InaTEWS. Developing such standards requires close cooperation and a validation process among the various national stakeholders along with further experience gained by the application of different approaches and products in other tsunami-prone regions of Indonesia.

As prioritised by the BNPB, inter-institutional working groups are addressing quality indicators as a means of measuring public service delivery and impact regarding minimum service standards for tsunami early warning and risk management at local levels. Additional criteria to determine human resource requirements for local tsunami-risk management and to assess human resource development are being discussed to define key competencies, training needs and recruitment in the field of tsunami early warning and tsunami preparedness. Guidelines for minimum standards on tsunami-risk assessments provide guidance for straightforward approaches that can be implemented at the local level.

National guidelines for tsunami warning services, as developed by the NTWC, provide official information regarding InaTEWS and the warning chain from national to local levels, the sequence and content of warning messages—including recommendations on reaction to local authorities—and a clarification on the roles, responsibilities and procedures of all relevant bodies. The purpose of these guidelines is to provide assistance and support to those agencies, both national and regional, that provide a public service in the reception and dissemination of tsunami early warnings, as well as providing assistance to all other stakeholders who are directly responsible for disaster management, especially in regional preparedness and response to emergency situations.

10.5.2 Horizontal and Vertical Knowledge Exchange Across the Country

Coordination and communication between provincial, district, city and national levels are considered prerequisites for both an effective InaTEWS and locally-adapted, sustainable capacity development within tsunami-risk management. Experiences from the GITEWS project showed that a facilitated exchange or dialogue process between local and national levels resulted in a better understanding of the system and contributed to the improvement of procedures, mechanisms and institutional capacities, in particular by addressing the link between the NTWC and local-level actors. The results from these exchange processes produced inputs for the development of national references and guidelines for InaTEWS, drawing on the participation of stakeholders at all levels.

The horizontal and vertical exchange of experience and knowledge plays an important role in the intended expansion process. A peer-to-peer learning approach can facilitate the transfer of knowledge between tsunami-prone regions. Learning from practical experience and case studies not only provides realistic insights into what works and how to overcome obstacles but also increases the motivation for the implementation and replication of processes based on positive examples.

Additionally, visits and discussions with key national actors, such as the BMKG and the BNPB, are held to discuss current state-of-the-art technologies and future plans regarding InaTEWS, and how local communities can link into the system. At the same time, providing an understanding about the expectations among local communities and the challenges they face helps to inform national actors about how to facilitate the implementation of tsunami early warning at the local level.

10.5.3 Capacity-Development Process for Tsunami Preparedness at the Local Level

In order to support Indonesia in strengthening the capacity of local governments and civil society actors so as to provide the services necessary for sustainable tsunami preparedness, the German government launched the "Project for Training, Education and Consulting for a Tsunami Early Warning System" (PROTECTS) as a follow-up project for GITEWS. The new project builds upon the experiences from the former GITEWS pilot areas and supports a horizontal expansion to reach a wider geographical area as well as a vertical expansion to achieve a broader impact by means of institutionalisation.

A capacity-development concept on tsunami preparedness for local communities was designed together with the BNPB and the provincial BPBDs in Bali, Central Java, DI Yogyakarta, East Java, West Java and West Nusa Tenggara. The concept adopts a combination of top-down and bottom-up approaches, along with a multi-level approach, and involves key players at all levels to strengthen the institutional

capacity of the BPBDs in providing services to those at risk. It follows a step-by-step approach towards tsunami preparedness as described in Sect. 10.4.1 (see Fig. 10.3) to build awareness, knowledge and solid procedures within at-risk communities.

Capacity development is practically facilitated through a sequence of workshops, implemented by the provincial BPBDs, involving representatives from local working groups at the district level. During the workshops, participants are introduced to specific topics, such as hazard and risk assessments, evacuation planning, the local warning chain, community awareness and tsunami-simulation exercises. The introduction of national guidelines helps to ensure that local implementation measures are in line with InaTEWS' end-to-end concept. Outside of these workshops, the local working groups are then charged with implementing the required action in their respective regions (Fig. 10.10), making use of existing local knowledge, values and human and material resources.

Additionally, technical trainings on evacuation planning and local warning services, as well as on facilitating preparedness processes and awareness campaigns at grassroots level, are provided to ensure that the necessary skills needed to implement the different components are met. The trainings are designed for specific target groups, such as employees of the BPBDs, community activists and even village residents. Those selected for the trainings are obliged to make a commitment towards supporting the local implementation processes.

10.6 Outlook

10.6.1 Status Quo

The 2011 Japanese tsunami killed about 20,000 people in what is considered the most tsunami-prepared nation in the world. Nevertheless it can be assumed that

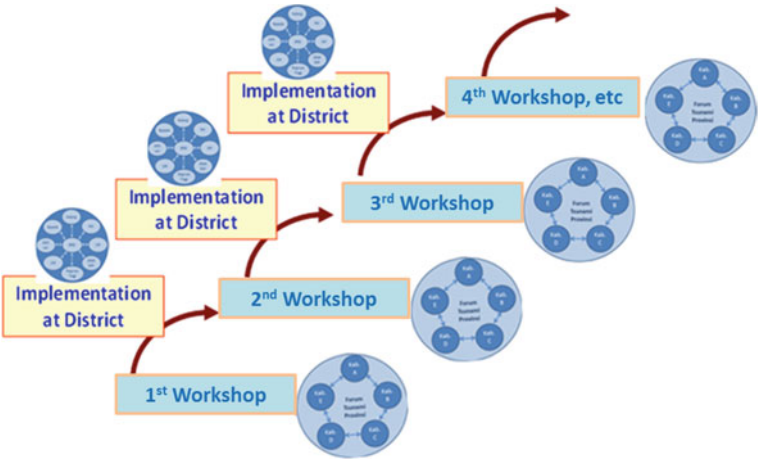

Fig. 10.10 Capacity-development approach

preparedness and early warning efforts in Japan saved many lives during this incident, considering the magnitude of the event and the number of people exposed if compared to the 2004 Indian Ocean tsunami. The assessment of this incident revealed that tsunami inundation in many areas was far more extensive than expected (Koshimura 2011). In the event, even designated evacuation-assembly points were flooded, which caused a loss of life in areas that had been assumed to be safe. This raises the question as to how such rare but extreme events can be properly addressed in hazard assessments and preparedness plans. During the UN University Japan Symposium in Tokyo, held in February 2012, a two-level approach was suggested, to distinguish between frequent tsunamis, (which in Indonesia occur approximately every two years), and extreme events, possessing estimated recurrence intervals of several hundred years. Such an approach may perhaps warrant the introduction of a two-zone concept for evacuation planning. A practical example for such an approach can be found in southern Bali where a two-zone concept was implemented in 2010 (GTZ-GITEWS 2010a). Discussions in Japan also led to the question of whether preparedness and mitigation plans should be based on extreme events with recurrence periods of several hundred years or on the more frequent events with recurrence periods of around 100 years or less. Ultimately, this is a political question, which depends upon how much risk a society is willing to accept or how much risk it can afford to reduce.

Experiences from recent tsunamis, tsunami warnings and tsunami-simulation exercises in Indonesia have been evaluated and documented (Artanti 2011; GIZ-PROTECTS 2011; Usdianto and Juliasman 2011) and provide valuable insights into the current status of the early warning system in Indonesia. The results show that Indonesia has made significant progress, but there is still a long way to go.

With regards to the downstream section, it can be concluded that warning services from the NTWC at the BMKG to interface institutions and national media are, in general, reliable and quick with warnings being sent out within 5 min. The assessments show that currently the general public primarily relies on information disseminated from media sources, as local governments—with a very few exceptions—are not yet ready to forward warnings and provide guidance. This means that people are forced to interpret warnings by themselves and then to decide how to react on them. Unfortunately, the public's understanding of InaTEWS, the national warning services and required reaction is still limited. Efforts are under way to improve understanding about the tsunami early warning system for both the public and institutions. Initiatives include the publication of a media handbook (UNESCO 2011), and a guidebook on the tsunami early warning service by InaTEWS (BMKG 2012).

Local authorities play an important role in the warning chain, as they are responsible for deciding whether to trigger sirens and/or call for an evacuation. In most areas, the required decision-making processes, 24/7 services, and dissemination procedures and technologies at local levels have either not yet been implemented or are not working in a reliable way. Often, even the communication link between the NTWC and the local 24/7 services do not function reliably. There are multiple reasons for this including the breakdown of communication channels during emergency

situations, missing back-up systems, a lack of maintenance of installed equipment as well as disregarding established procedures.

People in risk areas need solid references to determine when, how and to where they should evacuate. Such references include evacuation maps at community (sub-district, village, city quarters) or institutional levels (especially schools, hospitals, hotels and other vulnerable institutions), and local warning arrangements (local sources of information, decision making and calls for evacuation in local areas or institutions). Evacuation plans and local warning arrangements have been developed in some areas with the support of (pilot) projects by various organisations, but most communities still lack such reference information. While national guidelines on tsunami warning services are already available, standards and policies for hazard mapping and evacuation planning are still missing, leading to different approaches in producing community maps, with the consequence that the information produced varies significantly in quality and reliability.

The authors would like to highlight two other issues, which were raised as important points based on the recent experiences in Japan. First of all, it was emphasised that tsunamis are a problem for local communities and that proactive local initiatives are therefore needed to develop locally-adapted mechanisms and measures for tsunami preparedness and mitigation. However, in order to enable local efforts to be effective, such initiatives require substantial support from the national level in the form of policies, resources, references and services, which cater to local needs. Secondly, the experiences in Japan showed that self-protection arrangements played an outstanding role. In a tsunami emergency, survival very much depends on each individual's knowledge and capacity to react in a quick and appropriate way, especially in uncertain conditions. Therefore, it is recommended that preparedness strategies should more widely promote individual, family and community arrangements, which again require solid references provided by local and national disaster-management agencies.

10.6.2 The Way Ahead

Implementing and operating an early warning system involves a continuous learning and improvement process, which ideally contains ongoing improvement cycles of assessment, planning and design, implementation and evaluation. Having completed the initial establishment of InaTEWS and having entered the service-delivery phase, it might be a good moment to conduct a systematic review to obtain a clear understanding of what has been achieved so far and what needs to be improved. Such a review should address all aspects related to the end-to-end system and should include different perspectives from the scientists and practitioners involved in implementing the system, and the communities at risk. For the time being, and based on recent experiences, the following aspects are considered key points.

Building a common understanding of the system: To make the system work, technical and human capacity at all levels must continue to be developed and combined.

To build a common understanding of the system and encourage all actors to assume and play their respective roles, the provision of adequate references and guidelines is necessary. Developing these references is a multi-stakeholder task. Only a joint learning process can produce a tailor-made warning chain that really addresses the needs of communities at risk.

Improving public understanding of the warning service and the contents of warnings: Recently, InaTEWS introduced a new warning scheme based on three different warning levels. It is now necessary to train interface institutions and inform the public as to what reaction is expected according to each level.

Institutionalisation at all levels: During InaTEWS' development process, the system mainly came within the domain of specialised agencies involved with upstream technologies and the setup of the NTWC. In the future, it is envisaged that the National Disaster Management Agency (BNPB) will play a more significant role, especially in the downstream section. For the further development of InaTEWS, a coordination mechanism between all the actors and entities involved, plus a focal point for all issues related to the downstream section, would be extremely valuable.

Creating a sense of ownership at the local level: Strengthening the role of local disaster-management agencies and governments at the local level is crucial in the downstream section. In order to facilitate quick and reliable decision making at local levels, the utilisation of SOPs must be promoted. This will help local governments to deal with uncertainty and to be able to react quickly. As tsunamis will most possibly affect multiple administrative areas, multi-level and multi-sector coordination is required to synchronise SOPs within each of the administrative areas.

Scaling-up: Taking the existing experiences from various pilot areas and applying them to more districts along tsunami-prone coastlines is another challenge in InaTEWS' ongoing development. Now that a solid level of performance has been achieved, the system needs to be promoted proactively. This involves going public, explaining the system, and building relationships with the system's end-users—i.e. communities at risk. This is arguably the most important factor: building people's trust in the system so that it can achieve its ultimate goal—saving lives.

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