# Concepts & Recommendations for the Implementation of

# Tsunami Early Warning in Bali

Presented by

KESBANG, POL dan LINMAS

Bali Province

compiled by

GTZ IS

March 2009

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## Contents

# 1. Executive Summary

After the devastating tsunami on 26 December 2004, the affected Indian Ocean countries decided to build up a regional Indian Ocean Tsunami Early Warning System. The Indonesian Tsunami Early Warning System (INA-TEWS) is a crucial part of the regional system since the subduction zones offshore the Indonesian islands are a major (potential) source for ocean wide tsunamis in the Indian Ocean.

The end-to-end Early Warning System in Indonesia, however, can only be called a "system" once the national warning centre is connected to the communities at risk. Local governments at province, district/city level play a crucial role in the Early Warning System as they are responsible to implement Tsunami Early Warning (TEW) within their administration and communities and provide guidance to the communities in case that a warning is sent out by the National Warning Centre at BMKG in Jakarta. This division of responsibility is a huge challenge for many regions in Indonesia. It requires the set up of a local 24/7 service that is able to respond quickly and in a reliable way, the development of standard operation procedures and the strengthening of community awareness and preparedness.

The objective of this document is to provide advice on how Bali authorities can establish the link to INA-TEWS and describes how appropriate capacities can be build in order for Goverment of Bali as well as communities to fulfil its role in the warning system. In order to achieve this goal, certain political, institutional and technical requirements have to be met. The document suggests answers to six key questions referring to these requirements and hereby provides a comprehensive concept to implement TEW in Bali:

**I.** What are the principles of a TEW policy for Bali?

**II.** What are the institutional requirements for TEW in Bali?

**III.** What is required to receive warnings from the National Tsunami Warning Centre?

**IV.** What is required to decide whether communities should evacuate or not?

**V.** What is required to disseminate warning and evacuation guidance to the communities?

**VI.** What is required to strengthen people's awareness and understanding about INA-TEWS?

The document was compiled by GTZ IS and takes into account results from discussions with the Provincial Government (PEMPROV), Badung District Government (PEMKAB Badung), the Bali Chapter of the Indonesian Red Cross (PMI), and incoorperates input from the French Red Cross (FRC), the Bali Hotel Associaton (BHA) as well as experiences from the Pilot Areas in southern Java and Padang.

## 2. Introduction

Early Warning is essential to save lives when a tsunami strikes. Indonesia, with the support of Germany and other countries as well as International Organisations, is currently setting up the **Indonesian Tsunami Early Warning System** (INA-TEWS). This system will be an essential part of an integral Tsunami Early Warning System for the entire Indian Ocean Region.

The Indonesian Ministry for Research and Technology (RISTEK) coordinates the development of INA-TEWS. The National Agency for Meteorology, Climatology and Geophysics (BMKG) operates the National Tsunami Warning Centre. BMKG issues tsunami warnings to interface institutions and local governments. **Local Governments** are responsible for providing guidance to the community at risk based on the warnings from BMKG, i.e. local authorities are the ones in charge for calling for evacuation if needed.

The German contribution to INA-TEWS is known as **GITEWS** (German-Indonesian Cooperation for a Tsunami Early Warning System). One component of the GITEWS project focuses on **"Capacity Building in Local Communities"**. This component supports the Indonesian partners in developing procedures and mechanisms, which assure that people in risk areas are alerted in time and are capable to execute an appropriate reaction to a warning in a timely manner. GTZ IS cooperates with local governments and other stakeholders in three Pilot Areas while also maintaining close cooperation with national institutions. The results from the pilot project will contribute to enabling other tsunami prone communities to link themselves to the INA-TEWS and to better prepare for future tsunami events.

**Bali** was selected as one of the **Pilot Areas** for the project due to its risk regarding tsunami hazard. In early 2007 a close cooperation with the Bali Provincial as well as Badung District Government was agreed and formalized by MoU (PEMKAB Badung in March 2007, PEMPROV in May 2007). Since the beginning PMI joined the cooperation as an active third partner in the implementation of Tsunami Early Warning.

During the working process in Bali and the other GITEWS Pilot Areas new concepts, planning tools and procedures for the implementation and operation of Tsunami Early Warning at local level have been elaborated together with local stakeholders.

This document describes the Tsunami Early Warning concept developed for Bali. It focuses on the southern coast of Bali and provides recommendations to local decision makers and other stakeholders on how to develop structures and procedures that lead to a coherent and effective tsunami early warning system in Bali. The document was compiled by GTZ IS and takes into account results from discussions with PEMPROV, PEMKAB Badung, PMI and and incoorperates input from the French Red Cross (FRC), the Bali Hotel Associaton (BHA) as well as experiences from the Pilot Areas in southern Java and Padang.

The authors would like to emphasise that the implementation of an end-to-end TEWS in Bali requires the consideration of traditional knowledge. It needs to integrate

traditional means of communication means with new procedures and technology introduced by a technology based early warning system like INA-TEWS.

# 3. Tsunami Hazard and Early Warning in Bali: the Challenges

## 3.1. Short warning times and uncertainties

Bali is located very close to the collision zone between the Indian-Australian Plate and the Eurasian Plate which represents the main source area for local tsunamis that might affect the island. It has to be expected that tsunami waves will need only 20 to 60 minutes to reach the coast. Hence warning time is very short.

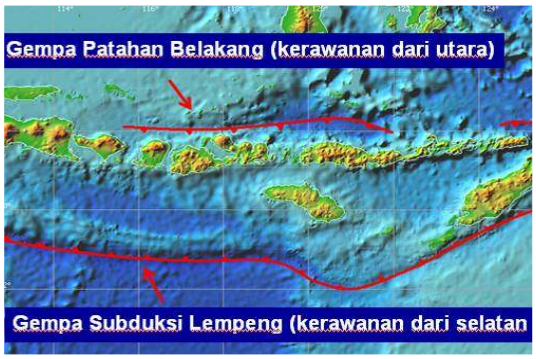



**Figure 1:** Subduction zone and back arc fault.

**Time is the most critical factor when defining procedures for early warning and evacuation!**

Every tsunami is different! Bali might suffer the impact of a smaller tsunami but also the worst case might happen. Historical research provides important insights into possible events in the future. Relevant historical tsunami records for Bali are the Sumba (1977) and Banyuwangi (1994) events that are related to subduction zone earthquakes (Gempa Subduksi Lempeng) as well as the Flores Tsunami (1992), which is related to an earthquake in back arc source (Gempa Patahan Belakang). Scientists also consider the "seismic gap" (related to the subduction zone in the south) as relevant for tsunami hazard assessment.

Understanding tsunami hazard and the assessment of possible impacts to their community are preconditions for local decision makers and other stakeholders to initiate preparedness activities to anticipate future tsunami events. Implementation of such activities and decisions that have to be taken can only be based on today's understanding of the hazard. Due to high level of uncertainty these decisions often appear to be difficult. They involve choices, tradeoffs and risk. While getting prepared has to be a priority some degree of risk must be accepted due to economic reasons.

**Due to the infrequent occurrence of tsunamis, information regarding their possible impact, occurrence and run up heights is very uncertain. It must be assumed that no reasonable action can take into account all possible risk...**

Most probably tsunamis in Bali will be triggered by tectonic earthquakes. But not all earthquakes in the collision zone of the tectonic plates cause tsunamis. Whether an earthquake has the **potential to trigger a tsunami** is currently evaluated by analyzing three factors:

1. **Location**: the earthquake has to be located under the sea
2. **Magnitude**: higher then 6.5 on the Richter Scale (RS)
3. **Depth**: less than 70 km

BMKG (National Agency for Meteorology, Climatology and Geophysics) currently uses the mentioned thresholds (M 6.5 RS, 70 km depth) to analyse whether an earthquake has tsunami potential or not. Even if an earthquake event matches all three criteria, this does not necessarily mean that a tsunami has been generated. A fourth criterion has to be fulfilled: the earthquake caused a vertical movement of the sea floor.

Besides earthquakes that occur in the subduction zone of the Sunda Trench and the back arc fault, two more sources for tsunamis have been identified: submarine landslides and volcanic activity. Submarine landslides are associated with earthquakes. They happen during an earthquake, can increase the energy of a tsunami and therefore add up to the effect of uplift by tectonic movements in the subduction zone (also caused by the earthquake).

In Bali, earthquakes frequently occur also on land. Bali experienced several strong earthquakes (M≥ 6 RS) in the past (1976, 1979, 1984 and 2004). These earthquakes are associated with the "Central Bali Right Lateral Strike Slip Fault Seismic Source Zone", a rupture zone under the island of Bali.

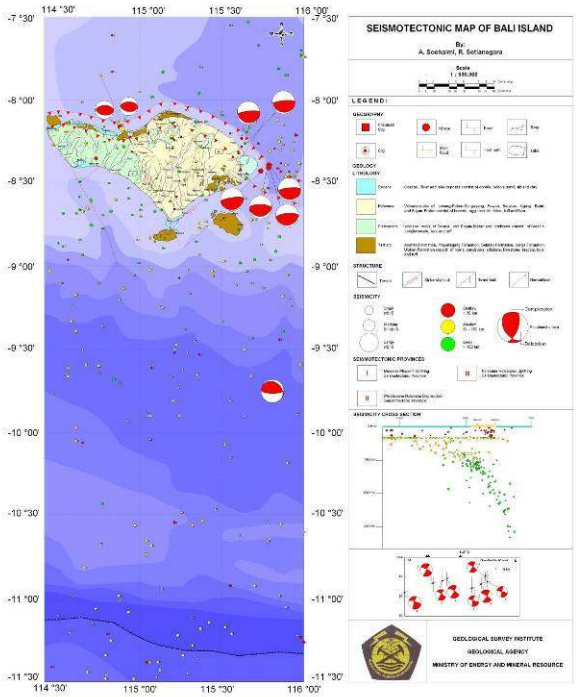



**Figure 2:** Seismotectonic Map of Bali

**Ground shaking should be treated as the first warning sign! However, since it is not possible to deduce earthquake magnitude and location from ground shaking alone, this measurement involves a high level of uncertainty!**

The Indonesian Tsunami Early Warning System (INA-TEWS) is designed to identify earthquake parameter and location within 5 to 7 minutes and to communicate the result to local authorities. At a later stage (second half of 2009) INA-TEWS will integrate data from GPS, buoys and tide gauges to observe possible vertical movements of the plates as well as the ocean water in order to confirm whether a tsunami was generated or not. For this reason it is important to distinguish between the current and the future warning scheme.

As the **current warning scheme** depends only on earthquake observation, it is obvious that BMKG can currently only advert that an earthquake has the potential to generate a tsunami, but cannot confirm whether a tsunami was actually triggered.

**Local governments will not know with certainty whether a tsunami is on the way or not when they have to decide for evacuation.**

Having clarified that, it is most important to understand that the moment of **ground shaking during the earthquake provides the first opportunity to react**, i.e. move away from the beach and to higher ground. **The first warning from BMKG (5-7 minutes after an earthquake)**, though it does not provide 100% certainty whether a tsunami will come or not, **is probably the last chance to call for evacuation** in case a tsunami becomes reality and hits the coast. **Waiting until natural warnings signs** (e.g. seawater withdrawal) confirm the arrival of a tsunami **is definitely not an option**, as it does not provide enough time for evacuation of the community at risk (see graphic 3).

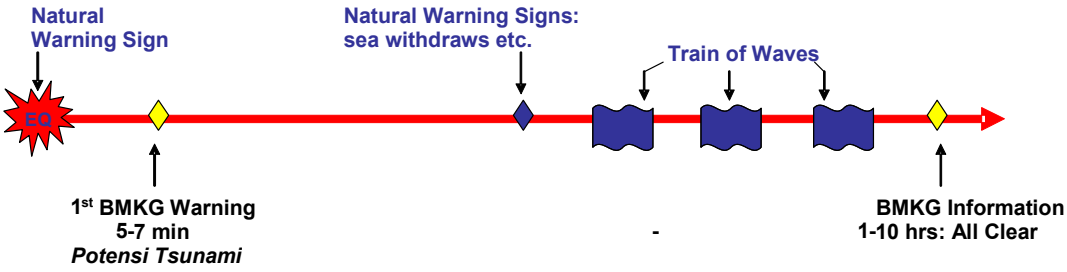



**Figure 3 - Current Warning Scheme:** Approximate time line of a tsunami event from the earthquake until an "All clear" message displaying available information (from nature and INA-TEWS) before, during and after the tsunami event. Note: time in minutes is just an estimation, time can vary!

As already mentioned, the warnings currently issued by BMKG only provide information about the earthquake parameter and whether these parameters represent a threat of a potential tsunami. They do not give any information about possibly affected areas.

**The current warning scheme by BMKG does not provide any information whether Bali might be affected in case of a particular warning and what level of impact would have to be expected.**

With the **future warning scheme** (second half of 2009) this situation will change. The warning system will provide information about potentially affected areas and the estimated impact. Additionally the system will give additional information that confirms whether a tsunami was generated or not. This confirmation will be based on the data from GPS, buoys and tide gauges. A Decision Support System will integrate all available data, refer to a tsunami simulation database and support the warning service (see page 18) of BMKG. Once the future scheme is in place it has to be assessed and discussed whether – and how long – it is worth waiting for a second warning message from BMKG. This second information might give more certainty about an actual tsunami occurrence but might not leave enough time for evacuation and probably risk many lives.

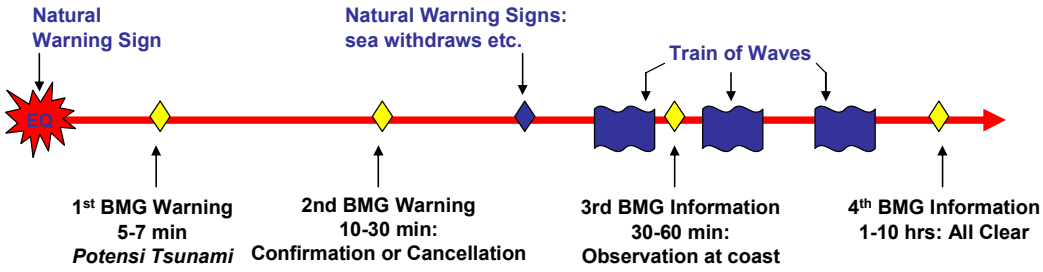



**Figure 4 - Future Warning Scheme:** Approximate time line of a tsunami event from the earthquake until "All clear" message displaying available information (from nature and INA-TEWS) before, during and after the tsunami event; Note: time in minutes is just estimation, time can vary!

In conclusion: short warning times and uncertainties related to (local) tsunami hazard and early warning represent a big challenge for Bali in its effort to improve tsunami preparedness and implement strategies for tsunami early warning. Recognizing these parameters and taking them into account should be the basis to develop a realistic preparedness strategy for Bali.

**Dealing with tsunamis always means dealing with uncertainty. This is a big challenge and requires a realistic preparedness strategy.**

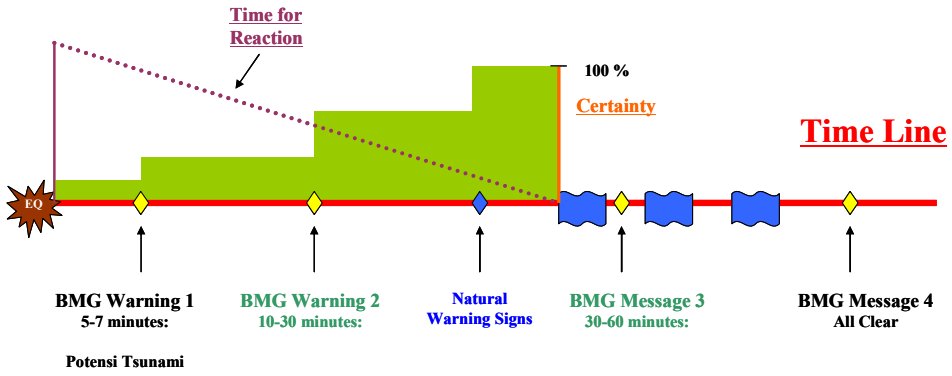



**Figure 5:** Relation between available information (uncertainty) and time for reaction along the tsunami time line. Note: time in minutes is just estimation, time can vary!

## 3.2. Institutional setting

Major challenges for the implementation of tsunami preparedness are related to the fundamental change regarding the disaster management framework that is currently ongoing in Indonesia. A new law for disaster management was released in 2007. The organisational structures of these institutions, however, have not been completed yet. The National Disaster Management Agency (BNPB) has been founded in the beginning of 2008. In some regions, the Local Disaster Management Agency (BPBD) has been established in some regions (provinces and/or districts/cities) while in others it does not exist yet. The former and still functioning SATLAK / SATKORLAK structure was never designed or mandated to deal with disaster preparedness or early

warning. Eventually, the roles and responsibilities of the new BPBD regarding Tsunami Early Warning in Bali still need to be determined.

Several meetings in 2008 stressed the need for clarification about the roles and responsibilities of **district** and **province level** regarding tsunami early warning. In a meeting at the Governor's office on 15 February 2008 it was agreed that the main responsibility for the provision of guidance to the community at risk (i.e. call for evacuation) and hence the establishment of local 24/7 services has to be taken care of by district governments. Following this agreement, the PUSDALOPS (Operations Control Centre) at province level should have a back-up function and take over in case district 24/7 services are not available.

As a next step it was decided to establish **temporary 24/7 services for tsunami early warning** at province level and in Badung District (at KESBANGLINMAS; Civil Defence Office). GTZ IS supported the initiative with the development of Standard Operating Procedures and an Operations Manual for PUSDALOPS, basic infrastructure for tsunami warning reception from BMKG (RANET, FM-RDS, VHF) and training of assigned staff. Yet, both services (at province level as well as at Badung District) have not been fully implemented and are not operational. **Consequently, at present Bali cannot count on these services for tsunami early warning.**

The experiences in Bali and also in other Pilot Areas so far show that the establishment of 24/7 services for tsunami early warning is difficult to achieve. This is due to constraints in the provision of human resources (number of staff required, professional capacity and motivation of staff), financial resources (not budgeted, not prioritized) and an unclear mandate (no official approval of SOPs and delegation of decision making to PUSDALOS).

Eight out of nine Balinese districts have tsunami prone coastlines. As Bali is a comparably small island the question arises whether it makes sense to establish a total of eight different 24/7 services in the various districts, which will need to be synchronized and coordinated. **The option of creating and operating only one highly professional 24/7 service (and PUSDALOPS) at province level to serve all districts in Bali appears to be far more realistic.**

**Coordination between Bali districts and authorities from Bali Province is another important issue to address.**

Special attention has to be drawn to the management and operation of the BMKG **sirens**, which are located in Badung District and Sanur. The maintenance of these sirens was already officially handed over to province authorities in 2008. Clarification is needed for the mandate and procedures to activate the sirens.

### 3.3. Inter-institutional cooperation and integration of the private sector (tourism)

Tsunami preparedness in Bali is on the agenda of local, national and international actors, the private sector as well as public institutions in Bali. Several initiatives and projects are currently being executed or prepared in order to provide inputs for tsunami preparedness and mitigation.

**Implementing tsunami early warning is a "group affair". Coordination is needed to avoid a duplication of actions and inconsistencies.**

There should be the **common understanding** that tsunami early warning in Bali is part of INA-TEWS and therefore closely linked to the initiative of implementing tsunami early warning in the Indian Ocean. It is important that all actors involved in tsunami preparedness in Bali understand the basic principles of INA-TEWS, its possibilities and limitations (see chapter 5) and how the system will be implemented in Bali.

As Bali is a prime international tourist destination, the integration of the **tourism sector** in the warning chain as well as in preparedness and evacuation planning is obligatory. It is recommended to establish close coordination and an efficient cooperation mechanism with all the major associations of tourism sector in Bali (BTB, BHA, PHRI etc.) in order to make use of synergies. Currently the Ministry of Culture and Tourism (BUDPAR) and the Bali Hotel Association (BHA) are supported by an integrated expert (co-funded by the German Government via CIM) to strengthen tsunami preparedness in the tourism sector.

There is a **high motivation in many parts of the Bali hotel sector** to link themselves to the INA-TEWS and to prepare for tsunamis. In order to enhance the security and safety of Indonesia as a safe beach holiday destination the BUDPAR together with the private sector (BHA) created a 'Tsunami Ready Toolkit', which includes information on how to prepare hotels for tsunamis. The toolkit is introduced to hotel associations all over Indonesia through BUDPAR.

**Many hotels are ready to cooperate** with the community at risk to provide vertical evacuation shelter within their premises and are willing to invest into establishing official evacuation routes. BHA and GTZ IS already established a close cooperation to set up a 24/7 tsunami warning dissemination service in BHA. Another initiative is the design of a joint strategy for the community of Tanjung Benoa and the hotel sector to assure the access to hotel buildings in case of a tsunami warning. Regarding the latter initiative, it is still necessary to clarify legal implications and questions of legal accountability of hotel managers who open their doors to the community – as related to cases of injuries or death of community members that might occur as a consequence of evacuation.

**From the perspective of the tourism sector there is still a number of uncertainties** that hinder the development of tsunami preparedness measures: basic references like a official tsunami hazard map and evacuation maps are still missing. Related to the Tsunami Early Warning System, the tourism sector still has to rely exclusively on BMKG warning messages from the National Warning Centre in Jakarta – as a

dissemination service for warning and guidance by Bali authorities has not been implemented until present. The information by local and national authorities regarding the readiness and reliability of sirens and other warning sources as well as test runs (etc.) is perceived as suboptimal. Contradicting information and a lack of credible, transparent official information sources leads to frustration of even the most motivated players of the private sector. Therefore trust on the part of the private sector regarding the capacity and reliability of national and local authorities to provide timely early warning is still limited.

The hotel industry is prepared to play a role in the preparation of public evacuation routes through (e.g.) the donation of signs. However, until present, despite several initiatives it was not possible to achieve clarity on legal procedures for the installation of signs in public space.

In summary, cooperation between the (private) tourism sector and the public sector in Bali provides a huge potential for a win-win situation with regards to tsunami preparedness. Such **cooperation** would yield benefits if it is built on mutual respect, trust and understanding and implemented with a **constructive and positive attitude as well as an appropriate way of communication.**

Important **public transport facilities** like Ngurah Rai Airport or Benoa Harbor also need to be linked to the early warning chain. They require specific procedures and should be involved in the development of overall tsunami preparedness planning in Bali.

### 3.4. Community Preparedness

Survival during a tsunami will depend in many cases on people's knowledge and how quick people are able to assess the situation and take a decision to evacuate or not.

**As Bali has to cope with local tsunamis and short warning times, strengthening community preparedness should be one of the backbones of its preparedness strategy.**

Initiatives for community preparedness in Bali are on the agenda of governmental institutions as well as PMI and other NGOs. These actors apply community approaches like CBDRM (Community Based Disaster Risk Management), drills, awareness campaigns, community workshops and participatory evacuation planning.

CBDRM activities need to be supported by official planning tools (e.g. hazard maps and reference plans for evacuation) and clear policies regarding early warning procedures. These tools and procedures often do not exist.

Participation of communities and their organisations, particularly those most vulnerable, is crucial to a people-centred early warning system. They should be actively involved in risk assessment, be aware of the hazards to which they are

exposed, understand the warning message, and be able to take actions to minimize injuries and loss of life.

The Balinese society is recognized for its strong culture, traditional customs and values of Hindu religion. Therefore the **cultural beliefs** and **customs** have to be respected and integrated in tsunami preparedness approaches at community level. The everyday life of many Balinese follows the local traditional provisions (Awig-Awig). Traditional structures like "Majelis Agung Desa Pekraman" (at province level), "Majelis Madia Desa Pekraman" (at district level) and "Majelis Alit Desa Pekraman" (at village level) are responsible for controling and maintaining the recognition of traditional customs and to provide life long education related to Hindu philosophy. Modern approaches towards understanding and explaining nature, i.e. natural science needs to be combined with traditional believes. In the Hindu philosophy "Tri Hita Karana" is considered effective to keep and maintain the balancing of earth. The three elements of the Tri Hita Karana philosophy comprise:

1. Maintain relation to God (Ida Sang Hyang Widi),
2. Maintain relation to the earth and all it consists of,
3. Maintain relation to the spiritual life on earth.

It is believed that ignoring these principles might in return lead to the occurrence of disasters.

As many Balinese respect and listen to their customary leaders, the implementation of TEW at community level should be promoted through a joint effort of the public sector (the local government), stakeholders already working with and representing communities and traditional structure. Therefore the local government should involve customary leaders to assure that the Banjar System (customary system in Bali) will support and share their ideas regarding tsunami hazard, tsunami preparedness and early warning.

Information from the INA-TEWS will help to support local decision makers as well as the community at risk in taking better (and quicker) decisions if warning messages and schemes, procedures and contents are well understood by all. Clear and reliable information that is sensitive to the perceptive capacity of the audience should be part of each tsunami preparedness initiative regardless of who is implementing it.

**Community preparedness activities in Bali need the support of Bali authorities. The latter need to provide clear guidance regarding hazard zones, procedures and messages for early warning as well as recommendations on how to react on warning signs and messages.**

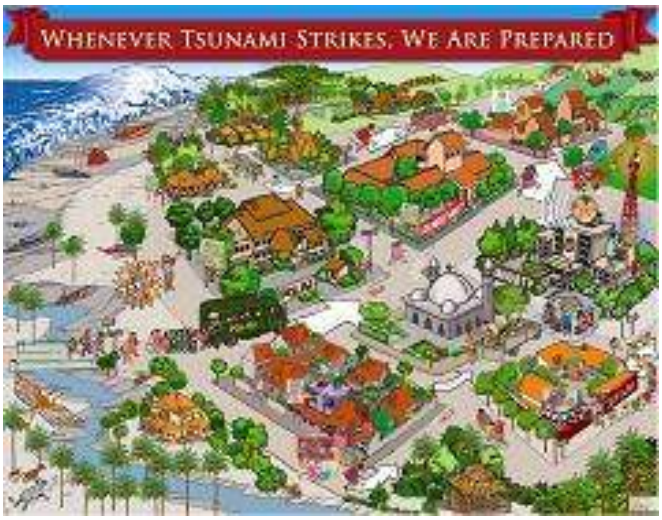
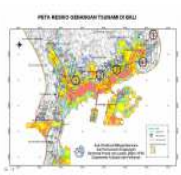



**Figure 6:** Tsunami preparedness poster explaining the early warning system (GTZ IS 2006).

## 4. Tsunami Hazard Maps: the Basis for Preparedness Planning

Bali needs to develop a clear framework for tsunami preparedness in order to assure that activities implemented by different actors are aiming at the same overall strategy and are not contradicting each other. Providing an official tsunami hazard map is definitely a priority task to achieve this goal.

Several maps related to tsunami hazard, risk and evacuation planning are available for Bali but none of them can be considered as an official one:

| Map | Institution | Type | Zoning |
|---|---|---|---|
|  | BAPPEDA | Tsunami zoning map with reference to Aceh tsunami (max. 33 m run-up) | **Zoning according topography:**<br>Tsunami Potential medium (elevation 30-40m)<br>Tsunami Potential high (elevation 0-30m) |
|  | BPPT (2006) | Tsunami "Run Up Map" for scenario M 8.9 (developed for Tsunami Drill 2006) | **Zoning according flow depth:**<br>Flow depth 0-0.1 m<br>Flow depth 0.1-1 m<br>Flow depth 1-2 m<br>Flow depth 2-3 m<br>Flow depth 3-5 m<br>Flow depth 5-8 m<br>Flow depth 8-15 m |
|  | Badan Geologi<br><br>CVGHM (2007) | Tsunami Hazard Prone Map based on worst case scenario M 9, 300x50km rupture south of Bali, depth 10 km, reverse fault | **Zoning based on elevation and inundation**<br>Tsunami Prone Area: high<br>*Elev. <10m / inund. max. 4.5 km*<br>Tsunami Prone Area: moderate<br>*Elev. 10-17m / inund.. ~7.8 km*<br>Tsunami Prone Area: low<br>*Elev. 17-25m / inund. ~ 8.3 km* |
|  | DLR: Multi-scenario (Draft 2008) | Hazard Map showing affected areas by several hundreds of different scenarios with EQ-magnitudes between 7.5 and 9 | **2 Zones related to BMKG warning levels:**<br>Impacted area if wave height at coast 0.5-3 m (Warning Level 1)<br>Impacted area if wave height at coast >3 m (Warning Level 2) |
|  | DKP (2005) | Evacuation Map based on inundation prediction: the map was built by using 'same level approximation', topographic data based on Global SRTM and the inundation height was | **Zoning according inundation prediction:**<br>Inundation height 1m<br>Inundation height 2m<br>Inundation height 3m<br>Inundation height 4m<br>Inundation height 5m |

| | | | |
|---|---|---|---|
| | | modeled by the 1977 Sumba Tsunami (tsunami wave height in the coastline as the result of the model was 5.2 meter) | |

**Table 1:** Bali Tsunami Hazard Maps, compiled by GTZ IS, 05-08-2008

In order to revise all existing mapping approaches and explore the current knowledge about tsunami sources and impacts for Bali a **Consultation-Workshop for Tsunami Hazard Mapping in Bali** was organized by PEMPROV with support from GTZ IS. During the workshop, held on 7-8 July 2008 in Denpasar, participants from national and international science institutions as well as local stakeholders gathered to achieve a better understanding about tsunami hazard and the possible impacts for Bali.

During the workshop the science group recommended to develop a **multi-scenario map** that includes all scenarios that have been calculated by the different institutions. This recommendation was based on the fact that current scientific knowledge does not allow for identifying one specific scenario as the most probable one. A multi-scenario approach combines the impact of a big number of calculated tsunami scenarios (generated by numeric modelling) in one map.

It was agreed that the German Aerospace Centre (DLR) should integrate the already calculated GITEWS scenarios (calculated by AWI – Alfred Wegener Institute) and the existing scenarios from Indonesian partner institutions into a **Multi-scenario Tsunami Hazard Map for Southern Bali**. An updated version was presented during the International Conference for Tsunami Warning in Bali in November 2008 and a second map, excluding the less probable scenarios (i.e. > M9 SR), was handed over in February 2009.

In March 2009 a **Technical Document** describing the process and technical background of the Tsunami Hazard Map was written.

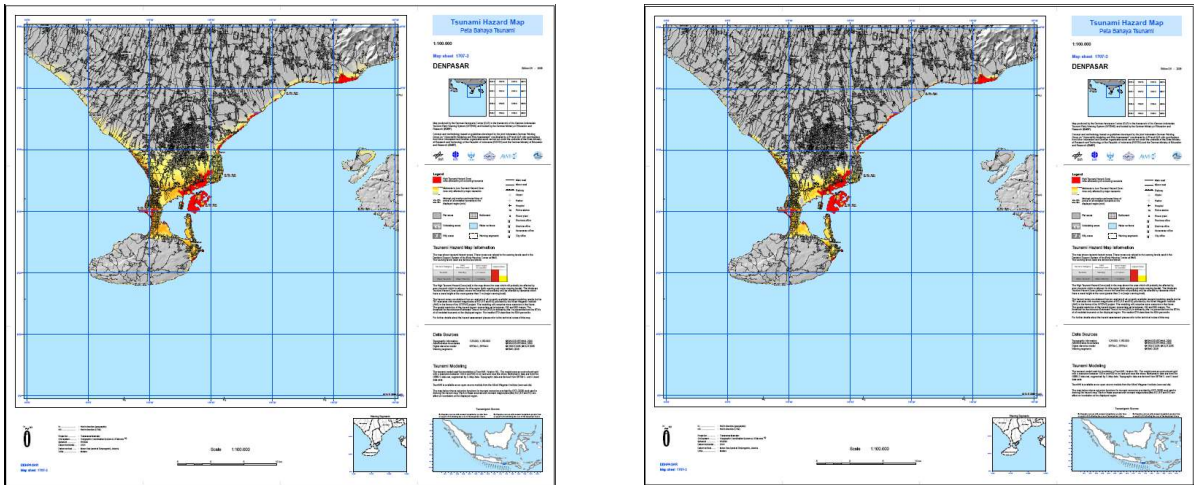



**Figure 7:** Multi-scenario Tsunami Hazard Map for Southern Bali including (left) and excluding (right) Magnitude 9 SR scenarios (by DLR).

A **working group** with representatives from KESBANGLINMAS, BAPPEDA (Local Planning Agency), PU (Public Works Department), BMKG and Uyadana University

was formed to steer and accompany the mapping process. The working group will present a consolidated map and a technical report to the Balinese authorities for further consideration and official recognition.

## 5. INA-TEWS: A System under Development – Roles and Responsibilities – the Current and Future Warning Scheme

After the devastating tsunami of 26 December 2004, the affected Indian Ocean countries decided to build up a regional Indian Ocean Tsunami Early Warning System. The Indonesian Tsunami Early Warning System is a crucial part of the regional system since the subduction zones offshore the Indonesian islands are a major (potential) source for ocean wide tsunamis in the Indian Ocean.

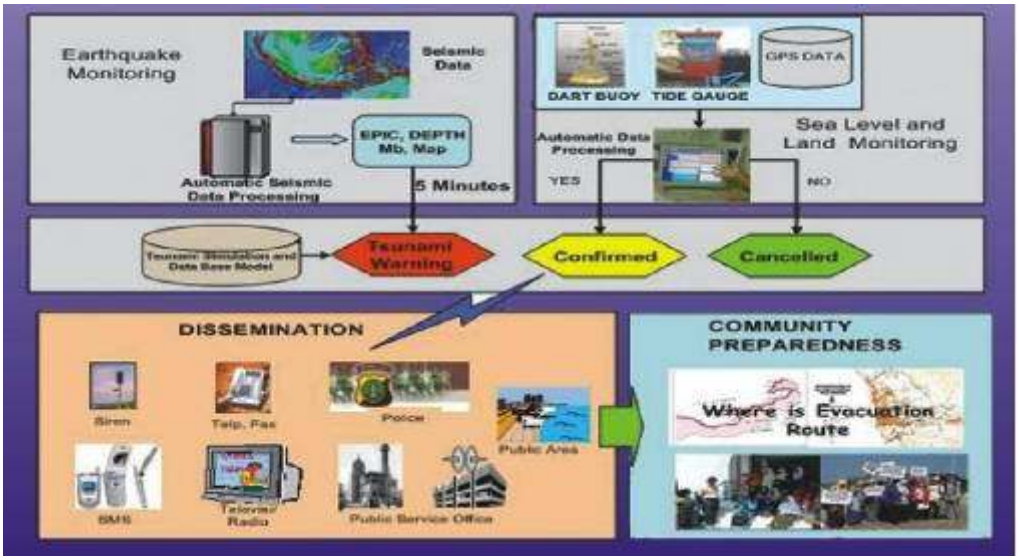



**Figure 8:** INA-TEWS concept of an "end-to-end" Tsunami Early Warning System

In the last years, substantial progress has been made in setting up INA-TEWS. The system was officially inaugurated in November 2008. A two-year testing phase is currently running. At present INA-TEWS has the means to provide credible data and issue tsunami warnings and hereby inform the general public in advance of a potential tsunami impact. INA-TEWS is an "end-to-end" early warning system. This means that the system only works if all components are functioning.

The different components of the system are (see figure above):

1) **Observation of earthquake data** from seismographs;

2) **Observation of ocean (and land, GPS) data** from tsunami detection technology;

3) **Generation of tsunami warnings** and related messages and information

4) **Dissemination of warnings** and other tsunami information to public, interface institutions and local authorities;

5) **Community preparedness** that allows for appropriate reaction by the community at risk in case of warning.

In the moment (March 2009) INA-TEWS is still a system under construction. While seismographs already provide earthquake data, not yet all ocean observation instruments and data processing technology in the National Warning Centre is operational. The technological components for tsunami detection and data processing that still need to be completed are:

- The tsunami detection and monitoring technology that consists of a network of ocean floor pressure sensors, buoys, and tide gauges at the coast. These instruments enable the warning system to detect tsunami waves. GPS units on land provide additional data to assess the potential for a tsunami occurrence.

- The tsunami database that contains thousands of tsunami simulations with varying earthquake parameters and the Decision Support System (DSS)[1]. Both components will be used by BMKG to facilitate the processing of incoming data from seismographs and ocean observation technology and support decision-making in the National Warning Centre.

Until all components are fully operational (scheduled for the second half of 2009) INA-TEWS operates on a temporary warning scheme that is based exclusively on earthquake data gathered from seismographs. The following figure shows the current and future warning scheme and the information that is already available now and will be available in the future:

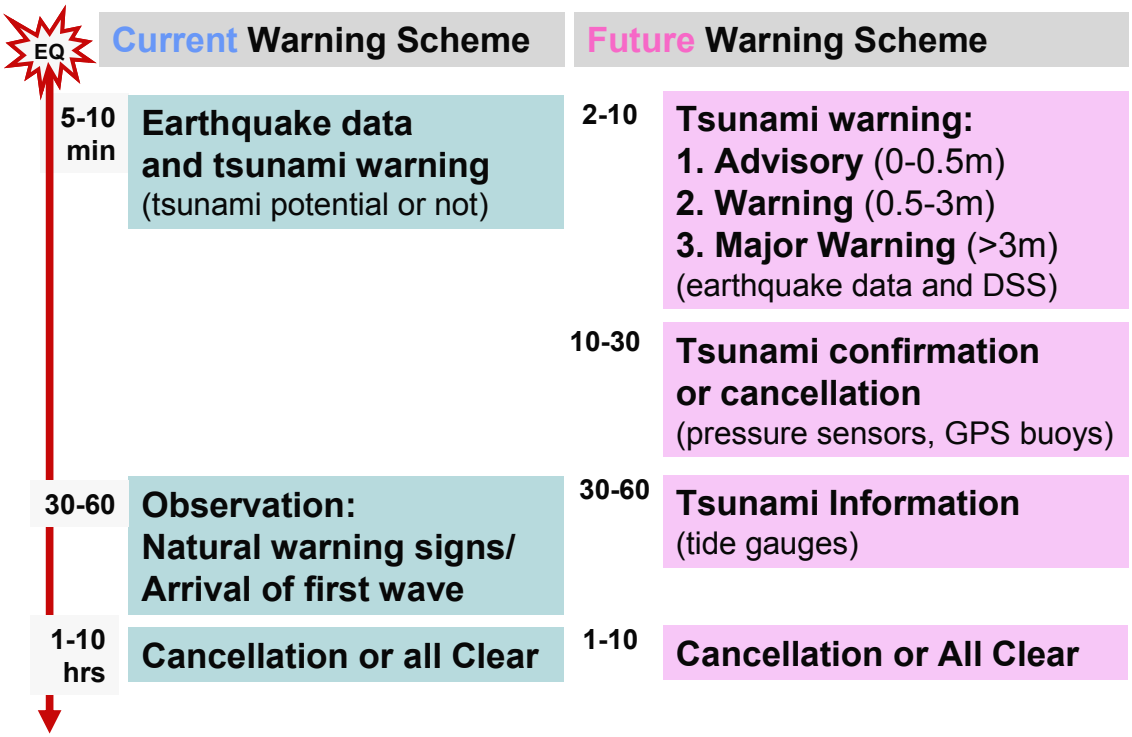



**Figure 9:** Current and future warning scheme of INA-TEWS

[1] The DSS – a computer system – is one of the core contributions of the German-Indonesian Cooperation for a Tsunami Early Warning System (GITEWS) to INA-TEWS. It combines the results from different sources (above described sensor and monitoring technology) and assesses the tsunami threat by comparing the information with pre-calculated tsunami modeling and risk analysis results for coastal areas. The DSS will provide an estimation of a potential tsunami occurrence, including affected areas, wave arrival time and wave height at the coast.

## 5.1 Division of roles and responsibilities within INA-TEWS

Within INA-TEWS there is a clear division of tasks (see below figure):

1. The central source of earthquake information and tsunami warnings is BMKG where the National Tsunami Warning Centre is located. BMKG monitors earthquake data and issues tsunami warnings to the general public via national media, to interface institutions and local government authorities.

2. Upon reception of a tsunami warning, local government authorities (at provincial/ district/ city level) are in charge of reacting to the warning. They are responsible for making a decision whether an evacuation is necessary or not, and if so what the extent of evacuation should be. This decision has to be translated into guidance for evacuation and disseminated to the people at risk as quickly and directly as possible.

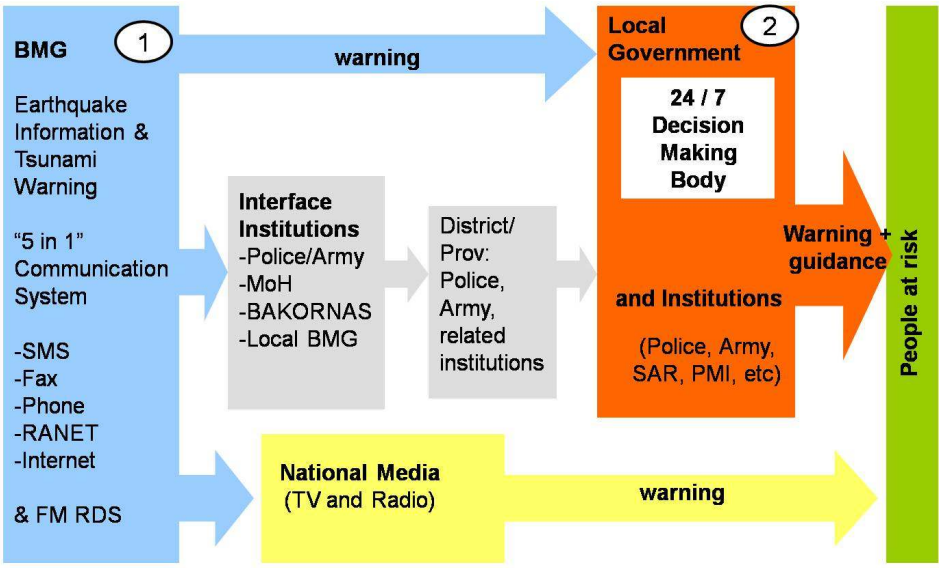



**Figure 10:** Information and warning chain from national to community level

As stated above, BMKG Jakarta currently distributes the warning of a potential tsunami to the national media. 11 TV stations and one radio station (Radio Republik Indonesia – RRI) receive earthquake information and the warning of a potential tsunami. The TV stations directly broadcast the tsunami warning during their programme. The warning message that comes via TV and radio, however, does only state that there is a potential tsunami threat for a certain (very broad) region but does NOT include any recommendation or guidance for reaction by the people at risk, i.e. whether to evacuate or not. This guidance for reaction has to come from local authorities since they are legally in charge of safety of their communities.

## 5.2 Current and future decision making reference for local authorities

The **current warning scheme** compared to the anticipated future scheme provides limited reference for local decision makers. Until the second half of 2009 the standard warning message of the current warning scheme that can be received by provincial and/ or district/ city governments connected to BMKG via SMS and other channels reads as follows[2]:

> *Info Gempa* (earthquake information) *Mag: 7.9 SR, 12-Sept-2007, 18:10:23 WIB* (Western Indonesian Time), *Lok* (location): *4.67 LS - 101.13 BT (159 km barat daya Bengkulu /* 159 km southwest of Bengkulu), *Kedlmn* (depth): *10 km*, *Potensi TSUNAMI utk dtrskn pd msyrkt* (potential for tsunami occurrence, to be forwarded to the public): BMKG

The first part of the message contains earthquake information (i.e. magnitude, date and time of earthquake occurrence, location of epicentre and distance from reference location, and depth). These earthquake parameters are followed by the second element of the message: *Potensi TSUNAMI*. The two elements: earthquake parameters and information about tsunami potential combined constitute the tsunami warning message format that is currently applied by BMKG.

In fact, the term *potensi tsunami* only indicates that the earthquake due to the given parameters has the potential to cause a tsunami. The actual occurrence of a tsunami cannot be determined from earthquake data. However, due to the short travel time of a local tsunami and the limited time for reaction the information about a tsunami potential has to be considered as the basis for decision making and guidance.

In the current warning scheme, the next information would come from coastal observation. The occurrence of a tsunami would be confirmed by natural warning signs and/ or the arrival of the first tsunami wave at the shoreline.

The **future warning scheme** – supported by additional monitoring and sensor technology as well as a tsunami database linked to the DSS – will produce more detailed information. The first warning message providing earthquake information and the warning of a (still) potential tsunami will be broken down into three warning levels, depending on earthquake parameters and database matching:

| | | |
|---|---|---|
| | **Advisory** | ⇨ expected tsunami **wave height** at coast **0 - 0.5 m** |
| | **Warning** | ⇨ expected tsunami **wave height** at coast **0.5 - 3 m** |
| | **Major Warning** | ⇨ expected tsunami **wave height** at coast **> 3 m** |

Additionally, this first message will provide information about potentially affected areas (districts) and estimated time of arrival of the first wave. Since the first warning

[2] The example is taken from the earthquake in West Sumatra Province (known as the Bengkulu-Earthquake, 2007) that actually triggered a minor tsunami in the area of Bengkulu (according to BMKG and DKP, Department for Marine Affairs and Fisheries, measurements).

most probably will be – similar to the current scheme – based on earthquake data it will only indicate that the earthquake has the potential to trigger a tsunami.

In the future warning scheme, BMKG will be able to confirm the first warning after tsunami waves have been detected by the network of buoys, ocean floor pressure sensors and tide gauges. According to estimations today, this information will be available approximately 10-30 minutes after earthquake occurrence – though the actual time can vary. The final confirmation message will be issued once the tsunami has reached the coast and has been detected by tide gauges or visually observed.

# 6. Recommendations for the implementation and operation of tsunami early warning in Bali

The end-to-end Indonesian Tsunami Early Warning System can only be called a "system" once the National Warning Centre is connected with the communities at risk. The objective of this document is to provide technical advice on how to establish this link and how to build the capacities in Bali so that local authorities as well as the people can fulfil its role in tsunami early warning and reaction to warnings.

In order to achieve this goal, certain political, institutional and technical requirements have to be met. This section of the document suggests answers to six key questions referring to these requirements (compare list and figure below) and hereby provides a comprehensive concept for the implementation of TEW in Bali:

**I.** What are the principals of a TEW policy for Bali?

**II.** What are the institutional requirements for TEW in Bali?

**III.** What is required to receive warnings from the National Tsunami Warning Centre?

**IV.** What is required to decide whether communities should evacuate or not?

**V.** What is required to disseminate warning and evacuation guidance to the communities?

**VI.** What is required to strengthen people's awareness and understanding about INA-TEWS?

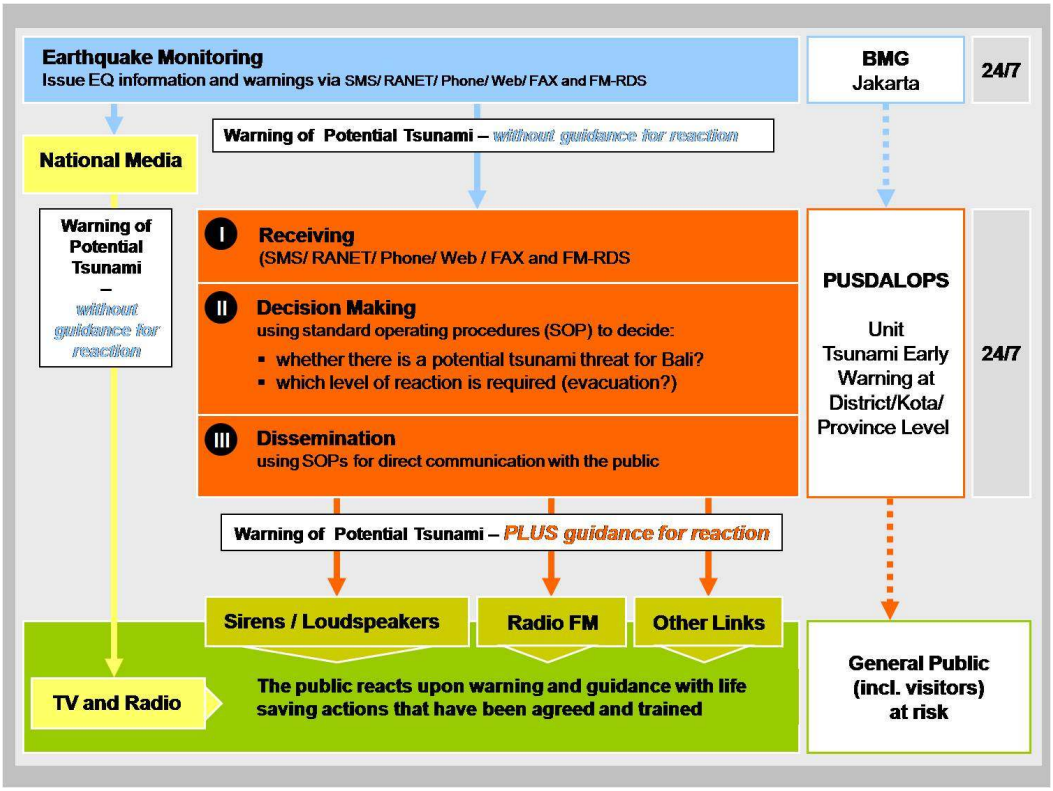



**Figure 11:** Roles and responsibilities and communication channels of the TEW chain

## 6.1 Principals of a TEW Policy for Bali

Implementing and operating Tsunami Early Warning is a "group affair". It involves institutions at national and local level. INA-TEWS can reduce the negative effects of a tsunami disaster substantially. This is only possible if it can rely on proper analysis and an effective communication chain as well as authorities and communities at the other end who can translate the warning effectively into action.

Consequently, the success of early warning will be judged by the quality of public reaction to the warning. Local actors play a very prominent role to achieve this goal. Generating Awareness and knowledge about tsunami hazard and its potential impacts, being capable of receiving warnings from national institutions, giving guidance and instructions to local population and preparing people for disasters are among the genuine responsibilities of local governments and other local stakeholders.

In order to connect to INA-TEWS, Bali needs to define its own policies. These policies should refer to national policies regarding Tsunami Early Warning that have been agreed already.

Nationwide, BMKG is the official source for tsunami information and warnings. BMKG has introduced the policy to send out earthquake information to the public, interface institutions and local authorities as quickly as possible after receiving earthquake data from seismographs. The time frame set for disseminating this

information is about 5 to 7 minutes. Local governments recognizing BMKG's policy can use it as a reference for setting up the local warning chain – knowing they can expect information from BMKG within a few minutes after an earthquake.

For Bali, the following key issues need to be addressed:

- **Strengthening tsunami preparedness and designing early warning procedures requires a coordinated approach and policy by the districts and the province**

  It needs to be clarified who is in charge of providing guidance for evacuation in case of a tsunami warning from BMKG. This requires an agreement on who will make the decision, how this decision is made and what is the reference for it (preferably an SOP). Special attention needs to be given to the management and operation of the BMKG sirens as one of the main dissemination devices. The BMKG siren towers are located in the District of Badung and the City of Denpasar (Sanur). The control over the sirens will be handed over to the province authorities.

- **Decision on evacuation (by authorities) has to be taken (latest) after receiving the first warning from BMKG (on a potential tsunami)**

  A tsunami preparedness strategy for local tsunami hazard needs to recognize the limited time for reaction – and therefore use the fastest information available. Ground shaking (if felt) is the first warning. People should start moving away from the beach and rivers. The next warning will come from BMKG, providing earthquake data and the information on whether the earthquake has the potential to cause a tsunami or not. Although this first BMKG warning does not provide certainty whether a tsunami is on the way or not, it is – most probably – the last timely information local authorities in Bali can get about the possibility of an imminent tsunami threat. Waiting for confirmation through natural warning signs, i.e. such as seawater withdrawal is not an option. The time for evacuation not be sufficient.

  Whether INA-TEWS will be able to deliver a timely message in the future that confirms a tsunami event has yet to be proven once the future system has been fully implemented and is operational. Currently, the timing for a confirmation message is estimated at up to 30 minutes after an earthquake.

- **Decision making for reaction to a potential tsunami threat should be based on Standard Operating Procedures (SOP)**

  Due to time constrains in regards to the local tsunami threat quick and reliable decision making procedures are required. Standard Operation Procedures (SOP) should guide local authorities or staff of 24/7 Operation Centres in the decision making process. Introducing SOPs will not only allow for delegation of decision-making to staff of 24/7 Operation Centres but also enable individual (but coordinated) decision-making by individuals or institutions in case of communication breakdown. Such SOPs need to be authorized by the local government.

SOPs for decision-making during a local tsunami threat will have to take into account natural warning signs (ground shaking) and warnings from BMKG. In the moment of an imminent threat of a local tsunami it is most unlikely that any other source can provide additional information that support decision-making.

Besides that, standard procedures should be also developed for warning reception and dissemination of warning and evacuation guidance.

➲ **The future warning scheme from BMKG will alter the possibilities of Bali to react to a tsunami warning. Bali should consider a two-level evacuation strategy, as the impacted area at Warning Level 1 will be confined to a narrow coastal strip. Only Warning Level 2 requires full-scale evacuation.**

The future BMKG warning scheme will provide one advisory and two warning levels. This enables Balinese authorities to make a differentiated decision depending on the estimated tsunami threat (as indicated by the respective warning level).

Results from inundation modelling can be used to visualize the impacted areas in relation to the different warning levels. The DLR multi-scenario Map has developed a zoning according to the two warning levels. The red zone represents the affected area at Warning Level 1, which is defined by wave heights at the coast < 3 m. The yellow zones might get affected by a tsunami with wave heights at the coast > 3 m (Warning Level 2).

As the impacted areas of Warning Level 1 (red zone in the map below) and Warning Level 2 (orange and yellow zones) differ considerably it makes sense to consider a differentiated approach.

This means: when receiving a BMKG warning for a minor tsunami threat (Warning level 1: *Peringatan*) there is no need for a large-scale evacuation. An evacuation of the red zone would be sufficient.

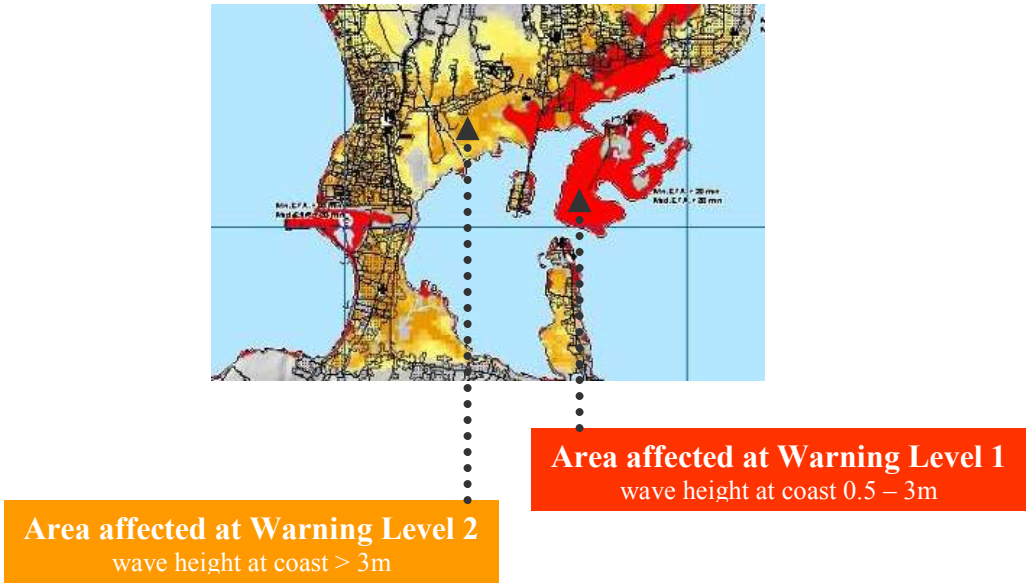



**Figure 12:** DRAFT of Multi-scenario Hazard Map with zoning according to BMKG warning levels (DLR 2009)

A differentiated, two level approach for evacuation, poses a challenge on community preparedness. However, it also offers opportunities to reduce the frequency of full-scale evacuation and its implications, i.e. panic, accidents, loss of assets during the evacuation process and communities' distrust in the warning system and its political implications.

### ➲ Link between warning levels, hazard zoning and evacuation strategy

The recently developed maps which relate tsunami inundation areas to warning levels will allow for a consistent link between hazard zones, warning levels and evacuation strategies.

### ➲ Documentation of policies and strategies as basis for implementation

In order to implement Tsunami Early Warning in Bali it is recommended to document the overall policy, its principles and strategies in official documents:

- Official Tsunami Hazard Map
- General policies for tsunami preparedness and early warning
- Standard Operating Procedures for Tsunami Early Warning
- Evacuation plan at district level
- Official evacuation map at district level

### ➲ Integrate the tourism sector into the tsunami early warning system

The tourism sector should be involved as a strategic partner, due to its importance for the local economy, potentials in terms of infrastructure and human resources as well as the specific needs of foreign visitors who are not familiar with local conditions.

## 6.2 Institutional Requirements: 24/7 Unit

Since an earthquake that causes a tsunami can happen at any time it is crucial that local early warning centres are operational at any time too. An institution that is vital for tsunami early warning is a 24/7 unit that operates around the clock – 24 hours a day and 7 days a week. This unit allows receiving warnings and issuing guidance to the people at risk at any time.

Province authorities, with support from the French Red Cross (FRC), are currently setting up a Multi-Hazard Emergency Operation Centre (EOC) in Denpasar. It was agreed that this **EOC will** also **host the 24/7 service for Tsunami Early Warning**. The completion of the building construction of this EOC is scheduled for April 2009 while equipment should be installed gradually between July and September 2009.

At present, Bali cannot count on a reliable 24/7 service for Tsunami Early Warning. Although it was agreed to establish a temporary 24/7 service at KESBANGLINMAS at province level and in the District of Badung, both services are not operational.

It is strongly recommended to assure a **temporary service** operated by the Province Government until the questions related to the division of roles and responsibilities between province and districts regarding warning services and its relation with the new Disaster Management Agency (BPBD) are answered.

Experience suggests that the installation of a highly professional **24/7 service within the PUSDALOPS of the province that can serve all Balinese districts** would be more reliable and economically feasible instead of implementing 24/7 services in each of the eight Balinese districts with tsunami prone coastlines. This recommendation takes into account the specific requirements of the INA-TEWS (short warning time and quick decision making). For other natural hazards this policy might not apply.

**In general any 24/7 unit for TEW in Bali requires:**

- An office or post that operates 24 hours a day and 7 days per week, including the usual office equipment;
- One Officer on Duty and two other 24/7 officers per shift who will be involved in operations in case of emergency. The Officer on Duty and all other personnel need to be trained on SOPs for decision-making, dissemination, operating communication equipment etc;
- Provision of a clear mandate to the 24/7 unit stating that the Officer on Duty is the person in charge of decision-making for reaction (based on agreed SOP) upon reception of tsunami warnings;
- Operations Manual containing all procedures and relevant information for the 24/7 unit;
- Communication technology for reception and dissemination of warnings and guidance;

- Power back up for the case of power black out during a strong earthquake. (The EOC built with support from the FRC) will include power back-up, i.e. UPS and Generator Set.

**What needs to be done?**

It is suggested to continue the definition of the institutional set-up for Tsunami Early Warning in Bali and in the meantime implement a temporary warning service as soon as possible.

As by March 2009, a first draft of an EOC guideline for Bali has been finalized by KESBANGLINMAS with the support of GTZ, FRC, PMI and IDEP Foundation. This document will be presented to the Governor of Bali in April and will hopefully be validated through a decree. It will then become a basis for various operational procedures that are currently being draft (TEWS, response coordination and command, information sharing, communication mechanisms etc.)

Meanwhile, KESBANGLINMAS is upgrading its EOC team with the recruitment of new operators. FRC plans to conduct a Human Resource Diagnostic of the new team in April and to start implementing basic, practical trainings on IT, reporting, data compiling etc.

## 6.3 Receiving information and warnings from BMKG

In order to be able to warn the people at risk in Bali, local 24/7 units for Tsunami Early Warning need to be capable of receiving information from BMKG through various channels.

**For receiving warnings and information from BMKG a local 24/7 unit requires:**

- Communication technology to receive information and warnings from BMKG;
- Standard Operating Procedures for warning reception;
- Personnel trained in operating and maintaining the communication equipment.

Strong earthquakes can cause power black out and other disturbance that might effect communication equipment. One principle of warning systems is redundancy in the means of communication. In order to effectively operate a 24/7 unit all below communication equipment has to be available to make sure that if one communication channel fails a warning can still be received through another channel.

**Receiving warnings from BMKG requires the following communication devices:**

| Communication device | Remarks |
|---|---|
| ⇨ RANET (will be substituted) | [available from BMKG] |
| ⇨ Mobile phone for SMS reception | [registration with BMKG required] |
| ⇨ Phone (landline) | [more than one line required] |
| ⇨ FM RDS (includes radio FM) | [service not yet operational] |
| ⇨ Computer with internet connection | [ – ] |
| ⇨ [multiband] VHF radio | [ – ] |
| ⇨ FAX | [registration with BMKG required] |
| ⇨ TV | [ – ] |
| ⇨ Power back up (UPS, generator) | [ – ] |

The EOC provided by FRC will include multimodal communication devices (internet, phone, fax, satellite phone and radio) and is designed to be operational on a 24/7 basis. There is a need for coordination with BMKG to make sure that the server and antenna required for certain devices is provided.

### What needs to be done?

To provide the 24/7 unit with equipment the following steps have to be taken:

- ➲ Revise the assessment of the existing communication devices – what is already in place?
- ➲ Provision of funds for procurement of missing communication equipment;
- ➲ Provision of budget for maintenance of communication equipment;
- ➲ Appointing a skilled person in charge of technical equipment;
- ➲ Training the personnel of the 24/7 unit in operating and maintaining the communication devices.

**RANET**


**FM-RDS**

**Telephone**

**Fax**


**Internet**

**VHF radio**

## 6.4 Decision Making by Standard Operating Procedures (SOP)

As stated in the principle policies (chapter 6.1) it is strongly recommended that the decision whether to evacuate or not is based on Standard Operating Procedures (SOP).

For the **current warning scheme** (valid until approximately mid-2009) the following temporary Standard Operating Procedure for decision-making can be applied:

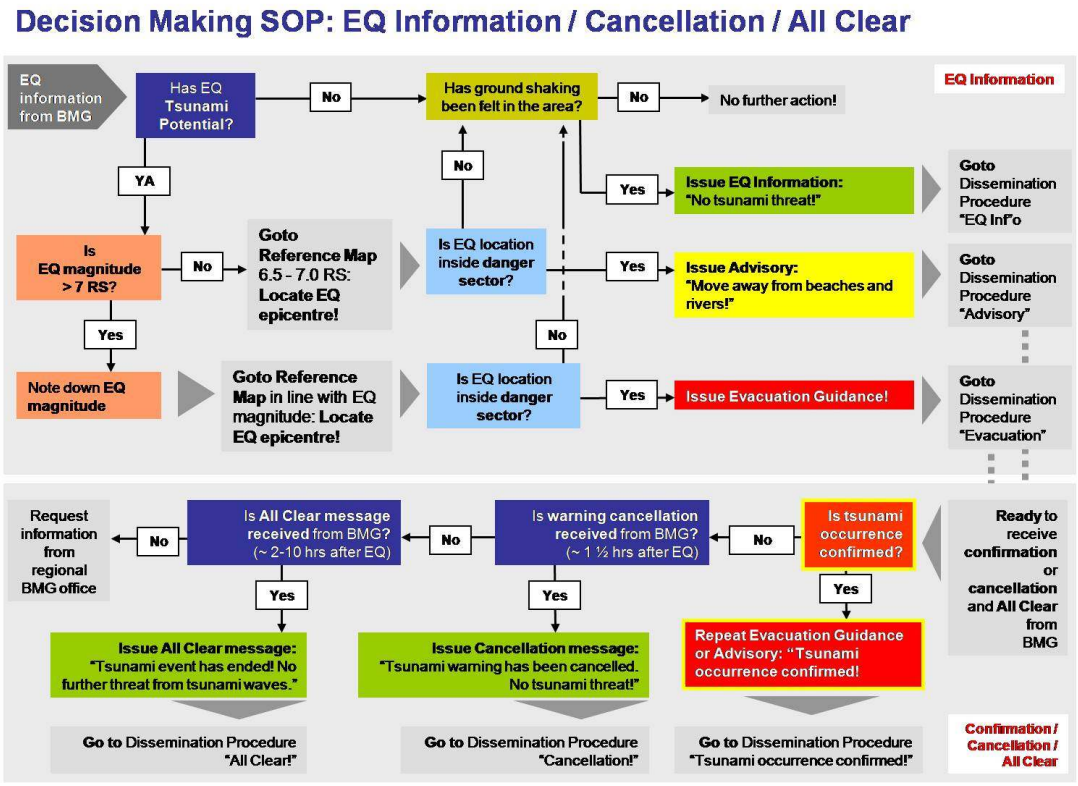



**Figure 13:** Standard Operating Procedure (SOP) for decision making in current warning scheme

Since the first warning message **in the current warning** scheme does not provide any information on potentially affected areas the decision maker in the local 24/7 unit requires an **additional data analysis and decision making tool**. In order to determine whether an earthquake with a potential for tsunami poses a threat on the coastline of Bali simple **reference maps** can be used. These maps allow for checking whether an earthquake epicentre is located in an area from which tsunami waves would still affect the coast of Bali. The areas in which earthquakes with a tsunami threat for Bali are located have been labeled "*zona bahaya*". As the size of this area varies with earthquake magnitudes, maps for four different ranges of magnitudes (6.5-7.5 / 7.6-8.0 / 8.1-8.5 / 8.6-9.0) have been designed to allow a quick location search. These maps have been developed by AWI in July 2008 and are based on the results of a big number of pre-calculated scenarios (see next page).

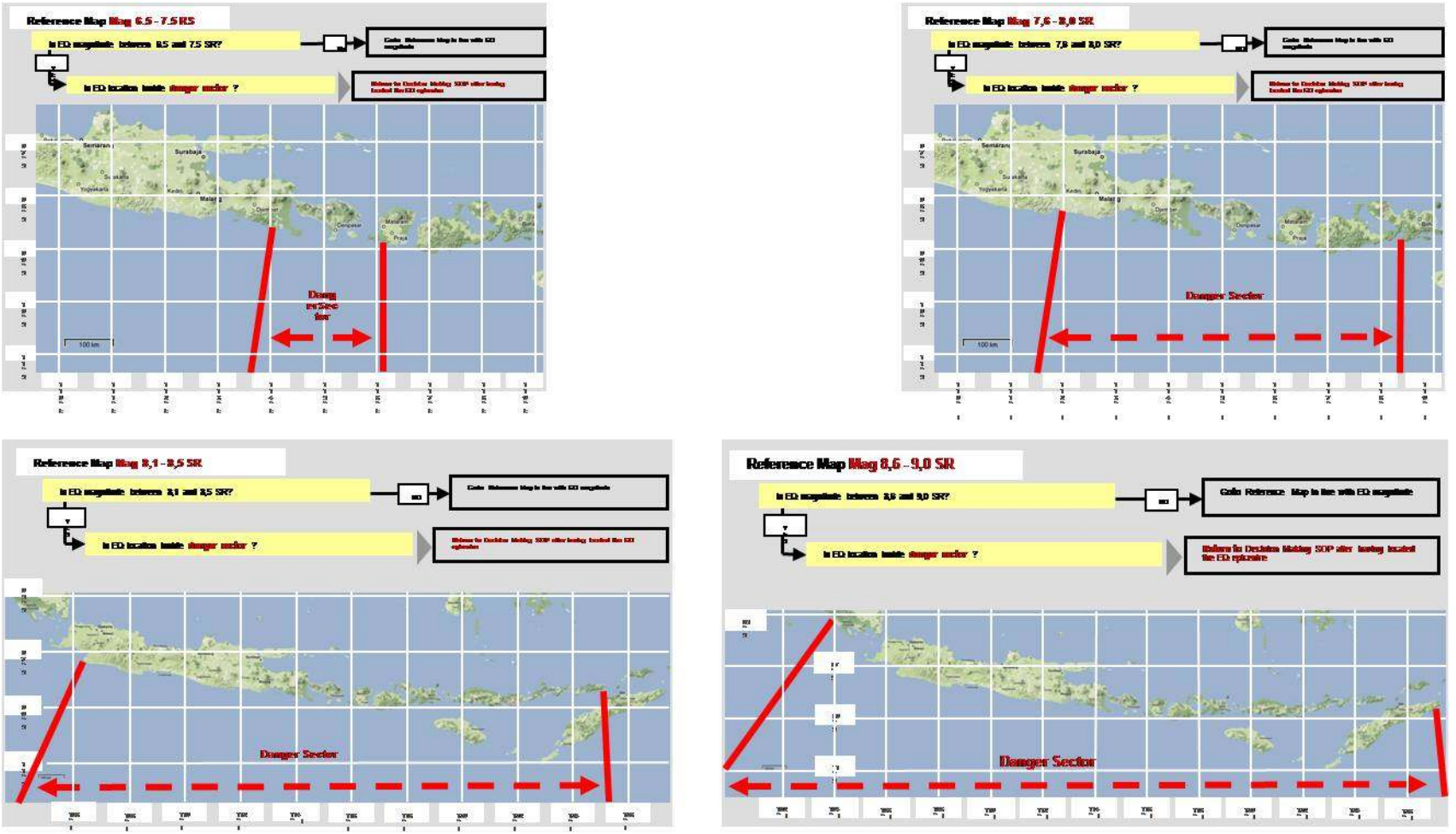



**Figure 14:** Reference Maps to locate earthquake epicentre and estimate whether tsunami waves would affect the coast of Bali (based on AWI modelling results, 2008)

For the **future warning scheme** starting mid-2009 the following Standard Operating Procedure for decision-making can be applied:

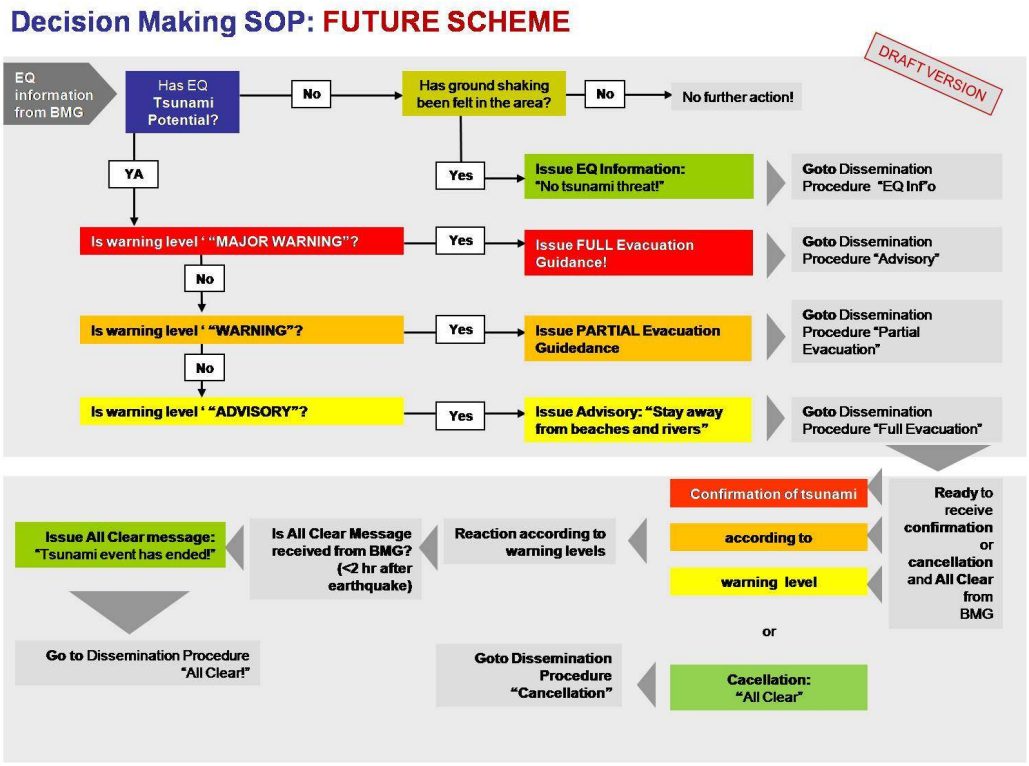



**Figure 15:** Standard Operating Procedure (SOP) for decision making in future warning scheme **(preliminary version)**

The first warning message **in the future warning** scheme will already provide information on potentially affected areas and warning levels (see 5.2: *current and future decision making reference for local authorities*). The SOP above already considers the two-level approach for evacuation (partial and full scale; see 6.1: *Principals of a TEW Policy for Bali*).

## What needs to be done?

In order to implement standard decision-making the following aspects require official and written approval by local authorities:

- The **standard procedure for decision-making needs to be approved by local authorities and understood by all stakeholders** in Bali. This has to be done long before the case of emergency. In case of emergency, the 24/7 unit analyses the incoming data from BMKG and uses the procedures to make a decision that is in line with previous agreements.

- It is also recommended to provide the mandate for decision-making upon reception of a warning to the 24/7 unit. An **Officer on Duty should be authorized for autonomous decision-making** based on the agreed reference (SOP).

## 6.5 Dissemination of warning and guidance to the communities at risk

In order for a 24/7 unit to be able to disseminate warning and guidance messages to the community at risk the following components are required:

- Standard Operating Procedures for dissemination of warning and guidance messages;
- Communication technologies and networks for dissemination;
- Set of standard warning and guidance messages.

**Standard communication and dissemination procedures** will help officers at a 24/7 unit to effectively disseminate warning and guidance messages to all relevant local institutions (e.g. Police, Military and SAR) and the community at risk.

These SOPs should be developed and regularly updated by the 24/7 unit in accordance to the communication networks and technologies used for dissemination of early warning in Bali.

The 24/7 unit should be equipped with all necessary **communication devices** which are necessary to (1) activate warning devices like sirens, (2) communicate with other emergency response agencies and decision makers and (3) disseminate warning and guidance messages to the community at risk:

**The following devices for communication and dissemination are required in the 24/7 unit:**

| Device | Purpose | Status | Comment |
|---|---|---|---|
| Trigger for sirens | Activate siren system | To be clarified with BMKG | Need personnel for continuous maintenance |
| HF/VHF/UHF and SSB Radio | Communication between the 24/7 unit and all emergency units (SATLAK & SATKORLAK) | Available? | |
| RANET 5in1 | Distribution of information from BMKG using SMS etc. | Not yet fully operational | |
| Telephony system (VoIP, PSTN, GSM and Satellite) | Dissemination | FRC, ongoing project | The telephone network in PUSDALOPS comprises four technologies, which backup one another if one channel fails to work. |
| Phone (landline) | Communication between 24/7 unit and authorized institution | Available | More than one line required |
| HP | Communication between authorized personnel | | It is proposed that VIPs hold a special number which is also registered in the phone provider in order to be able to |

| | | | |
|---|---|---|---|
| | | | receive prompt alert |
| Internet (terrestrial and satellite) | Global information dissemination and communication | FRC, ongoing project | It is important for PUSDALOPS to have redundant system of internet connection since internet is crucial the information system |
| Portable multimode communicator | Communication and dissemination from the field to PUSDALOPS and authorized personnel | FRC, ongoing project | This smart portable system enables the authorized person to send report, warning, needs and even command in critical situation |

EOC are planned to be equipped with ten landline connections, including two for fax and eight for voice.

Warning and guidance messages from a local 24/7 unit for Tsunami Early Warning can reach the people at risk in Bali through **different channels and networks:**

- **Public announcements through sirens and loudspeakers.** Due to short warning times a direct communication link to communities at risk is vital and has to be prioritized. For this purpose sirens and loudspeakers shall be used that will be operated directly from the local 24/7 unit. Announcements by the local warning centre should be heard directly.

- Furthermore warning and guidance messages should simultaneously be announced through local public **FM radio** and community radios. It is recommended to identify local radio station(s) that will be used for broadcasting information in emergency situations. Agreements and reliable links between the 24/7 unit and the respective radio station should be established. The general public should be aware of which radio station or frequency they should tune in to in case of emergency. The selected radio station(s) should be on air 24/7 and equipped with a reliable power back up system in case of power black out.

- Bali was a Pilot Area for the testing of **FM-RDS technology** for TEW purposes. Around 30 receivers have been distributed to public and private institutions. Warnings will be sent out by BMKG in Jakarta. In principle it is also possible to trigger the FM-RDS radio devices from the province level and disseminate guidance information via the integrated text display screen.

- Dissemination of warning and guidance by **community networks and organisations.** For those areas that are not covered by loudspeakers and sirens local organisations and networks should be used (e.g. RAPI, ORARI).

- Additionally, warning and guidance messages can be disseminated by using **traditional communication means** or religious infrastructure (e.g. kulkul) at Banjar level.

- PMI maintains a network of CBAT (Community-Based Action Teams) at village level who could be an effective relay for the warning at community level. This would require that CBAT members are provided with basic communication tools (i.e. radio handsets) and that the PMI "POSKO" which

is active on a 24/7 basis (at province and district level) receives messages directly from the EOC.

Clear messages containing simple, useful information are critical to enable proper reaction to warnings will help to safeguard lives and livelihoods. Therefore the development of **standard warning and guidance messages** is required. It has to be assured that warning and instruction messages from the different levels and institutions are consistent in content and time. The content and meaning of those messages need to be introduced to the communities at risk (awareness campaign) and trained beforehand (drill).

**Clearly defined siren sounds** are known as appropriate means for early warning. Within INA-TEWS a standard national sound scheme has not been officially approved yet. A national standard, however, is crucial for consistent application of sirens all over the country.

Tsunami Early Warning requires the following set of standard warning and guidance messages:

| Type of message | When to disseminate? |
|---|---|
| Warning and Evacuation Guidance:<br>▪ Move away from Beaches and Rivers!<br>▪ Partial Evacuation<br>▪ Full Scale Evacuation | <br>▪ Potential for minor tsunami<br>▪ Potential for medium tsunami<br>▪ Potential for major tsunami |
| EQ Information | EQ felt but no tsunami threat |
| Cancellation | No tsunami generated by EQ |
| Confirmation | Tsunami occurrence confirmed |
| All Clear | Tsunami event over |

**Note:** Immediate reaction upon ground shaking – i.e. moving away from beach and rivers – should not need an official announcement but should be an individual standard reaction by people in Bali when being close to the coast or rivers.

**Content and wording of clear warning and guidance messages for Bali needs to be determined!**

### What needs to be done?

In order to support the mechanisms for disseminating warning and guidance the following aspects have to be considered:

- ➲ Development of Standard Procedures for dissemination;

- Agreement on who triggers the sirens (Province/ BMKG?), definition of standard siren sounds and their meaning;
- Assessment of existing communication devices for dissemination in the 24/7 unit;
- Provision of additional funds for communication devices in the local 24/7 warning centre (as required);
- Agreement on official local radio FM frequency (radio channel) for tsunami warnings and guidance that people can tune in to in case of emergency;
- Assessment of coverage by sirens and other means of dissemination, including communication networks such as RAPI/ ORARI;
- Provision of funds for dissemination equipment in the communities, i.e. loudspeakers and sirens (as required);
- Development, official approval and introduction of content, wording and meaning of standard warning and guidance messages.

## 6.6 Strengthening people's awareness and understanding about INA-TEWS

Timely and effective community reaction will be achieved when people respect and trust the warning service and understand the tsunami risk. Therefore the public perception of tsunami risk and warning services has to be understood and strategies need to be developed by the local government to build confidence towards warning and guidance services. This includes the assignment of a credible source authorized to generate and distribute warning and guidance, minimize false alarms, and communicate the progress to set up the warning system.

In its effort to strengthen community awareness and understanding of INA-TEWS, Bali can draw from the strength and experience of its civil society organizations, including PMI.

Special attention should be drawn to the tourism sector, which needs to develop a strategy to inform national and international visitors about basic facts and procedures. Basis for this strategy is, however, a functioning official Tsunami Early Warning System with reliable and credible early warning dissemination channels as well as official references (hazard, risk and evacuation maps). Currently BUDPAR is conducting 'Tsunami Ready' workshops throughout Indonesia to encourage hotels to prepare for tsunamis on the basis of its 'Tsunami Ready Toolbox'. The creation of a common standard for evacuation route signs to be used within private hotel grounds was a success. The signs resemble the official Indonesian tsunami evacuation signs to avoid confusion when crossing from public into private hotel space. The signs are already used by BHA Member Hotels. Other hotels are encouraged by BUDPAR to use the same design for their own evacuation routes.

### What needs to be done?

- Information of the general public about source(s) for Tsunami Early Warning in Bali and how warning and guidance messages will be disseminated;

- Development of a special program to equip highly vulnerable institutions and public facilities (schools, hospitals, markets, public transport facilities etc.) in the risk areas with communication devices which will allow the direct reception and dissemination of warning and guidance messages from the local 24/7 unit;

- A public information campaign (once official standard messages have been developed and tested) to assure that people in the risk areas understand the different types of warning messages and know what kind of information they can expect from the local authorities in case of an emergency.

- Awareness campaigns and drills that are run on a regular basis to familiarize people in risk areas with evacuation procedures and strengthen basic knowledge regarding risk zones and safe areas.

- Community preparedness activities by NGO or other initiatives in Bali that are supported with the provision of official information and guidance from

Balinese authorities regarding hazard and risk zones, evacuation, procedures and messages for early warning as well as recommendations how to react on warning signs and messages.

- Cooperation with the private sector, especially within the tourism industry as essential activity to include visitors and tourists

# 7. References

## 7.1 Information regarding GTZ IS' Cooperation for Tsunami Early Warning in Bali

Cooperation partners are the governments of the District of Badung and the Province of Bali. The Balinese branch of the Indonesian Hotel Association (PHRI) and the Bali Hotel Association (BHA) are private sector cooperation partners. The project further cooperates with local branches of BMKG, RRI, PPLH and PMI. Relations were also initiated with representatives of traditional religious and *adat* groups to include the Balinese traditional perspective on natural disasters and preparedness. The provincial government of Bali provides facilities for the local project office in Denpasar. Objectives and modes of cooperation are documented in agreements and work plans.

Project activities in Bali started in November 2006 with an information event about FM-RDS and the introduction and testing of this technology on behalf of BMBF (German Ministry of Education and Research) and RISTEK (Indonesian Ministry for Research and Technology). Assessment workshops were held at district (April 2007) and province level (May 2007) to obtain a common understanding of basic concepts of Tsunami Early Warning and to assess what is already in place and thereby define the working strategy.

SOP development was the initial focus at province level. Representatives from PEMPROV participated in a series of SOP workshops and continued as in the form of a working group. Open questions related to the Tsunami Early Warning chain were addressed in several inter-institutional meetings organized by BMKG and PEMPROV with support from GTZ IS. In February 2008 a meeting between representatives from province and several district governments led to an agreement on the division of responsibilities between the two levels.

As a result of the presentation of GITEWS tsunami inundation scenarios to the Bali Governor in January 2008, the development of an official tsunami hazard map was prioritized. In July 2008 Indonesian and German scientists analyzed existing hazard maps for Bali and agreed on recommendations regarding methodology and type of an official tsunami hazard map. DLR provided an updated version of its Multi-scenario Tsunami Hazard Map for Southern Bali at the end of 2008, incorporating data of other organizations. DLR and GTZ IS drafted a technical document in close cooperation with the Balinese Working Group for Tsunami Hazard Mapping in March 2009.

Additionally, the project provides advisory to SATKORLAK members regarding the development of the legal framework (PERDA, RENSTRA) and budgeting for disaster management. Mid 2008, KESBANGLINMAS created an own division (UPT) for early warning and is now preparing staff to operate 24/7 services.

The main focus in the District of Badung was the implementation of a 24/7 Tsunami Early Warning service within the SATLAK structure. After an initial assessment of existing communication facilities and procedures, the project conducted a series of training workshops to develop SOPs and to prepare a group of government officials to operate the local warning centre. The concept of 24/7 operations and the SOPs were discussed with local decision makers and are documented in an Operations Manual. Another project initiative is related to evacuation planning in Kuta. Shelter buildings and locations in Kuta had been identified based on DLR research regarding population distribution and spatial accessibility. The study provides valuable inputs for the development of a future evacuation strategy. GTZ IS is currently accompanying and advising a local working group to develop the evacuation plan for Kuta.

The project contributes to strengthening knowledge and awareness about tsunami hazard and TEW by facilitating or supporting training workshops and information meetings for representatives from local government institutions, coastal villages, NGOs, women groups, SAR and the education sector. Meetings with representatives from villages were held to inform about tsunami preparedness and promote the link between villages and INA-TEWS. In cooperation with the province government the project organized a seminar on Hindu Religion, Balinese Custom and Cultural Perspectives on Tsunami Early Warning in September 2007.

Cooperation with the tourism sector addressed questions on how to access and interpret tsunami early warning. In several occasions hotel managers were updated on the implementation process of INA-TEWS. In cooperation between the Indonesian Ministry of Culture and Tourism and BHA a “Tsunami Ready Tool Kit” for the tourism sector has been developed – supported by a German CIM expert. GTZ IS supported this initiative through advice and the joint development of fact sheets. Currently the focus shifts to the relation between hotels and neighbouring communities due to the fact that hotel facilities will play an important role during evacuation in highly populated areas in southern Bali. Evacuation procedures for Tanjung Benoa have been agreed upon between the community and the hotel sector recently.

## 7.2 Reference Documents:


- Grand Scenario INA-TEWS
- Decree No. 21/ix/2006 of the Coordinating Minister for People's Welfare in the capacity of Executive Director for National Coordinating Agency for Disaster Management (Bakornas PB), 2006
- Memorandum of Understanding (MoU) between Meteorological and Geophysical Agency (BMKG) and Local Governments on Tsunami Disaster Management, March 2007
- Warning Chain Analysis, GTZ IS, 12-2006
- TEW Assessment Workshop, Badung District, GTZ IS, 04-2007
- TEW Assessment Workshop, Bali Province, GTZ IS, 05-2007
- Bali Consultative Workshop on Hazard Mapping, Meeting Report, 01-2008
- Buku Pedoman Operasi Peringatan Dini Tsunami dalam INA-TEWS untuk PUSDALOPS Provinsi / Kabupaten / Kota di Bali, GTZ IS, October 2008
- Technical Document: Tsunami Hazard Map for southern Bali, March 2009
- Multi-scenario Tsunami Hazard Map for southern Bali, 1:100.000 with zoning based on wave height at coast and related INA-TEWS warning levels as well as probabilities of areas to be affected by a major tsunami, DLR, March 2009
- FM-RDS Dissemination Technology - Manual for Pilot Project Bali, GTZ IS, December 2006
- Checklist for Assessment, Planning and Monitoring - English and Indonesian Version", GTZ IS, 2007
- Warning Dissemination Technologies for Tsunami Early Warning in Local Communities, GTZ IS, November 2007

## 7.3 Abbreviations:

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|---|---|
| AWI | = Alfred Wegener Institute |
| BAKORNAS | = Badan Koordinasi Nasional (National Disaster Coordinating Agency) |
| BAPPEDA | = Badan Perencanaan Pembangunan Daerah (Local Planning Agency) |
| BHA | = Bali Hotels Association |
| BPBD | = Badan Penanggulangan Bencana Daerah (Local Disaster Management Agency) |
| BMBF | = German Ministry of Education and Research |
| BMKG | = Badan Metereologi, Klimatologi dan Geofisika (National Agency for Meteorology, Climatology and Geophysics) |
| BTB | = Bali Tourism Board |
| CBDRM | = Community Based Disaster Risk Management |
| CBAT | = Commnunity-Based Action Teams |
| CGS | = Centre for Geological Survey |
| CIM | = Centre for International Migration |
| CVGHM | = Centre Volcanology and Geological Hazard Mitigation |
| DEPDAGRI | = Departemen Dalam Negeri (Ministry of Home Affairs) |
| DKP | = Departemen Kelautan dan Perikanan (Department for Marine Affairs and Fisheries) |
| DLR | = German Aerospace Centre |
| DSS | = Decision Support System |
| EOC | = Emergency Operation Centre |
| FAX | = Faxcimile |
| FRC | = French Red Cross |
| FM-RDS | = Frequency Modulation Radio Data System |
| GITEWS | = German-Indonesian Tsunami Early Warning System |
| GPS | = Global Positioning System |

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| GSM | = Global System for Mobile Communications |
| GTZ | = German Technical Cooperation |
| Hp | = Handphone |
| Ina TEWS | = Indonesian Tsunami Early Warning System |
| KESBANG, POL dan LINMAS | = Kesatuan Bangsa Politik dan Perlindungan Masyarakat (Civil Defense and Community Protection) |
| MoU | = Memorandum Of Understanding |
| NGO | = Non Goverment Organization |
| ORARI | = Organisasi Radio Amatir Republik Indonesia (Indonesian Amateur Radio Association) |
| PEMKAB | = Pemerintah Kabupaten (District Government) |
| PEMPROV | = Pemerintah Provinsi (Provincial Government) |
| PERDA | = Peraturan Daerah (Provincial Regulation) |
| PHRI | = Perhimpunan Hotel dan Restoran Indonesia (Indonesian Hotel Association) |
| PMI | = Palang Merah Indonesia (Indonesian Red Cross) |
| PPLH | = Pusat Penelitian Lingkungan Hidup (Environmental Research Centre) |
| PSTN | = Public Switched telephone Network |
| PU | = Pekerjaan Umum (Public Works) |
| PUSDALOPS | = Pusat Pengendalian Operasi (Operational Control Centre) |
| RAPI | = Radio Antar Penduduk Indonesia |
| RANET | = Radio and Internet |
| RENSTRA | = Rencana Strategis (Strategic Plan) |
| RISTEK | = Kementrian Negara Riset dan Teknologi (State Ministry of Research and Technology) |
| RRI | = Radio Republik Indonesia |
| SAR | = Search and Rescue |
| SATLAK | = Satuan Pelaksana (Implementing Unit) |
| SMS | = Short Message Service |
| SR | = Skala Richter (Richter Scale) |

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|---|---|
| SSB | = Single Sideband Modulation |
| SOP | = Standard Oprating Procedures |
| TEW | = Tsunami Early Warning |
| TNI | = Tentara Nasional Indonesia (Indonesian Army) |
| TV | = Television |
| UHF | = Ultra High Frequency |
| UPS | = Uniterrutible Power Supply |
| UPT | = Unit Pelaksana Tekhnis (Technical Implementing Unit) |
| VHF | = Very High Frequency |
| VIP | = Visual Information processing |
| VoIP | = Voice- over Internet protocol |
| WIB | = Waktu Indonesia bagian Barat (Western Indonesia Time) |